SPATIAL TRANSFER OF KNOWLEDGE IN HIGH-TECH MILIEUX: LEARNING vs. COLLECTIVE LEARNING PROCESSES

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1. Dynamic elements in spatial innovation processes[1]

During the eighties, the neoclassical paradigm explaining innovation as a "manna from heaven" has been overcome by the more realistic approach dealing with uncertainty and imperfect information accompaining the decision making processes of firms. The innovative capacity of each firm is mainly driven by dynamic elements such as search and learning, which define in the long term the technological trajectory followed by each firm (Dosi, 1982; Dosi et al. 1989; Nelson and Winter, 1988).

In the literature on spatial innovation processes, the same kind of break with the static view of the neoclassical world has been provided by the theory of the "milieu innovateur", developed by the Gremi group during the eighties[2]. This theory is the dynamic counterpart of the concept of "industrial districts" or "system areas" developed in the seventies in the framework of the endogenous growth theory: local efficiency factors, like geographical and organisational proximity, external economies promoting a sort of industrial atmosphere, are overcome by more dynamic spatial elements like dynamic synergies and collective learning, which explain innovation processes at the spatial level. In a milieu, the more traditional and static elements of smithian division of labour, of marshallian externalities, generated by a common industrial culture and by dense input-output exchanges, coexist with more dynamic elements, like Schumpeterian entrepreuneurial spirits enhanced by long standing and specific skills and by wide imitation possibilities, learning by doing and by using à la Arrow, cross fertilisation processes à la Freeman, generating systems of integrated and incremental innovations (Camagni, 1991).

The concept of collective learning is at the basis of the milieu concept: the presence of a common knowledge which goes beyond the boundaries of the firm, but which remains within the spatial boundaries of the milieu, gives rise to a process of cumulative local know-how, of a spatial technological trajectory, which in its nature is the territorial counterpart of the Dosi's concept of technological trajectory of a firm. In the case of the

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[2] See among others, Aydalot, 1986; Aydalot and Keeble, 1988; Camagni, 1991; Maillat et al., 1993.

firm, the long term permanence of the technological trajectory is given by the physical specificities of each technology, while the evolutionary and self-reinforcing process of incremental innovation determines the upgrading through incremental innovation. At the spatial level, the specificity is given by a socio-geographical entity, the milieu, which evolves around its internal know-how and innovation potential through a process of collective learning. The latter seems, in the theory of the milieu, to be intrinsic to the nature of this socio-economic entity, and characterises its evolutionary patterns.

If the theory of the milieu innovateur provides a good framework for the spatial dynamics of local areas, as a relatively efficient territorial counterpart of the evolutionary theory of firms, still some elements of ambiguity exist, which are addressed in this paper.

A first element open to further reflections lies in the concept of collective learning. Collective learning is generally defined as "a social process of cumulative knowledge, based on a set of shared rules and procedures which allow individuals to coordinate their actions in search for problem solutions"[3]. Although at a first glance this definition could provide a clarification of the concept, a deeper interpretation of this definition shows that the difference with the most traditional and more well-known concept of learning is still weak. The evolutionary theory in fact defines learning as "a process of cumulative knowledge, taking place in firms where common and shared rules (or routines, in the words of Nelson and Winter, 1977 and 1982) exist which allow individuals to coordinate their action in search for problem solutions".

Looking at the definitions provided by the literature of learning and collective learning, the word "social" seems to differenciate collective learning from learning; if this is the case, a clear definition is required for this word; in this respect, space exists for further reflections, and this paper provides a first attempt to pursue such a goal.

A second element which requires further reflection is the concept of collective learning as an intrinsic element of the milieu: it may in fact be interpreted as a result of a *cooperative behaviour of local agents*, and thus by definition stems from a conscious behaviour of agents present locally, as a local externality, *generated by the local environment*, that agents may feel free to exploit if they are interested in it.

The main difference in the two interpretations is that while the former implies a conscious behaviour of local agents, which find in a cooperative behaviour a useful and efficient strategy to share a common knowledge, the latter stems from the intrinsic nature of the milieu, the dynamic counterpart of the industrial atmosphere, an external economy which does not require a conscious behaviour of local agents to take place. Like it is impossible to foresee a local district where a marshallian industrial atmosphere is not present, it seems from what have just been said that an area is difficult to be defined as a milieu when a collective learning is not present.

[3] See among others Dupuy e Gilly, 1995; Favereau, 1994; Haas, 1996; Lazaric and Lorenz, 1996; Livet and Thévenot, 1994; Rallet, 1993.

This paper addresses these two elements that still present an ambiguity and provides some theoretical reflections in two directions:

- towards a more precise definition of the meaning given to the word collective learning, clarifing similarities and differences with the concept of learning (Section 2);
- towards the identification of a methodology to clarify the difference between the concept of the milieu and of collective learning. May a socio-economic entity like the milieu exist without a mechanism of collective learning (Section 3)?

These research issues have also stimulated the interest for an empirical analysis. In particular, the main goal of the empirical exercise is to analyse the role of collective learning as a vehicle for spatial transfer of knowledge in three Italian high-tech milieux. The high-tech sector has been chosen for the high intensity of innovation activities, intrisic to the nature of the sector. In particular, our interest is to describe:

- learning behaviour in innovative activities of high-tech firms. Our interest is to find out the channels through which firms get their knowledge inputs, and if these channels are the same for each type of innovation and each firm in the milieu (Section 4.2);
- the degree of importance of collective learning in different innovative activities (process innovation, incremental product innovation, radical product innovation) (Section 4.3).

