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INSTITUTIONAL VARIETY, NETWORKING AND KNOWLEDGE EXCHANGE: COMMUNICATION AND INNOVATION IN THE CASE OF THE BRIANZA TECHNOLOGICAL DISTRICT[1]

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ABSTRACT. Elaborating on the literature on innovation systems and technological districts, this paper suggests that localisation is conducive to a multilateral exchange of interdependent and external knowledge bases but requires explicit communication efforts in order to lead to innovation. In particular, the case of the Brianza technological district shows that different and yet complementary knowledge bases are built upon the institutional variety characterising the local economic system. Moreover and more importantly, this case provides empirical evidence for the fact that the construction of an inter-organisational network of dissimilar but complementary co-operative relations – in contrast to a concentration on one dominant kind of interaction – is the key source of innovation and growth of local firms.

KEYWORDS: Communication; Knowledge exchange; Innovation; Networking; Technological districts

1. INTRODUCTION

Evidence provided by the innovation systems and technological districts literature shows that firms are parts of innovation processes that do not exclusively involve other firms within the production chain, such as clients, suppliers, subcontractors and more generally upstream and downstream agents. A plurality of actors that are external to the production system accounts for different kinds of knowledge and competences, which are interdependent with those controlled by the firms.

[1] This paper draws on an empirical data set collected up within the Nomisma project n° 2000/34 funded by the Business Association of Monza and Brianza. The funding of the research project "Technological Knowledge and Localised Learning: What Perspectives for a European Policy ?" carried on under the research contract No. HPSE-CT2001-00051 of the European Directorate for Research within the context of the Key Action "Improving the socio-economic knowledge base" is acknowledged, as well as the assistance of Sonia Cantoni in statistical analysis and the comments of Cristiano Antonelli.

Within this context, the overall institutional environment in which firms interact becomes the relevant source of innovation. Here, it is possible to identify a series of actors contributing to the enhancement of the opportunities to exchange different kinds of knowledge. For example, SMEs, which play a complementary role within the supply chain, and multinationals, which may be the initial innovators in a certain technological field, are major players in the dynamics of knowledge exchange and diffusion. Another key role is played by knowledge-intensive business services such as consultants and financial markets. Knowledge-intensive business services act as 'knowledge interfaces' between the different kinds of knowledge-producing institutions, which generate diverse kinds of knowledge because both of technological and sectoral diversity, and of institutional diversity between, for example, R&D institutions and manufacturers. Finally, also the scientific and research community plays a crucial role, for instance in codifying and disseminating a plurality of different knowledge bases.

In order to assess the various factors improving the innovative performance of the firms, this paper elaborates upon the growing empirical evidence of a regional concentration of innovation activity. This evidence suggests that localisation is a major factor enhancing firms' innovation performance because it creates favourable conditions fostering the exchange of knowledge.

The understanding of the role of local environments in favouring the exchange of knowledge benefited from the analysis of two different elements. On the one hand, the approach emphasising the importance of externalities underlines the effect of strong indivisibility among interdependent production factors, with the agglomeration of actors providing the social and technical conditions for a dynamic exchange of complementary competences and know-how among local firms (ANTONELLI, 1986; BECATTINI, 1987 and 1989; BRUSCO, 1982). On the other hand, the approach emphasising transaction costs underlines the importance of proximity, because it facilitates the building of trust and confidence and creates a co-operative environment where the risks of leakage and opportunistic behaviour are counteracted (STORPER and HARRISON, 1991; HARRISON, 1992). ANTONELLI, 2000, elaborated an integrated framework demonstrating that localisation is conducive to innovation because agglomeration and proximity create an environment where interdependent knowledge bases can be exchanged through a variety of relationships based on trust. In this context, the conditions and features of various communication processes are key factors in explaining the clustering effect and the rate of innovation.

In this perspective, the main object of this paper is to provide empirical evidence to support an approach that appreciates institutional variety of local economic systems as the determinant shaping a multilateral communication network that makes local environments innovation-conducive for firms embedded in that network. Interaction among firms and among firms and institutions (i.e., universities, consultants, collective research and technical centres) becomes a key factor in fostering innovation dynamics. Furthermore, this paper argues that the development of a plurality of dissimilar but complementary co-operative relationships – rather than the concentration on one dominant kind of interaction – is the key source of innovation. When firms co-operate in innovation processes with other firms, or consultants, or research institutions, they improve their innovative outputs. But when they co-operate in innovation processes within a multilateral network made up of firms, consultants and R&D institutions, which allows firms to absorb, use, reorganise and transmit dissimilar but interdependent bits of knowledge, innovation develops even further.

This is to say the degree of innovation increases with the range of institutional variety characterising the collaborative network, i.e. with the variety of agents with which local firms

interact in order to innovate. Furthermore, the paper empirically verifies whether there exists a positive correlation between the plurality of communication channels and the growth of the firms embedded in the network.

The paper is organised as follows. Section 2 outlines the conceptual framework underpinning our case study. Emphasis is given to the role of external knowledge, knowledge exchange and interactive learning in the systemic dynamics of innovation. Section 3 presents the empirical case of the Brianza technological district. First, the methodological framework employed in the case study is defined, explaining both the methodology (section 3.1) and the definitions of the key variables introduced (i.e., co-operation, innovation and growth) (section 3.2). Second, a qualitative analysis of the district is presented, describing the key features and conditions we assumed would favour innovation, i.e. the local institutional endowment (section 3.3). Third, the correlation analysis between networking, innovation and growth is developed (sections 3.4 and 3.5). Conclusions summarise main results, highlighting implications for economic analysis and technology policy.

2. KNOWLEDGE, COMMUNICATION AND INNOVATION

The role of knowledge as crucial input in the innovation process has been the object of increasing attention in recent economic analysis.

New growth theory, elaborating upon the seminal contribution of SOLOW, 1956, explains the notion of knowledge as fundamental input in economic growth. Where learning mechanisms function among agents (ARROW, 1962; LUCAS, 1988), the production and accumulation of knowledge originating from different sources is a leading factor in fostering innovation and growth (AGHION and HOWITT, 1992 and 1998; ROMER, 1986 and 1990).