2. Collective learning as a vehicle for spatial transfer of knowledge: similarities and differences with the concept of learning

In the theory of the milieu innovateur, collective learning is the territorial counterpart of learning in an industrial context; it is thought as the vehicle for knowledge transmission, both in a temporal and in a spatial dimension. However, as mentioned in the introductory section, collective learning is still a fluid concept; its definition has been provided by many authors[4], applied to different fields (industrial economics, when the entity of analysis is the single worker, rather than the firm as a whole, and regional economics), but an unambigous definition differenciating this concept with respect to the concept of learning is still lacking.

In this section some reflections on similarities and differences are provided which may help in comparing the two aspects. In the case of both learning and collective learning, the transfer of knowledge over time is guaranteed by an element of continuity in time, and by one of interaction among agents, which guarantees the transmission among individuals and firms and which becomes, in the case of the milieu, an element for the spatial trasnfer of knowledge; from this point of view, a collective learning is a learning process, because it is:

[4] See note 2 for key references.

- *cumulative*, since it lasts over time. Learning is a dynamic process, developed on the basis of an element of continuity, on which knowledge rests and cumulates while time passes;
- *interactive*, since a new creative knowledge of a first inventor is transferred through other agents on the basis of an element of synergy and of an interactive process among different agents (either different individuals, different departments or different firms), giving rise to a cumulative process of knowledge.

2.1. Knowledge transfer over time: the role of an element of continuity

A first important vehicle for the transfer of knowledge is the existence of an element of continuity over time, which allows the cumulation of knowledge, in terms of know-how and previous experience.

According to the traditional evolutionary school, innovation is characterised by discontinuity and breakdown of a static framework of productive processes in which technologies and information are given and perfectly known ex-ante. If the perfect information world is left aside, uncertainty in decision making processes is the clear outcome, and the tendency of an entrepreneur to base his decisions on *already existing knowledge* is the feasible consequence. This uncertainty reducing entrepreneurial behaviour explains the "path-dependent" nature of the innovation: continuity, sequentiality and cumulativity of technical, organisational and managerial knowledge is the outcome. In this perspective, a new concept of time is envisaged in this kind of literature, a time defined by the rhythm of innovation, by the pace of learning processes which cumulate in an entity constantly present in the firm.

In large enterprises, the presence of large scale R&D functions and engineering departments plays the role of information collection, of its assessment and transcoding, of selection of decision making routines, thanks to the fact that the entreprises themselves are long-term units (Table 1). But especially, R&D functions play the role of entities where knowledge is cumulated, embedded in routines of the firm, and transferred as a tacit knowledge in the process of searching for new technological innovations, giving rise to specific technological trajectories. As underlined by many authors, the cumulativity of know-how generates irreversible patterns and choices, at a point that a more efficient technology may never become profitable since adopters are locked-in the cumulative competence processes and the positive feed-back effects stemming from the old technology (Arthur, 1988 and 1990).

In small firm districts, a function playing a role of stable entity of innovation searching does not exist for both a reason of diseconomies of scale and of instability of life cycles of single production units which tend to be shorter and more turbolent than those of large firms. In local districts, information collection and cumulation of knowledge takes place in a *socialised way* outside each firm and finds its elements of continuity in the local labour market and in the local inter SMEs linkages, both horizontally, and vertically (with customers and suppliers) (Table 1) (Camagni, 1995).

The labour market is traditionally stable over time within the local district, and this element finds an explanation in both social and economic reasons. In local districts, a strong social sense of belonging to a specific territorial entity guarantees a very low mobility of the labour force with the external world. Moreover, the high degree of sectoral specialiation and of innovative production systems, particular of the milieux, turns into a barrier to exit from the local labour market; a limited market for local skills outside the area generates lock-in mechanisms, to such an extend that the stability of the local labour market is guaranteed.

If the labour market constitutes the main element of continuity of knowledge transfer over time, a second element of continuity may be envisaged in *the 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. Also in this case, the comparison with the firms' technological trajectory is straightforward, with the only exeption in the way technological trajectories develop: in the case of the milieu, the technological patterns of incremental innovations find their roots outside the single firm, being the result of a strong social interaction also in input-output linkages. As Aydalot suggested (1986), the innovation process in a territorial entity like the milieu is a process of "rupture/filiation" (break and continuity): if an innovation is a break with a preexisting situation, economic creativity and innovation potential have their seeds exactly in the local cumulated knowledge and in the local scientific know-how acquired over time.

2.2. Knowledge transfer in space: the role of elements of dynamic synergies

However, the existence of an element of continuity is not sufficient to produce learning, and collective learning. A second element is required in both firms and districts, to assure the transfer of cumulated knowledge, an element that may be interpreted as dynamic synergies.

In large enterprises, information collection and knowledge is transferred through functional interaction, among R&D, production, marketing and organisation departments. Since most of the cumulated knowledge is tacit and based on "intangible assets", the preconditions for strong and innovative interaction among functions is the creation of common rules and routines, imposed by hierarchy and control, typical of a large enterprise (Nelson and Winter, 1977).

Also in territorial systems of small firms, an element of dynamic synergy is vital to achieve a (collective) learning, an element which guarantees the transfer of cumulated knowledge and local know-how over space. This function of transferring information and know-how within the boundaries of the milieu is played by the *high mobility of the labour force, by intense innovative interactions with suppliers and customers and by mechanisms of local spin-off.* Let us analyse these spatial channels of knowledge transfer in more detail.

A high turnover of the labour force in small firms districts is the result of different mechanisms which characterise the milieu. First of all, a short and turbolent life-cycle of single production units generates an inevitable turnover of employees in local firms, as a result of a physiological process of firms life-cycle. Moreover, the redundancy of qualified local labour supply with specific technical skills which can be fed primarily with local skills facilitate the high mobility of the labour force within the area, and at the same time decreases labour opportunities outside the milieu, creating a sort of lock-in mechanism of local labour force to its territorial origin.

Intense interactions between suppliers and customers are an element of continuity over time for the transfer of knowledge. However, they may also be interpreted as a vehicle for spatial transfer of knowledge, when these economic relationships are interpreted as the result of dynamic strategies, in search for uncertainty reducing mechanisms (socialisation of risks, transcoding of complex information and know-how), rather than only as mere strategies oriented towards the achievement of static efficiency (reduction of transaction costs because of trustworthy long term relationships), traditional of local districts theories. The dynamic strategies behind these interactive linkages are the reasons for their long term permanence and strategic importance in the definition of a technological trajectory in the milieu, since they set in motion a circular positive relationship between needs identifications and possible new stimuli and ideas for needs satisfactions which feed both process and product innovative processes.

The mobility of the labour force in spatial SMEs production systems may take place even through *local spin-off*: theoretically, a spin-off is defined as an indipendent firm fullfilling two critera (Perhankangas and Kauranen, 1996): a) the start up a new business by an agent previously belonging to another local firm, b) the derivation of the business idea leading to the formation of a new firm from the previous employment of the founder. 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 an acceptable event[5]. Local market conditions, like stable interactions with suppliers known in the previous job, a receptive local demand of particular products developed in the previous job, and the presence of external economies, assure locational advantages, guarantee the achievement of profits and thus give rise to chances for survival on the local market.

As in the case of learning processes, preconditions exist at the spatial level which guarantee the development of dynamic and creative synergies. These preconditions are embedded in the capability of local firms to cooperate, not only in terms of technical elements, but also managerial and organisational aspects, thanks to their organisational, institutional and cultural proximity. As the French school underlines, organisational proximity overcomes the economic separation among actors, or organisations, by generating common interpretations of the reality used by formulating personal strategies and economic choices (Bellet et al., 1993; Rallet, 1993).

[5] On the social homogeneity of local districts a vast literature exists. See among others, Bagnasco and Trigilia, 1984; Becattini, 1990. An overall synthesis of local district theories is contained in Rabellotti, 1997 and in Bramanti and Maggioni, 1997.

Trust among actors is another element on which dynamic synergy rests, since it helps in decreasing the risk and uncertainty accompaining each inter-firm relationship (Dupuy and Gilly, 1995). Because of their common role of uncertainty reducing elements, power and trust are often regarded as the two main elements beyond dynamic synergies: the former in the large entreprise context, the latter in SMEs territorial contexts.

2.3. Collective learning as a club good

The concept of learning and that of collective learning tend to have great similarities; however, a crucial difference exists between the two, and lies in the social nature of the collective learning process. Beyond the elements of cumulativity and of interaction, a third one can be given to the word collective, that of *public*. The mechanisms of spatial transfer of knowledge identified before take place in *a socialised way*, since a new creative knowledge of a first inventor is transferred to other agents, despite his will, thanks to common technological, organisational and institutional common routines and behaviours which facilitate the tacit transfer of information and know-how. In other words, the outcome of the innovative process may be exploited by everybody, despite the will of the first inventor. In this way, the creative knowledge cumulates outside the firm, and becomes a club good: no rivarly in its use by agents belonging to the club, and excludability of external agents from taking advantage from this good. In this sense, collective learning is a typical "club good" à la Buchanan (1965) from which club externalities may be exploited.

In this perspective, collective learning may be defined as a dynamic process of cumulative knowledge, transferred, even against the will of the first inventor, among economic agents via interactive mechanisms existing thanks to common rules and common organisational and managerial procedures.

In the case of large entreprise, the profit of the innovation achieved via the cumulative knowledge remains within the boundaries of the firm, and is explained in Schumpeterian terms as the remuneration of entrepreneurial activities which embedd the costs of uncertainty and risk. Moreover, its role of private remunaration represents an incentive for further investments in knowledge, through new R&D expenditures, leading to a cumulative know-how and to continuous innovative processes.

In the case of local systems of small firms, the profit of the innovation achieved via the cumulative knowledge is by definition public, since knowledge is assembled and cumulated in a socialised way on the labour market through inter-SMEs linkages and labour force turnover. The local cumulated knowledge is transferable to all agents present locally, through the local labour market, through SMEs linkages and through local spin-off, facilitated by organisational, institutional and social proximity. These preconditions for the exploitation of local and cumulated knowledge guarantee the exploitation of this external economy only by local actors, with no rivalry in its use among local actors, and with excludability of external agents to take advantage of it: in this sense, imitation, reverse engineering, technological upgrading of product and

process innovation as well as radical product innovation mainly occur against the will of the first innovators (Camagni, 1995).