Consistent with this school of thought, recent findings in the economics of innovation support the position that endogenous technological change depends on the production of new knowledge. Knowledge enters into various processes of absorption and recombination of internal and external, tacit and codified knowledge. The plurality of complementary and interdependent pieces of knowledge controlled by a plurality of complementary and interdependent economic actors interacting in the innovation dynamics is thus highlighted. Innovation is now seen as a process facilitated by diverse learning activities leading to the recombination of different knowledge bases (ANTONELLI, 1999).

Within this theoretical context of analysis, growing empirical evidence suggests that agglomeration is a major factor favouring innovation because it facilitates the processes of learning and knowledge acquisition. In particular, much empirical evidence demonstrates that the regional clustering of economic activities provides the basis for distinctive firms' performance in terms of innovation and growth (BAPTISTA and SWANN, 1998; DAVIES and WEINSTEIN, 1999; DE PROPRIS, 2000; JAFFE and TRAJTENBERG, 1999; LÓPEZ-BAZO et al., 1999; TERRASI, 1999). The focus of analysis has been especially concentrated on the positive impact of agglomeration and proximity on knowledge spillovers (AUDRETSCH and FELDMAN, 1996; AUDRETSCH and STEPHAN, 1996; HARRISON, et al., 1996; JAFFE, et al., 1993; KRUGMAN, 1991b and 1991b). Benefiting from a wide variety of social and economic mechanisms acting as channels for knowledge exchange, proximity and agglomeration enable local firms to appropriate the advantages stemming from knowledge externalities. Where agglomeration takes place, there are more opportunities for

interactions, and thus for knowledge exchange and learning: labour mobility, feedback through formal and informal networks, the common base of social and cultural norms, technology agreements, and specialised sub-contracting are a few examples of interactions through which external knowledge is transmitted and shared in a local context.

Evidence from technological districts and innovation and technology systems plays a key role in understanding the systemic conditions that make localisation conducive to innovation. Insofar as innovation and technology systems account for the variety and complementarity of productive conditions, endowment of scientific and technological infrastructures, and systematic communication mechanisms, they also appear to comprise a far more positive institutional context explaining the features of the collective dynamic of innovation. The plurality of technological and industrial structures (e.g., the variety of sectors and typology of firms), combined with the presence of intermediary institutions (e.g., financial markets and business services), and knowledge infrastructures (e.g., universities) favour the development of relationships based on trust among innovators with different knowledge bases. Because it enhances the absorption, accumulation, use and recombination of interdependent kinds of knowledge, such a complex system of interactions acts as a factor enabling knowledge exchange, in turn strengthening firms' innovation performance (EDQUIST, 1997; LUNDVALL, 1992; NELSON, 1993; STORPER, 1996).

The exchange of such different but complementary pieces of knowledge can build up a kind of collective knowledge that is diffused beyond the intended actors and which can be partially appropriated and used by third parties, thanks to the positive effect of knowledge spillovers. On the other hand, due to the risk of opportunistic behaviour, knowledge is effectively shared and becomes collective only when explicit efforts are made to counteract leakage and manage the effects of externalities. Localisation *per se* seems to account for knowledge externalities and trust only to a limited extent. Learning innovators need to be connected; thus communication channels must be implemented in order to co-ordinate the variety of sources and to channel the various knowledge flows into the desired directions (ANTONELLI, 2001; CARTER, 1989; COHEN and LEVINTHAL, 1989).

Explicit learning efforts to connect innovators via various communication channels strengthen the innovation-conducive effects of complementary knowledge bases stemming from different sources. Moreover, and more importantly, horizontal and vertical, internal and external interactive learning activities underscore the positive impact of a plurality of communication channels on innovation.

In particular, evidence from technological districts (ANTONELLI, 2000) shows that the processes of absorption of external knowledge, knowledge exchange, learning and innovation all seem to benefit from institutional variety creating several communication opportunities. In fact, whereas traditional industrial districts vertically integrate the positive effect of externalities stemming from complementary SMEs, regions in which multitechnological systems are present illustrate the importance of economic variety especially from the perspective of the institutional endowment of economic systems. Where different and yet interdependent industries and actors are at play, the traditional mechanisms linked to local externalities originating from interdependent actors within the same industry are in place among a great number of economic institutions: SMEs and big firms, clients, suppliers, subcontractors, collective R&D laboratories, local agencies for economic development, universities, and consultants, each of which may belong to different technological fields and industries. Within this economic context, first, the institutional structure accounts for the diverse actors that exchange knowledge and interact in modes relative to innovation. Second, the

risk of leakage, which might affect relations within the same industry, is also counteracted. Finally, technological districts in the proximity of metropolitan areas especially benefit from the favourable institutional environment to access the diverse knowledge bases and create various new opportunities of communication.

In such a context, innovation results as the output of a diffused and collective process where different knowledge bases are absorbed, recombined and shared through diverse communication channels. Based on a network of communication channels, learning by interacting emerges as the crucial mechanism effectively build up the collective character of knowledge, in turn ensuring innovation.

3. THE CASE OF THE BRIANZA TECHNOLOGICAL DISTRICT

3.1. Sources and data

The methodological approach employed in order to address the empirical evidence of the Brianza technological district couples quantitative and qualitative information. The information used in this study was collected through both a mailed questionnaire and face-to-face interviews in which a 'sample' of local experts was asked to describe the mechanisms characterising the local dynamics of innovation.

Concerning the mailed questionnaire, a survey was carried out to collect empirical data about firms located in the Brianza region, near Milan, within the wider region of Lombardy, in Northern Italy (AMB, 2000). Such a survey aimed to identify the characteristics and performance of local firms in terms of four larger themes: organisation of business and production; internationalisation of production and business; organisation and production of innovation; and competition strategies.

The questionnaire was mailed to the 880 firms that are members of the Business Association of Monza and Brianza between February and April 2000 and 149 valid responses were received. The questionnaire referred to attained production, innovation and co-operation choices between 1995 and 1998 and expected growth performance in 2000-2001. It was addressed to firms of all categories in terms of numbers and types of employees and sectors (i.e., manufacturing and services)[2].