This externality is an element which occurs in the local environment at the same level of those more traditional elements of static efficiency, such as the industrial atmosphere and the external economies associated with a clustering of small firms: it is indipendent from a conscious cooperative will by single actors while its exploitation is set apart from an explicit strategy of each single local actor, when some pre conditions are met. In this sense, it is a collective element rather than a cooperative one.

3. Collective learning and the milieu concept: similarities and differences

Our inclination is to interprete collective learning as a club good, rather than the result of a conscious cooperative behaviour of local agents. However, this interpretation creates a sort of overlapping with the definition of milieu, and in particular, an interesting research question is whether a local area is a milieu only when collective learning processes are envisaged.

Figure 1 presents our logic framework of analysis to reply to the question: it represents different spatial systems, from areas of single geographical proximity, through to industrial districts, towards milieux, underlying for each stage the spatial pre-conditions which characterise a certain territorial entity. In fact, at each stage, the local system may evolve around different development patterns, according to the pre-conditions fullfilled locally.

A simple area whose economic activities are characterised by geographical proximity turns into a specialised area when stable inter SMEs linkages and a stable local labour market guarantee the continuity over time of local technological and scientific know-how in specific sectors, on which comparative advantages with other areas rest. The lack of these customer-supplier relationships leads towards a diversified labour market, and thus a diversified local area, with no sectoral specificity.

If an element of institutional and social proximity is added to the specialisation of a local labour market, the framework of an industrial district arises. Organisational and social proximity gives in fact a different meaning to the customer-supplier relationships and to the local labour market: these relationships become qualitatively greater, since they are based on trust and social interactions, which set in motion an informal and tacit transfer of information and know-how, and of non-codified immaterial assets among local firms which help in determining the true characteristics of an industrial district on which static efficiency is based: those of industrial atmosphere and reduction of transaction costs[6]. If this local precondition is not met, the specialised area turns into an area of high atomistic competition.

[6] On Local Districts see, among others, Becattini, 1977; Bianchi, 1994; Brusco, 1982; Garofoli, 1981, For a revue, see Bramanti and Maggioni, 1997.

The dynamic interpretation of the customers-suppliers relationships, of the element of cooperation and continuity leads towards the concept of a milieu; as the Gremi group has underlined since the eighties[7], when cooperation and tacit transfer of knowledge is understood in terms of innovative capacity, and of innovative synergy, more than in terms of social solidarity and social interaction, a local district becomes, in abstract terms, a milieu. The milieu is characterised by definition by collective learning, by a local labour market which local firms feed with their own knowledge against their will, and from which they can get the local dynamic advantages. This local cumulative and "socialised" knowledge may be grasped by local actors whenever they feel interested, and represents the source for local dynamic comparative advantage. If these dynamic synergies are not present, the district remains a local district since it bases its competitive advantage on static efficiency like the reduction of transaction costs and the exploitation of Marshallian external economies.

The interest and capacity of local actors to grasp collective learning may explain the difference between a milieu, and a milieu innovateur: the latter turns collective learning into profits. These profits only partly remunerate the risk of innovation and of uncertainty associated with an innovation process: the most part of them originates from the externalities grasped by the innovateur. In the absence of these local pre-conditions, a milieu remains a potential innovative area.

The pre-conditions to exploit collective learning in a milieu are of two different kinds:

- the *internal capacity* of each local firm to grasp collective learning;
- the *private strategies* of each local agent, willing to grasp for its own economic purposes the club good offered.

The capacity of local firms to exploit collective learning may be interpreted in a schumpeterian way like the entrepreneurial expertise to turn knowledge, even if socialised, into a business idea. In this sense, cafeteria effects for informal exchange of ideas among producers and customers may lead to the identification of specific needs and in this sense may be an important mechanism to build local entrepreneurial capacity.

The decision of each local actor to grasp collective learning turns around two specific elements: a) the type of innovation to develop; b) the firm size. Collective learning embeddes all historical knowledge accumulated in the local labour market over time, which is the pre requisite for a jump on a new technological trajectory in respect with the technological trajectories typical of the single firm. Radical product innovations are mainly based on a new technological creative knowledge and on new scientific resources, those resources which stem from an historical process of cumulative know-how. Once an agent is willing to achieve a radical innovation, it is more inclined to grasp the opportunity to exploit the local labour market, where these creative resources have been cumulated over time. It is also in this respect that, once a local actor exploits collective learning, he participates, even against his will, to the process of creation of new resources, which will be in the long run embedded in the local market. On the

[7] See note 1 for key references.

contrary, in front of process innovations which require incremental innovation and feed themselves of cumulated knowledge within each firm, the choice of local actors will be more oriented towards the exploitation of internal knowledge.

In the same logic, the size of the firm is another determining element in the decision to exploit collective learning. A large firm is more oriented towards the exploitation of internal creative resources even for breakthrough innovations: by definition, a large firm has more resources to devote to knowledge creation, is less willing to grasp and to participate unconsciusly to the socialisation process of creative knowledge. A small firm is for the opposite reasons more inclined to grasp collective learning, once this externality is present in the area.

Once a milieu innovateur is achieved, positive feedback effects arise put in place by the innovative process, reinforcing the elements of continuity (stable labour market, stable inter SMEs linkages) and of dynamic synergies (interactive mechanisms leading to innovation) (Figure 1). However, the existence of these positive feedbacks do not guarantee a long term innovative capacity of the milieu. The element of continuity of cumulative knowledge turns in the long run to play the opposite role of increasing risk, since it drives the milieu towards an increasingly small specificity, and may lock the local agents in technological trajectories which may result in the long run to be obsolete, non-competitive and inferior, but still be stable in time (Coriat and Dosi, 1993; Camagni, 1995). The collective learning which is at the basis of the dynamic comparative advantages of the milieu since it is also a “barrier to entry” in the local market may be transformed in the long run into a “barrier to exit” (Bianchi, 1989), obliging the milieu to follow a less competitive technological trajectory. In this respect, a different channel through which knowledge may be cumulated, and may contribute to the creation of collective learning is cooperation with firms outside the milieu, which provdes external energy to the local technological trajectory. External learning to the district is another important channel for an innovative milieu (Camagni, 1991).

These reflections lead to some interesting empirical questions which we investigate in the empirical part of the paper. In particular, the questions are the following:

- whether it is true that collective learning is exploited by local firms only if they are interested in it. If this is true, *we would expect different learning behaviours of local agents, depending on the kind of innovative activities and of firms size*;
- whether it is true that collective learning is the way of achieving new creative resources for SMEs in local areas. If this is true, *we would expect product innovation and breakthrough innovation to be positively correlated with collective learning.*

In the next sections, we reply to the previous questions through an empirical analysis based on three Italian high-tech milieux.

4. Learning behaviours in innovative activities: an empirical analysis

4.1. Database and methodology

The first research issue we want to investigate at empirical level is the learning behaviour of innovative activities in firms belonging to a milieu. For this reason, a questionnaire is developed and run in three high-tech milieux areas in Italy, namely Pisa, Piacenza and the North-eastern part of Milan, where high-tech firms are geographically clustered. The questionnaire covered five main themes, which regarded:

- the characteristics of the firms, in terms of employees, turnover, innovative activity, economic dynamics;
- the characteristics of the local labour market, in terms of quality of the labour force, formal and informal channels for labour acquisition, the turnover within the firm, stability of the labour market;
- the relationships with customers, and especially with local customers, and their role in the innovative activity of the firm;
- the relationships with suppliers, emphasising local suppliers and their role in the innovative activity of the firm;
- the local spin-off mechanism, in terms of intensity of the phenomenon and importance within the innovative activity of the firm.

63 firms in the three milieux are interviewed in a period of a month[8], and the database built, mainly as binary (yes, no) or discrete (a qualitative judgement) variables.

The methodology used to describe learning behaviour for innovative activities among our firm sample is a cluster analysis. However, before entering the behavioural analysis, factor analysis is run, with the primary goal of simplifying the description of local systems and of their innovative and learning behaviour. Factor analysis allows the identification of a relatively small number of underlying principal elements of "factors" that explain the correlations among a set of variables; in other words, it summarises a large number of variables with a smaller number of "derived" variables[9]. In fact, from our questionnaire, many variables could be used to describe:

a) firms characteristics, in terms of:

- growth, size, and innovative activity;
- relationships with suppliers, in terms of role played by suppliers in the innovative activity of the firm, and whether organisational and institutional proximity matters;
- relationships with customers, as in the case of suppliers;

b) the local area characteristics, in terms of:

[8] The sample covers both small (1-49 employees) and medium (50-199) firms. The former represent 81% of the sample, the latter 19%. The average number of employees is 16 for the first group, and 123 for the second group.

[9] The use of factor and cluster analysis to local districts theory is not new: see, for example, Rabellotti, 1997; Rabellotti and Schmitz, 1997.

- district locational advantages, like industrial atmosphere, stable labour market, cultural proximity with the labour force;
- local labour market, especially in terms of mechanisms associated with the learning of the local labour force, either internal or external to the firm, and in this latter case, either within or outside the district.

Factor analysis has been run in order to identify for each group of characteristics mentioned above, which could be represented by many explanatory variables of our questionnaire, a smaller number of "derived" variables. The main results of this statistical exercise are summarised in Table 2. In statistical terms, the results are quite satisfactory: all factor analyses run in each of the above mentioned groups of characteristics explain a large share of total sample variance.

In the case of firms characteristics (Table 2.a)[10], three main principal factors are significant and meaningful, explaining 67% of total sample variance, and being simple to be interpreted from an economic point of view. A first factor, labelled DININ, represents firms with increasing turnover (a2bin), highly innovative (a5). A second factor, labelled SMIN, can be interpreted as a size and product innovation factor: firms of small size (a1bin) with breakthrough innovation (a3n). A third factor in this area, labelled PROCIN, represents firms characterised by high process innovation.

In the area of suppliers relationships, the results lead to three main factors (Table 2.b), explaining 69% of the total sample variance. The first factor represents the technological proximity of firms with their suppliers (TECHPROS), the second factor the institutional and organisational proximity (ISTORGPROS), the third represents the importance of local suppliers in the innovative process of firms (PRELOCS). These factors are composed by variables reflecting important elements of our conceptual framework. They stress the role of local suppliers in the innovative activities, as well as the pre-conditions for dynamic synergies, embedded in the institutional and organisational proximities with suppliers.