[2] It has to be noted that manufacturing firms are prevalent in the returned questionnaires: they cover 94 per cent of total valid responses, while the business service sector accounts for 6 per cent. Although the service sector seems underestimated, the overall weight of the business service sector is of minor importance within the local economic system (i.e., including agricultural, manufacturing, services and building sectors). In fact, data from the national census of industrial and service firms (ISTAT, 1996) allow for an estimation that reveals that the total incidence of business service firms in Brianza amounts to 5.2 per cent. As far as the incidence of manufacturing system amounts to 25 per cent in terms of firms, it accounts for the most of local firms. Also comparing the local, regional and national economic systems, the higher concentration of manufacturing firms in Brianza is highlighted. In fact, the regional and national manufacturing systems amount to 18 per cent and to 16 per cent of the overall economic system, respectively. Moreover further comments are needed when considering the characteristics of the sample, in order to assess some potential problems which could derive from biases in the sample. Firstly, the 880 firms members of the Business Association of Monza and Brianza are a sample when considering the wider (sub) region of Brianza, but are the whole population when considering the closer context of the Brianza technological district. In that the latter is the focus of our survey, the 880 firms to which the postal questionnaire was mailed are to be considered as the whole population of our empirical analysis. In this case, differences in terms of issues addressed in the paper between member and non-member firms are not relevant. Secondly, the same point concerning biases in the sample could apply to firms that finally answered the

Although the questionnaire referred also to other aspects of the activity of the firm (e.g., internationalisation of activity) because it was a part of a wider research project, for the purposes of this paper our analysis focuses on the questions aimed at understanding the issues of networking, innovation and growth. Hence, the four main sections of the questionnaire used in the paper are the following: 1) The structure and organisation of the firm; 2) Innovative activity; 3) Collaboration on innovative activity; 4) Economic performance of the firm. (See Appendix for the scheme and the phrasing of the questionnaire).

Since issues such as the dynamics of local networks, collaboration and knowledge exchange are extremely complex, a deeper investigation into more qualitative aspects of these issues was needed, complementing quantitative information gathered through the questionnaire. Open and face-to-face interviews may allow to capture the very qualitative nature of such interdependences. In this perspective, following the basic scheme used for the questionnaire, 45 face-to-face interviews with managing directors or senior economists of public bodies for local development, research technology and innovation centres, universities, business associations, chambers of commerce and representative large and small firms located in the district were carried out. They were asked to provide qualitative descriptions of the interactions between local knowledge-producing institutions (section 3.3. is mainly based on these face-to-face interviews).

Finally, it is fair to say that an important element of the approach on innovation systems is the localised nature of learning processes. As far as co-operation favours innovation and improved economic performance, it is useful to distinguish co-operative relations among local agents from those involving also external partners. In this context, although the empirical information gathered in the case study initially suggests that local interactions account for the most of the co-operative relationships, it does not fully explain the particular contribution of local co-operation on innovation (and growth). In other words, 97.41 per cent of interactions are 'fully' local (i.e., interactions that involve firms and institutions which are embedded in the district) and 2.59 per cent of interactions are 'partially' local (i.e. interactions between firms that are embedded in the Brianza technological district and institutions which are external to this district). Nevertheless, the analysis does not account for the peculiar correlation between fully local networking and innovation against partially local interactions.

3.2. Defining co-operation, innovation and performance

Co-operation efforts linked to innovation are defined as formal relationships explicitly oriented towards the collaborative production of innovation. According to this definition, respondents should not have considered co-operation as also including arms-length transactions (such as purchase of components) connected with the introduction of innovation. In other words, collaboration is considered as interaction that is formalised by means of various kinds of agreements into which firms enter with the explicit aim of improving the level of innovation in processes, products and organisation. A number of examples of such agreements are the following:

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questionnaire. Nevertheless, the adequacy of the firms that answered the questionnaire to the wider population is assessed, at least when considering the technological variety of the economic system. Finally, in that our sample is most of all made up by small firms, we could reasonably argue that bias in the size does not contaminate innovation and co-operation propensity, assuming that large firms are more innovation and co-operation oriented than small firms.

?? Production-oriented agreements, which are the result of the increasing trend toward outsourcing specialised production phases, involves both users and contractors and subcontractors;
?? Firms can contract pure research activity with research and technology centres and universities;
?? Consultants are partners in that they can act as connecting agents, specialising in the transfer of technological information from universities to industrial firms.

Co-operation is thus classified into three categories: 1) among firms, i.e. within the supply chain; 2) among firms and research institutes, universities, and technology transfer centres; 3) among firms, consultants and business services. Co-operation is measured in terms of the number of relationships and is conceived as a binary variable. Firms were classified into two groups: those that have established at least one co-operative relationship (code 1) and those that do not co-operate at all (code 0). Although these are very broad categories, they are justified by the fact that the focus of our analysis is concentrated much more on the extent, i.e. on the plurality of co-operative efforts rather than on the degree of intensity of one kind of interaction.

Networking takes place when a firm interacts with at least one actor belonging to each of the three different categories. The case 'co-operation with two kinds of partners' has not been considered because each kind of partner belonging to the three different categories is assumed to employ a specific body of knowledge, which is complementarily necessary to others' one. The main hypothesis to be tested is in fact the link between innovation and multilateral networking in the local area where each of the specific actors is embedded.

Innovation is measured in terms of the number of changes in processes, products and organisation. We employed three categories (1-2 innovations, 3-4, 5 and more) as measures of innovation propensity (low, medium, and high, respectively). Innovation is defined as the introduction of new products, technologies and procedures representing distinct changes in the process of business development, in turn allowing enterprises to achieve improvements in the production processes (e.g., increasing efficiency or improving product quality) and substantial competitive advantages in general.

Innovation can concern the product, the productive process or the business organisation of internal as well as external business relations. Organisational innovation was also included because of its complementary role with product and process innovation and because evidence seems to suggest that behavioural and organisational changes are conducive to further innovations. This classification is to be thought of as a taxonomy, since innovations in products, processes and organisation are often highly interdependent. For example, product innovations are often the results of changes in the productive processes, and *vice versa*. At the same time, organisational innovations can affect the design and/or the perceived quality of the product. In any case, this classification is useful in understanding the different types of changes, in turn accounting for the variety in the innovative outputs of the sample.