In the area of customers relationships, similar results are achieved (Table 2.c). Four main factors emerge, explaining 79% of the total sample. In order of importance, these are: the institutional and organisational proximity with customers (ISTORGPROC), the technological proximity of customers (TECHPROC), the presence of local customers which stimulates innovative activities (PRELOCC) and the role of standard contracts with customers in innovative activities STANCONC). As in the case of suppliers, some strategic variables of our conceptual framework emerge.

The area of traditional local district advantages provides interesting statistical and economic results (Table 2.d). Four main factors are identified, explaining 67% of the total sample variance: cultural proximity with the labour force (B72 and B73) (labelled CULPRO), proximity to the original firm (ORFIRPRO); stable local labour market (STABMKT); and industrial atmosphere (INDATM). Also in these results, the

[10] For the complete statistical results, see Table 2, which contains also each factor explanation of sample variance.

economic interpretation is simple: the main industrial districts locational efficiency, (reduction of transaction trasaction costs due to labour market cultural proximity), and external economies (industrial atmosphere) are clearly represented in the factors while more traditional locational advantages, related to a traditional accessibility element (geographical proximity to important motorways or airports contained in question a91), do not emerge as important.

The area of learning incorporates all possible variables representing possible channels for learning. In our conceptual framework learning is a process of cumulative knowledge ebbedded in the labour force: for this reason, all questions related to the training channels of the local labour force are part of this factor analysis. Again, also in this case the results are quite satisfactory at both the statistical and economic level: four factors are achieved (Table 2.e). A first factor represents learning external to the district (LEXDIS): scientists and technicians coming from other firms in the area (b32) and informal mechanisms of hiring (b65 with a negative sign). The second factor represents a learning internal to the firm (INLEAR) being composed by an emerging variable represening the number of technicians and scientists that have trained in local firms (B42 in negative). The third factor deals with the turnover of the labour force (TURN), merging a high percentage of both employees which joined and left the firm in the last five years. The fourth factor represents the spin-off mechanism.

This statistical exercise is needed to run a multivariate cluster analysis, based on the factors identified, instead of the original variables. Cluster analysis is the methodology used to identify different learning behaviours with respect to different innovative activities and goals of firms. In statistical terms, cluster analisys groups firms according to their degree of vicinity in respect to the main underlying factors which characterise the economic structure and the local relationships of the sample (Rabellotti, 1995).

We would expect that for each of the innovative and structural factors identified above (Table 2.a), different learning behaviours and different customer-suppliers relationships would emerge. If this is the case, we would be able to prove the hypothesis that collective learning is exploited for innovative activities in certain circumstances.

4.2. Learning behaviours in innovative activities: empirical results

The research hypothesis we would like to test in this part of the analysis is that collective learning may be interpreted as a local external economy, similar to other local externalities that is likely to be grasped by actors who are smaller in size and more innovative in general. Thus, in the milieu we expect heterogeneous learning behaviours of local firms, according to their size and to the intensity of their innovative activity.

In particular, as explained in Section 3, we expect collective learning behaviours to be put in place by smaller firms and by firms which have more breakthrough innovation: in both cases, collective learning may be required as a substitute for learning within the firm, typical of large entreprises.

The results of our cluster analysis are presented in Table 3. Three main clusters explain the learning behaviours of our firms sample:

- a first cluster depicts *a milieu with a networking behaviour*: the *learning is in this group of firms based primarily on know-how external to the local area*. This cluster is in fact characterised by dynamic and innovative firms, and at the same time by traditional local district elements of static efficiency (like industrial atmosphere and cultural proximity with the labour force, which decreases transaction costs), which are at the basis of the competitive force of these firms. These firms need to add to these traditional static locational advantages acquisition of know-how and learning from outside the district: it is probably in these external linkages that the innovative roots of these firms feed themselves;
- a second cluster shows a *sub-system of authonomus firms within the milieu*: *learning is in fact based on firms internal competences*. Firms belonging to this cluster are specialised in process innovation: for these firms, as expected, the main channels of learning are a) learning within the firm; b) technological proximity with customers and suppliers;
- a third cluster depicts a *pure milieu behaviour where the learning stems from socialised mechanisms of spatial transfer of knowldege, i.e. on collective learning*. The smallest and most innovative firms in terms of radical product innovation feed their innovative activities through collective learning mechanisms: local spin-off, a stable market over time associated with a high turnover of the labour force, high dynamic synergies with local suppliers and organisational and industrial proximity with them, informal contracts with customers, are all characteristics of this cluster, and represent all channels through which the innovative breakthrough activity of these firms probably feeds itself.

These results support our theoretical expectations. The learning mechanims even within a milieu are rather different, and seem to be correlated with two main elements: a) the kind of innovative activity a firm has to face and b) the firm size. Collective learning is, as expected, more linked with small firms and with radical innovation processes. Process innovation, on the contrary, seems to require mostly internal knowledge, cumulated by the firm, and some technological proximity with suppliers and customers.

Other important aspects of our conceptual framework are underlined in these empirical results. The collective learning plays a crucial role when both the continuity element and the dynamic synergy element are present: a stable local market is associated with a high turnover of the labour force. The dynamic sysnergies among suppliers and customers, empirically measured as the importance of the local suppliers and customers in the innovative process of the firm, are associated with the institutional and organisational proximities, what we called the local pre conditions for the constitution of a milieu (see Figure 1 above).