Finally, economic performance is considered to be object-seeking behaviour and is measured in terms of percent changes in planned returns, planned turnover, and planned investment in the two financial years 2000-2001. Although the use of forecasted economic performance invites some scepticism, the reasonable range of forecasts registered in the study is reassuring. Percent changes in economic performance are classified into the following categories: less than 0; equal to 0 or no

change; between 1.0 and 5.0; between 6.0 and 20.0; and more than 20.0. Furthermore, when analysing the correlation between co-operation, innovation and growth, the positive correlation between the three variables could be initially acknowledged as indicating an implied direction of causality between co-operation, innovation and growth. In other words, firms develop contacts and partnerships in order to innovate and achieve higher growth rates.

Elaborating upon this methodological framework, the following hypothesis will be tested by means of a set of descriptive statistical analyses employing contingency tables[3] (section 3.4 and 3.5) in order to determine: 1) whether a link exists between co-operation and the innovative output of firms, and, more importantly, 2) whether there is a link between the plurality of co-operative interactions and the innovative output of firms; and 3) whether there is a link between networking and firms' market performances.

The 1995-1998 period was observed in order to determine whether a firms belongs to the 'co-operative firm' category and to ascertain the degree of innovation of sampled firms.

3.3. The institutional endowment

As far as the population of firms belonging to the Monza and Brianza Business Association is concerned, the Brianza region shows the characteristics of a multi-technological context. In fact, in terms of the number of firms, mechanical and engineering-based automation accounted for 35.5 per cent of the total firms belonging to the manufacturing system, and it is the fastest growing industrial branch in the area. The electronics industry represents about 8 per cent of local manufacturing, while textiles and clothing account for 10.4 per cent. The furniture industry is comprised of more than 16 per cent of firms, whereas chemicals, plastics and rubber represent 13 per cent of firms belonging to the local industry (see table 1)[4].

INSERT TABLE 1 ABOUT HERE

Sampled firms reflect this multi-technological context quite well, in that 33.5 per cent of firms belong to the mechanical and engineering-based automation branch, 17.4 per cent to the furniture industry, 12.8 per cent to the textile and clothing branch, 13.5 per cent to chemicals and plastics, 5.4

[3] Although the empirical evidence used in the paper is apparently rather simple as based on descriptive statistics, when considering the qualitative analysis of the institutional context (section 3.3), the complementarity between descriptive statistics and a more qualitative approach could be considered as suitable. Especially when assessing puzzling and composite issues such as co-operation and knowledge exchange, such a 'mixed' approach between descriptive statistical tools and more qualitative descriptions seems proper. Moreover, it is fair to say that the structure of our sample does not allow for further statistical elaboration: especially multivariate models have been employed without having really explanatory results.

[4] Confronting different sources which collect up data only for member firms, Brianza region shows an industrial specialisation where the importance of each sector may vary. If the whole industrial context is still multitechnological and in most of the cases differences in the data are of minor importance, it is fair to say that in terms of number of firms the weight of furniture industry may largely vary from 9.4 per cent to 28 per cent. Certainly, due to heavy crises during last decade, furniture industry underwent widespread selective mechanisms, and strongly reduced his quantitative importance within the local manufacturing system. Nevertheless, local firms in the furniture industry are world leaders in terms of product quality and design, highlighting the fact that the sector gives still a major contribution to the overall innovation capacity of the technological district (Data sources: Business Association of Monza and Brianza and Chambers of Commerce, updated to year 1999).

per cent to electronics, and 2.7 per cent to the food industry. Six per cent of the sample belongs to the business service sector.

The variety of the industrial patterns is confirmed by the description of the dimension of sampled firms, measured in terms of both employees and turnover and also in terms of the governance and ownership models. In fact, an analysis of the governance and ownership models shows that 90 per cent of firms are joint-stock or limited companies, whereas 21.6 per cent are owned by a group and 34 per cent of firms are made up of managerial firms (managerial firms are conceived as firms where, although the ownership is family-based, the governance of the firms is controlled by executives that are not shareholders). Finally, in terms of turnover, 28 per cent of firms belong to the 4-10 billion-lira category, 25 per cent to the 10-50 billion-lira category, and over 11 per cent generate turnovers of more than 100 billion liras. In terms of number of employees, 32.2 per cent are small firms with less than 20 employees, while firms with 20-49 employees account for 28.2 per cent. Firms with more than 50 employees represent 39.6 per cent of sampled firms.

The variety in terms of sectors, firm types and entrepreneurial models so far described in the Brianza district suggests suitable conditions for the existence of complementary relationships between economic institutions. As a matter of fact, the diffusion of a wide variety of complementary economic institutions such as universities, research institutes, consultants and business services is guaranteed by the proximity to the metropolitan area of Milan. Here, an important university presence is increasingly expanding its activities throughout the region, in some cases developing in areas associated with the different local industrial specialisations and their traditions. The Politecnico of Milano (Polytechnic school of engineering), the Università Cattolica (Economics and Political sciences), and the Università Commerciale Luigi Bocconi (Economics) are the three excellent institutions which provide for research-based and training-based partnerships oriented toward the development of innovation both on a technical and organisational scale. Moreover, consultants and business services are much more concentrated in this area than in the rest of Italy. The 1996 national census of industry and services shows that in terms of finance, management, and support to R&D, in the province of Milan business services amount to 39 per cent of the total region and to 12.2 per cent of Italian business services. In terms of telecommunications and new technology business services, 71 per cent and almost 20 per cent of regional and Italian business services, respectively, are concentrated in this area (ISTAT, 1996).

In this context, the proximity to the Milan metropolitan area is emphasised in that it provides a greater institutional context favouring the development of positive local dynamics through which complementary kinds of knowledge are generated and shared. More precisely, metropolitan areas accounts for institutional variety in terms of the mix of scientific and technological infrastructures and in terms of systematic communication mechanisms (PATRUCCO, 2002). First, the high concentration of technology centres and laboratories and academic infrastructure provides suitable endowments for the generation of opportunities for co-localised firms to take advantage of the diversity of science- and technology-based knowledge. The local diffusion of complementary scientific and technological knowledge bases is further increased via knowledge externalities stemming from the university and R&D laboratories, e.g. by means of postgraduate and researcher mobility and professional and personal linkages (AUDRETSCH and STEPHAN, 1996; FELDMAN and AUDRETSCH, 1999). Second, the local agglomeration of R&D institutions favours the establishment of the conditions for localised market exchange and accumulation of codified knowledge: when considering the outcomes of pure research activities (i.e., patents), agglomeration significantly improves the flow of knowledge and the creation of positive externalities, in turn

strengthening local markets for the generation of formalised knowledge (JAFFE et al., 1993; JAFFE and TRAJTENBERG, 1999; PATEL, 1995). Third, the Milan metropolitan area provides a suitable environment for the establishment of multilateral collaborative and innovation-oriented relationships since it is characterised by better communications infrastructures and conditions favouring the access to and the recombination of external knowledge. Technology-enabled communication channels, reinforced by co-ordination via business associations and the local presence of knowledge-intensive business services are in this case major factors ensuring the access to and the recombination of dispersed and yet complementary pieces of knowledge, in turn strengthening the localised generation of new knowledge and innovation (ANTONELLI, 1999; CASTELLS, 1989; FREEMAN, 1991; HARRISON et al., 1996; RICHARDSON, 1972).