Another consideration stems from the empirical analysis: learning from outside the local area seems to be useful in two cases: a) first of all, as a channel through which a local district may obtain innovative forces and resources, when its competitive advantage is

based on static elements; b) secondly, it is important in the innovative milieu itself[11], since it may avoid collective learning mechanisms to lock the milieu in trajectories which in the long run may turn out to be inferior.

An interesting and meaningful result is the distribution of firms sample among the three statistical clusters obtained: more than 85% of our sample firms belong to the first cluster, 13% to the second, and the remainging 2% to the third. In these local systems, the prevailing spatial elements are those of local district system, rather than of milieux innovateurs. Although this may seem an astonishing result, it is in line with what already suggested in previous analyses on Italian high-tech milieux (Camagni, 1996): spatial preconditions for the development of local high-tech milieux in Italy exist only in a limited way. The behavioural analysis run in this study confirms that high-tech local systems seem to to more oriented towards the exploitation of static efficiency elements, typical of a traditional local district, rather than towards the exploitation of dynamic elements, like collective learning.

4.3. Collective learning as a determinant of innovative activities in high-tech milieux

The second research issue we would like to address is the role played by collective learning in the innovative activities of firms in the milieux. In fact, if it is true that collective learning is the way of achieving new creative resources for SMEs in local areas, we would expect product innovation and breakthrough innovation to be positively correlated with collective learning.

Linear regression analyses have been run to test this hypothesis among the factors identified above. In particular, the three factors explaining structural and innovative characteristics of the sample firms have entered the model as dependent variables, and regressed on the other factors. The results confirm our expectations and our hypotheses (Table 4):

- the radical innovation activity of the smallest firms deeply depends on both the turnover of the labour force within the firm, and spin-off mechanisms. Both describe mechanisms of tacit transfer of collective learning within the district, are significant from a statistical point of view, and have the expected positive sign;
- the process innovation activity is negatively correlated with the turnover of the labour force, witnessing an independence of process innovation activities from collective learning processes;
- product innovation activities (both incremental and radical) very much depend on cultural proximity with the labour force, which expressed one of the traditional locational advantages of local districts.

5. Concluding remarks

[11] This statement stems from the fact that in the third cluster this factor assumes a medium value, between the three clusters. See Table 3.

Collective learning is a fascinating concept at the basis of modern theories on spatial production system dynamics. So far, however, some ambiguities exist in the definition of collective learning and on its interpretation within spatial theories.

For what concerns the first aspect, the distinction between learning and collective learning requires some further elements of reflections. In this paper, a first attempt has been made to define both similarities and differences between the two concepts: while elements of continuity and dynamic synergies are common to both concepts, they manifest themselves at the firm level and at the territorial level in different ways. The element of club externality is the main distinguishing feature of the two concepts. At the territorial level, the element of continuity is the local market, where the local know-how comulates overtime; the element of dynamic synergy is the tacit spatial transfer of creative know-how among local agents via dynamic inter-SMEs linkages, spin-off mechanisms and turnover of the labour force. Local creative know-how thus cumulates outside the firm and is in this sense the result of a process of socialisation facilitated by the common cultural and organisational rules and codes.

In this respect, collective learning is a club good, and this is what differenciates it from learning. Collective learning is characterised by no rivalry in its use by agents belonging to the club, and instead guarantees excludability of external actors from taking advantage from this externality.

If this is the definition given to collective learning, its interpretation is that of an externality, rather than that of a cooperative mechanism: the transfer of creative and cumulative knowledge takes place even against the will of the first inventor, and, on the basis of private interests and of their structural features, local agents may decide to take advantage of this collective learning.

The empirical analysis supports these theoretical hypotheses: the cluster analysis run to describe the learning behaviours of firms depicts different groups of firms, according to their innovative activity and learning behaviour. A collective learning mechanism is present in those firms which are very small and very dynamic in terms of radical product innovation. For process innovation, a profile of leaning internal to the firm is more typical.

Regression analyses demonstrate that a positive and significant correlation exists between collective learning and radical innovation activities of small firms: in this respect, the main idea that collective learning enhances the innovative capability of small firms turns out to be proved.

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Table 1. Elements for knowledge transfer

Elements for knowledge transfer	Continuity	Dynamic synergies	
Context			
Firms	R&D functions	Functional interaction Tacit transfer of knowledge	*LEARNING*
Territory	Low mobility of the labour force outside the milieu	Labour force turnover within the milieu	*COLLECTIVE LEARNING*
	Stable linkages with suppliers and customers	Innovative cooperation with suppliers and customers	
		Local spin-off	

Table 2.a. Factor analysis for the structural characteristics of firms

Variables	DININ	SMIN	PROCIN
Turnover over the sample average	0.51	-0.74	0.01
Increasing turnover	0.74	0.04	0.18
75% of the turnover depending on innovation	0.35	0.84	-0.04
Significant product innovation developed over the last 5 years	0.45	0.08	-0.61
Breakthrough product innovation developed over the last 5 years	0.64	0.012	-0.15
Significant process innovation developed over the last 5 years	0.19	0.009	0.84
Explained variance by each factor (in %)	26	21	19
Share of total explained variable: 67%			