Furthermore, the institutional variety and particularly the links between the different institutions are increased due to the coexistence of different industrial clusters that are well embedded in the local economic system. Centres for innovation and technology transfer, professional associations and industrial clubs are widespread and well rooted in the local area, in turn giving rise to different technological systems. In fact, in the area around Agrate Brianza, Vimercate, and Concorezzo a technological cluster specialising in new communications technologies is being developed by several large multinationals, namely ST Microelectronics, IBM, and Alcatel. Large firms, as they utilise the services of the local agency for technology transfer, AGINTEC, as a third-party co-ordinating agent, are acting increasingly as engines of diffusion of technological knowledge and innovation to local SMEs within such clusters. Moreover, the technological system is becoming far more cohesive as a result of interactive projects between universities, multinationals, and SMEs focused on both basic research and professional training, thus overcoming the problem of fragmentation found in many cooperation projects of such a nature.

Similarly, in the southern part of Brianza, in the areas around the towns of Cesano Maderno and Monza, a chemicals and plastics cluster has evolved from declining industries and firms. Due to serious crises in the chemicals industry and, less related, in the automotive sector, large firms faced the prospect of market exit and the economies of the surrounding areas went into decline. Following the creation of a consortium aimed at the industrial reorganisation of the area (CAAM), local municipalities and business associations improved policies for the inflow of investments and large chemical firms moved in into the area. Among them are BASF, Bracco, Roche and more recently also Patheon, which contributed to the increase in downstream linkages, in turn improving linkages between local SMEs. Institutional support became more and more important as far as municipalities formalised their partnerships in the Municipalities Committee and increased its interactions with the Business Association of Monza and Brianza, trade unions and social partners.

The new communications technologies cluster and the chemical cluster have demonstrated in particular the role of large firms in the local dynamics of knowledge exchange. First, the presence of large firms and particularly the relationships between large and small firms has increased the role played by complementary features of the production system in facilitating by-product interactions and the dissemination of knowledge. In this context, upstream and downstream user-producer relations (i.e. sub-contracting, and the provision and purchase of specific and complementary intermediate inputs) are crucial elements in supporting the generation and exchange of knowledge. Much economic analysis has acknowledged such production interdependences as factors enabling external knowledge, especially tacit knowledge, to be accessed and learnt and in turn becoming sources of innovation (LUNDVALL, 1985; RUSSO, 1985; VON HIPPEL, 1988). Second, large firms are major sources for the production and diffusion of codified knowledge based on

investments in R&D activities that are vertically integrated. In this regard, large private firms' research and development departments can be thought of as R&D institutions contributing to the growth of local demand and supply of codified knowledge as well as outputs of public research and academic centres. Since large firms have clear advantages in terms of economies of scale in conducting research and development activities, their innovation activity is based significantly on internal codified knowledge, which is incorporated and hence tradable in the form of the results of formal R&D activities undertaken by the firms, e.g. by means of patents. Moreover, and perhaps more importantly in this context, such codified knowledge is also shared and transmitted to SMEs by means of production-related interactions, i.e. user-producer relationships, and interactive coexistence in general. While large firms have clear advantages in the production of codified knowledge, SMEs can benefit from the accumulation of tacit knowledge. The reciprocal benefits of the coexistence of large and small firms are appreciated when taking into consideration that collaborative and interactive relationships make it possible for small firms to access external codified knowledge and for large firms to access external tacit knowledge, in turn creating the conditions for knowledge exchange and communication.

Finally, two well-developed industrial districts are well-rooted in the region and have increased the opportunities for co-operation among a wide range of SMEs, Chambers of Commerce, universities and technical schools, and centres for product quality and innovation. The mechanical district in the north and the furniture district in the eastern part of Brianza have established extensive and yet focused relationships which contributed to the growth of firms and the development of relevant areas through technical partnerships, professional training and innovation-oriented projects.

3.4. Co-operation and innovation: empirical results

Elaborating upon the framework thus far articulated, the main objective of this section is to provide empirical evidence for the thesis that there exists a positive correlation between the establishment of a plurality of co-operative relationships between economic actors and the innovative output of the firms. In the next section, we will test whether the existence of a plurality of co-operative relationships provides the necessary conditions for enhancing the growth of firms.

Concerning the sample of firms, the Brianza technological district shows a high level and, more importantly, a high variety of innovation activities (see Table 2). 64.2 per cent of firms introduced innovations in processes, of which 27.7 per cent were of radical type. Innovation propensity becomes even higher when changes in products and business organisation are considered. Moreover, in the former case, radical changes in the product mix were undertaken by 32.8 per cent of the firms, while for the latter, such were recorded by 38.7 per cent of the firms. Finally, firms largely innovate also in the organisation of sales.

INSERT TABLE 2 ABOUT HERE

Such a data set, in which there is a plurality of different but often interdependent innovations, shows that the development of innovative activities is well rooted in the local clusters and also pertinent to the variety of industrial patterns thus far described[5].

[5] In that the main object of this paper is not to ascertain the absolute innovativeness of sampled firms, but to account for the role of a multi-layer network over innovation, a comparison between local data on innovation degree and regional and national data seems of minor usefulness. Moreover, the strong differences among available kinds and sources of data at the local, regional and national level might make any conclusions on such a comparison next to useless. The sole

Such widespread diffusion of different types of outcomes calls for the investigation of the role of co-operative relationships among the plurality of agents in improving innovation.

Data on co-operation linked to innovation among firms and research institutes, universities, and technology transfer centres (Table 3) show that these co-operative relationships and firms' innovation performance are closely linked (chi-square Probability = 0.001) and positively related. In fact, although the field of research and innovation services is one where firms' relationships are less developed (only 16.78 per cent of sampled firms co-operate with research institutes, universities, and technology transfer centres on innovation-related issues), 64.10 per cent of the firms which do co-operate have higher levels of innovative outcome, and only 12 per cent exhibited weak innovation performances.

INSERT TABLE 3 ABOUT HERE

Similarly, the correlation between inter-firm co-operation and innovation performance of the firms is assessed (Table 4). Inter-firm co-operative relationships aimed at enhancing the innovative outputs of firms are the most common means of co-operation: 63.76 per cent of firms engaged in explicit innovation-oriented interactions within the production chain with clients, suppliers, sub-contractors, and specialised firms. Only 15.79 per cent of firms that co-operate on innovation show weaker performance. Moreover, the share of firms recording high performance rises from 18.52 per cent of those engaging in no inter-firm co-operation to 33.68 of firms which co-operate. Among the firms with weak innovation performance, the share of firms is 29.63 per cent for those which do not co-operate as opposed to about a half (15.79 per cent) when they do co-operate.

INSERT TABLE 4 ABOUT HERE

Finally, firms' innovative outputs are also enhanced when firms establish co-operative relationships with consultants and business services (Table 5). The close positive correlation (chi-square Probability =0.001) between innovation and co-operation with consultants is shown by the fact that 40.70 per cent of the firms that established co-operation in innovation activities with consultants and business services are within the group with higher performances, while only 8.14 per cent of such firms exhibited weaker innovative outcomes. Moreover, when firms do not cooperate, higher degrees of innovation fall to 11.11 per cent and weaker performances rise to 38.10 per cent.

INSERT TABLE 5 ABOUT HERE

The main finding is the existence of a positive correlation between co-operation activities and the innovation performance of the firms: the innovative process of the firms does not involve only forward and backward linkages with other firms, but also implies co-operative relationships between firms and other economic institutions such as universities, research and innovation centres, consultants and business services. The question now rises whether the plurality of co-operative relationships – multilateral, i.e. inter-organisational networking – provides a greater contribution to firms' innovation outputs than monolateral communication.

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kind of corresponding data available at local, regional and national level is the share of R&D personnel on the total employment in manufacturing firms, where data are updated to 1998: such data show that within sampled firms the share of R&D personnel on the total employment in manufacturing amounts to 4.2 per cent, while at the regional and national level the same share is 1.5 per cent and 1.3 per cent respectively (ISTAT, 1998).

Table 6 couples three levels of firms innovation performance (high, medium, and low) with three levels of co-operation: we identify firms which co-operate with only one kind of partner, firms which establish co-operative relationships with all the three classes of partners so far considered, and firms which do not co-operate at all. The data clearly suggest the existence of a close positive correlation between multilateral partnerships and the innovative performance of the firms. When firms engage in multilateral and inter-organisational co-operation, the likelihood of strong innovative performance grows (46.38 per cent of firms show highest innovation performance). At the same time, when firms do not co-operate on innovation issues, more than one out of two firm results among those with the weakest innovative performance and only 8.33 percent of firms show higher levels of innovation. Finally, when co-operative relationships are monolateral, most of the firms show medium/low levels of innovation.

INSERT TABLE 6 ABOUT HERE

In conclusion, we found a positive and close correlation between a firm's co-operation with other economic agents and the innovation performance of the firm. Moreover, and more importantly, we discovered that networking among firms, downstream and upstream production partners, consultants, universities, and research and technology transfer centres makes high innovation performance much more likely than unilateral co-operation.

3.5. Co-operation and economic performances: empirical results

We will now test whether networking is also related to increasing economic performance of the firm. Firms participating in the survey showed an overall increasing level of market performance in terms of expected turnover, profits and investment for the two financial years 2000 and 2001. For instance, 65 per cent of firms expected that they would achieve growth varying from 6 per cent to 20 per cent in turnovers, while 33 per cent and 52.6 per cent of firms, respectively, expected to raise their profits and investments from 6 per cent to 20 per cent. In parallel, expectations with regard to decreasing performance characterise only a negligible part of the firms (see Table 7).

INSERT TABLE 7 ABOUT HERE

The analysis developed thus far, in which a high degree of innovation propensity is closely related to networking, and in which expectations of growth are also increasing, would suggest testing whether there exists a positive link also between networking and economic performances. Thus we will show how the firms' growth expectations in terms of profits, turnovers and investments are related to the different categories of co-operation.

Table 8 shows that profits are expected to increase for 51.32 per cent of the firms which co-operate with multilateral partners, whereas only 9.21 per cent of firms that do not co-operate on innovation issues expect to have increasing profits. Moreover, 46.43 per cent of firms that have only one dominant typology of partnership expect to face decreasing profits. Finally, where innovation is seen as an individualistic process, 70.83 per cent of firms expected to experience decreasing profits.

INSERT TABLE 8 ABOUT HERE

In short, a similar pattern emerges when the link between networking and expected turnover performance is considered. Table 9 shows the close positive link (Chi-Square=0.029) between increasing turnover and networking with a plurality of agents.

INSERT TABLE 9 ABOUT HERE

Finally, if we consider the link between multilateral co-operation mechanisms and planned investments (Table 10), we also see that expectations of increasing investments are more and more related to multilateral co-operation.

INSERT TABLE 10 ABOUT HERE

In sum, when the linkages between networking and expected profits, turnovers, and investments are considered, the main finding is that firms embedded in the network tend to be more characterised by increasing market performances. Moreover, since market performances are registered in terms of planned returns, planned turnovers, and planned investments in the two financial years 2000-2001, we suggest that firms embedded in the network are driven by growth-seeking behaviours which do not focus only on the short term perspective and on shareholders returns, i.e. on profits, but also seek to promote the growth of the firm and therefore act accordingly to increase their market shares and their investments.

4. CONCLUSIONS

This paper has provided empirical evidence for the existence of a positive correlation between the plurality of co-operative relationships among economic agents acting as channels of communication and the innovative outputs of local firms. More precisely, the paper shows that a) co-operating firms have introduced a greater number of innovations than firms that do not co-operate, and b) the degree of innovation increases with the institutional variety of partners communicating and cooperating within the network. In addition we also show that growth expectations are correlated with the extent of interactions.