Table 2.b. Factor analysis on suppliers relationships

Variables	TECHPROS	ISTORGPROS	PRELOCS
Standard supply contract	0.43	0.63	-0.46
Contract based on technical standard	0.62	-0.1	-0.1
More than 75% of suppliers are local	0.08	0.22	0.85
Very important role played by suppliers in technical innovative processes	0.64	-0.0002	0.44
Common approach with suppliers to institutional aspects	0.002	0.83	0.18
Common approach with suppliers to technical aspects	0.79	0.17	0.16
Common approach with suppliers to organisational aspects	0.21	0.8	0.24
Complementary knowledge	0.87	0.14	0.08
High trustworthyness in cooperation	0.82	0.17	0.01
Explained variance by each factor (in %)	34	21	14
Share of total explained variable: 69%			

Table 2.c. Factor analysis on customers relationships

Variables	ISTORGPROS	TECHPROC	PRELOCC	STANDCONC
Standard supply contract	0.27	-0.63	-0.07	0.56
Contract based on technical standard	-0.1	0.11	0.007	0.87
More than 75% of suppliers are local	0.13	0.05	0.84	-0.30
Very important role played by suppliers in technical innovative processes	0.18	0.11	0.83	0.28
Common approach with suppliers to institutional aspects	0.89	0.23	0.24	-0.05
Common approach with suppliers to technical aspects	0.37	0.79	0.09	0.023
Common approach with suppliers to organisational aspects	0.92	0.28	0.14	-0.007
Complementary knowledge	0.41	0.75	0.04	0.14
High trustworthyness in cooperation	0.30	0.5	0.37	0.32
Explained variance by each factor (in %)	24	22	18	15
Share of total explained variable: 79%				

Table 2.d. Factor analysis for the location advantages

Variables	CULTPRO	ORFIRPRO	MKTSTAB	INDATM
Proximity to motorways and airports	-0.02	-0.63	0.27	0.06
Cultural and industrial atmosphere	0.29	0.26	-0.06	0.84
Lower production costs	-0.12	0.35	-0.64	-0.02
Common culture	0.81	-0.02	0.15	-0.10
Common technical background	0.81	0.03	-0.27	0.21
Stable local labour force	-0.11	0.08	0.80	-0.07
Very important role played by the local market in providing high quality labour force	0.49	0.18	0.44	0.17
Proximity to the residential place	0.34	0.50	-0.06	-0.64

Proximity to the original firm	0.03	0.81	0.20	0.19
Explained variance by each factor (in%) Share of total explained variable: 67%	20	17	16	14

Table 2.e. Channels of knowledge acquisition

Variables	LEXDIS	INLEAR	TURN	SPIN
The firm is the result of a spin-off	-0.12	-0.06	-0.15	0.74
Firm's technicians and scientists were previously employeed in firms outside the milieu	0.54	-0.41	-0.26	-0.25
Firm's technicians and scientists were previously employeed in local firms	-0.73	-0.29	-0.09	0.31
Firm's technicians and scientists were previously employeed in local research centres	0.47	0.39	0.05	0.46
Firm's technicians and scientists were previously employeed in external research centres	0.02	0.09	-0.12	-0.62
Firm's technicians and scientists had their training within the firm	0.21	0.75	-0.10	-0.23
Firm's technicians and scientists had their training outside the firm	-0.13	-0.85	-0.17	0.005
More than 50% of firm's labour force has been recruited by the firm	0.19	0.28	0.81	0.18
More than 50% of firm's labour force has left the firm	-0.11	-0.11	0.89	-0.15
Importance to recruite technicians through informal channels	0.51	0.08	0.02	0.11
Importance to recruite scientists through informal channels	0.75	0.11	0.01	-0.07
Explained variance by each factor (in %)	18	16	15	13
Share of total explained variable: 62%				

Table 3. Results from the cluster analysis on learning behaviour

Factors	Cluster 1	Cluster 2	Cluster 3
Dynamic and innovative firms	**0.127**	-1.32	-0.24
Industrial atmosphere	**0.047**	-0.33	-0.48
Cultural proximity	**0.010**	-0.039	-0.20
Learning external to the miliex	**0.02**	-0.19	-0.18
Process innovative firms	-0.01	**0.25**	-0.103
Proximity to the mother firm	0.009	**0.08**	-0.46
Learning internal to the firm	-0.04	**0.55**	-0.18
Presence of local inn. customers	-0.05	**0.51**	0.28
Technological proximity with customers	0.039	**0.17**	-1.53
Technological proximity with suppliers	0.009	**0.15**	-0.64
Smallest and most innovative firms	-0.0009	-0.35	**0.89**
Market stability	0.014	-0.30	**0.33**
High labour force turnover	0.0021	-0.18	**0.41**
Spin-off	0.0027	-0.039	**0.02**
Standard contracts with customers	0.02	-0.52	**0.63**
Institutional and organisational proximity with customers	-0.05	0.29	**0.68**
Presence of local innovative suppliers	-0.059	0.42	**0.61**
Institutional and organisational proximity with suppliers	-0.03	0.18	**0.47**

Table 4. Results from Regression Analyses

Dependent variables:	DININ	SMIN	PROCIN
Independent variables			
Turnover		0.666 (2.33)	-0,19 (-2.025)
Cultural proximity	0.465 (2.339)		
Spin-off		0.655 (3.219)	