Although co-operation on innovation issues among clients, suppliers, sub-contractors and specialised firms has important effects on the innovative output of the firms, the variety of communication channels is the key source of innovation. When firms establish interactions not only with other firms, but also with consultants, research and technology centres, and universities, the network fully accounts for the positive effects of communication on innovation. The variety both of inter-organisational relationships and of organisations involved in these relationships, and also the interactions between different relationships is hence highlighted.

We argue that within the Brianza technological district the following are the three main elements fostering the development of enhanced communication opportunities: the role of large firms as knowledge-producing and -disseminating institutions, and the complementarity between SMEs and large multinational firms in particular; the well-developed knowledge infrastructure provided by universities, consultants, business services and technology centres; and the proximity to the Milan metropolitan area, which accounts for the existence of such a knowledge infrastructure.

Institutional variety thus emerged as the crucial factor determining communication opportunities. Institutional variety accounts for the diversity of coexisting and complementary knowledge bases in the local industrial and economic structure. Different kinds of specific know-how and knowledge are present, because of the diverse sectors that are well established in the region as well as the complementarity between a large number of local SMEs belonging to different technological branches and certain large multinational firms. Moreover, the existence of an extensive consulting and business services sector and an important university presence, both due to the proximity to the Milan metropolitan area as well as the role of well established centres for research and innovation, business associations and local municipalities, all create the conditions for the implementation of a multilateral communications system where different kinds of knowledge provided by a variety of knowledge-producing institutions can be exchanged.

In this respect, we suggest that the case study provides corroborating supportive evidence for the fact that, within technological districts characterised by a high degree of institutional variety, the establishment of a multilateral network enhances the opportunities for the diffusion of specific knowledge bases in different contexts in an innovative manner. We can reasonably argue that relevant knowledge generated by external sources can be learnt and adopted in new contexts by means of two mechanisms: either directly, from work carried out in R&D institutions undertaking basic research efforts in various scientific and technological fields because of the presence, for example, of diverse industries; and indirectly through the contacts of research institutes and consultants with firms operating in different technological fields and generating different knowledge bases in the area.

Secondly, we argue that the local innovation system in this particular case is regarded as a network of complementary learning innovators within which a plurality of knowledge bases is exchanged. Complementary kinds of knowledge are conceived as key economic inputs in the innovation processes, and localisation is a factor facilitating the exchange of external knowledge. Because of positive externalities and an environment of trust, the absorption, use and recombination of different but interdependent kinds of knowledge can take place.
This case study empirically shows that the network based on the variety of local economic agents, and impinging upon a plurality of communication opportunities, increases both the innovation and growth propensity of embedded firms. We suggest that such multilateral communication system offers a plurality of opportunities for the transmission, absorption, use and recombination of knowledge and provides the mechanisms that effectively make the exchange of knowledge possible, in turn favouring innovation. The communication system is considered an essential part of the innovation system.

Third, we argue that localisation is not, *a priori*, a key source of innovation, but that it provides the conditions for close interactions and communication. Thus, the specific advantages derived from localisation are linked to the repeated exchanges of knowledge and learning activities, based on environment of trust, among the variety of players in the local marketplace. This may lead to the notion of a local innovation system resulting from production interdependences and complementarities, related services, and exchanges of different knowledge bases among a wide variety of economic institutions and innovation processes (LONGHI and QUÉRÉ, 1993). The relational dimension of innovation systems is now becoming far better understood and it underlines that communication efforts strengthen the sharing of knowledge, related innovations, and in turn the performances of the firm (AMIN, 2000). We have provided evidence for the positive link between

networking and the increase in the innovative and growth performance of firms embedded in the communication network.

Fourth, recent empirical evidence on the positive effects of industrial clustering on firms' innovation performance emphasises that the strength and the coherence of local innovation systems, particularly in terms of enhanced communication and learning mechanisms, are major factors in the attraction of new agents, hence of enhanced variety and increasing innovation and, consequently, growth (BAPTISTA and SWANN, 1999; MASKELL, 1998; PHELPS et al., 1998). This would argue for the implementation of focused technology policies. Where different types of exchanges of knowledge are considered and a network of complex interactions is required, the social and organisational context becomes the key issue for technology policy (LUNDVALL, 1999). Because both of the tacit and formal nature of know-how and the resulting importance of face-to-face communication, the localised pattern of communication and diffusion of learning mechanisms becomes a crucial factor in promoting innovation (HOWELLS, 1996). Consistent with these points of view and with the evidence provided here, we argue that where the communication system is multilateral and based on economic variety, new communications technologies will find a receptive organisational and social structure, i.e. network, spreading their full innovation-conducive impact by transmitting, absorbing, recombining, and in turn socialising complementary knowledge, fostering a multilateral knowledge exchange and shaping innovation and growth.

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LIST OF TABLES

Table 1 The sector distribution of sampled firms compared to population and local industrial system (1998)

Sector	Sampled firms (per cent)	Population* (per cent)	Local industrial system** (per cent)
Agro-food	2.7	3.0	3.6
Electronics	5.4	8.0	11.6
Chemicals	8.8	10.4	2.6
Plastics	4.7	2.6	4.6
Furniture	17.4	16.5	28.5
Mechanics	33.5	35.5	29.8
Textile and clothing	12.8	10.4	9.9
Other industries	8.7	7.9	4.2
Business services	6.0	5.7	5.2
Total	*100.0*	*100.0*	*100.0*

* firms that are members of the Business Association of Monza and Brianza

** total firms located in the Brianza region; year 1996; Source: ISTAT, 1996

Table 2 The distribution of innovation within firms (years 1995-1998) *

Innovation output	Incremental innovations (per cent)	Radical innovations (per cent)	Total (per cent)	Non innovative firms (per cent)
Processes	36.5	27.7	64.2	35.8
Products	41.6	32.8	74.4	25.6
Business organisation	38.7	38.7	77.4	22.6
Sales organisation	35.8	22.6	58.4	41.6

*Due to cumulative answers, total column percentages exceeds 100

Table 3 Firms' innovation and co-operation with University, research institutes, and technology transfer centres (years 1995-1998)

Count, Row Pct, Col Pct	**No Co-operation**	**Co-operation**	**Row Total**
High Innovation Level	26	16	42
	61.90	38.10	100.00
	20.97	64.00	
Medium Innovation Level	70	6	76
	92.11	7.89	100.00
	56.45	24.00	
Low Innovation Level	28	3	31
	90.32	9.68	100.00
	22.58	12.00	
Column Total	124	25	149
	83.22	16.78	100.00

**Chi-Square: 19.083 (Value), 0.001 (Prob)*

Table 4 Firms' innovation and inter-firms co-operation (years 1995-1998)

Count, Row Pct, Col Pct	**No Co-operation**	**Co-operation**	**Row Total**
High Innovation Level	10	32	42
	23.81	76.19	100.00
	18.52	33.68	
Medium Innovation Level	28	48	76
	36.84	63.16	100.00
	51.85	50.53	
Low Innovation Level	16	15	31
	51.61	48.39	100.00
	29.63	15.79	
Column Total	54	95	149
	36.24	63.76	100.00

**Chi-Square: 5.991 (Value), 0.050 (Prob)*

Table 5 Firms' innovation and co-operation with consultants and business service (years 1995-1998)

Count, Row Pct, Col Pct	**No Co-operation**	**Co-operation**	**Row Total**
High Innovation Level	7	35	42
	16.67	83.33	100.00
	11.11	40.70	
Medium Innovation Level	32	44	76
	42.11	57.89	100.00
	50.79	51.16	
Low Innovation Level	24	7	31
	77.42	22.58	100.00
	38.10	8.14	
Column Total	63	86	149
	42.28	57.72	100.00

**Chi-Square: 26.976 (Value), 0.001 (Prob)*

Table 6 Firms' innovation and kinds of co-operation (years 1995-1998)

Count, Row Pct, Col Pct	**No Co-operation**	**Mono-lateral co-operation**	**Multi-lateral co-operation**	**Row Total**
High Innovation Level	2	8	32	42
	4.76	19.05	76.19	100.00
	8.33	14.29	46.38	
Medium Innovation Level	9	36	31	76
	11.84	47.37	40.79	100.00
	37.50	64.29	44.93	
Low Innovation Level	13	12	6	31
	41.94	38.71	19.35	100.00
	54.17	21.43	8.70	
Column Total	24	56	69	149
	16.11	37.50	46.31	100.00

**Chi-Square: 36.301 (Value), 0.001 (Prob)*

Table 7 Firms' market performances
(expected percent growth; years 2000 and 2001)

Growth (per cent)	Turnovers	Profits	Investments
	Firms (per cent)	Firms (per cent)	Firms (per cent)
<0	1.0	3.4	0
0	3.9	14.7	7.2
1.0-5.0	14.6	43.2	33.0
6.0-.20.0	65.0	33.0	52.6
>20.0	15.5	5.7	7.2
Total	*100.0*	*100.0*	*100.0*
Growth (mean)	**17.8**	**11.5**	**10.6**

Table 8 Co-operation and expected profit performances

Count, Row Pct, Col Pct	Decreasing profits	Increasing profits	Row Total
No co-operation	17	7	24
	70.83	29.17	100.00
	23.29	9.21	
Mono-lateral co-operation	26	30	56
	46.43	53.57	100.00
	35.62	39.47	
Multi-lateral co-operation	30	39	69
	43.48	56.52	100.00
	41.10	51.32	
Column Total	73	76	149
	48.99	51.01	100.00

**Chi-Square: 5.568 (Value), 0.062 (Prob)*

Table 9 Co-operation and expected turnovers performances

Count, Row Pct, Col Pct	**Decreasing turnovers**	**Increasing turnovers**	**Row Total**
No co-operation	14	10	24
	58.33	41.67	100.00
	26.92	10.31	
Mono-lateral co-operation	16	40	56
	28.57	71.43	100.00
	30.77	41.24	
Multi-lateral co-operation	22	47	69
	31.88	68.12	100.00
	42.31	48.45	
Column Total	52	97	149
	34.90	65.10	100.00

**Chi-Square: 7.064 (Value), 0.029 (Prob)*

Table 10 Co-operation and expected investments performances

Count, Row Pct, Col Pct	**Decreasing investments**	**Increasing investments**	**Row Total**
No co-operation	15	9	24
	62.50	37.50	100.00
	25.42	10.00	
Mono-lateral co-operation	20	36	56
	35.71	64.29	100.00
	33.90	40.00	
Multi-lateral co-operation	24	45	69
	34.78	65.22	100.00
	40.68	50.00	
Column Total	59	90	149
	39.60	60.40	100.00

**Chi-Square: 6.285 (Value), 0.043 (Prob)*

APPENDIX: The structure and the phrasing of the questionnaire

1. The structure and organisation of the firm:

   1.a. Business sector of the firm;

   1.b. Size of the firm, in terms of the number of employees;

   1.c. Size of the firm, in terms of the level of turnover classified into the following categories: <1 billion lira; 1-4 billion lira; 4-10 billion lira; 10-50 billion lira; 50-100 billion lira; >100 billion lira;

   1.d. Ownership model of the firm, as indicated by the following categories: limited company; joint-stock company;

   1.e. Professionals involved in the governance of the firm: entrepreneur; entrepreneur and his family; entrepreneur and managers; managers;

2. Innovative activity:

   2.a. Number of innovations introduced to processes of the firm, in terms of both radical and incremental changes introduced through the adoption and use of new techniques, technologies and organisation in the manufacturing processes;

   2.b. Number of innovations introduced to products of the firm, in terms of both radical and incremental changes introduced to the technical features and design of outputs of the manufacturing processes;

   2.c. Number of innovations introduced to the organisation of the firm, in terms of both radical and incremental changes introduced to the organisation of decision-making processes, management operations, and routines;

3. The collaboration on innovative activities:

3.a. Number of collaborations the firm has established, with the explicit aim of improving the level of innovation in processes, products and organisation, in terms of partnerships with the following actors: research centres; universities; technology transfer centres; consultants; upstream actors (users); downstream actors (contractors); subcontractors;

4. Economic performance:

4.a. Economic objective of the firm in terms of profits, as measured by the forecasted percentage changes in the level of profits;

4.b. Economic objective of the firm in terms of turnover, as measured by the forecasted percentage changes in the level of turnover;

4.c. Economic goal of the firm in terms of investment, as measured by the forecasted percentage change in the level of investment;