Spatial Transfer of Knowledge in High Technology Milieux:
Learning Versus Collective Learning Processes

ROBERTA CAPELLO
University of Molise, Department of Economics and Politecnico of Milan, Dipartimento di Economia e Produzione, Piazza Leonardo da Vinci 32, 20133 Milano, Italy

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CAPELLO R. (1999) Spatial transfer of knowledge in high technology milieux: learning versus collective learning processes, Reg. Studies 33, 353–365. An analysis of the definitions provided so far in the literature shows ambiguities in the conceptualization of collective learning. A parallel analysis of the concepts of learning and collective learning is provided, and similarities and differences underlined. One of the main distinguishing features of collective learning is embedded in the element of ‘club externality’, while ‘continuity’ and ‘dynamic synergies’ are common properties of learning and collective learning. These reflections lead to some interesting empirical questions which are investigated in the empirical part of the paper. In particular, the empirical analysis addresses the questions: (1) is it true that collective learning is not the result of co-operative behaviour, but of a collective behaviour; and (2) is it true that collective learning is the way of achieving new creative resources for SMEs in local areas, and not other kinds of learning? The empirical analysis is based on three Italian high technology milieux. Descriptive and interpretative statistical methodologies are used in this part of the paper.

Collective learning   High technology   Small and medium sized enterprises   Innovative milieux   Industrial districts


Apprentissage collectif   Technologie de pointe   PME   Technopôles   Districts industriels


Kollektives Lernen   Hochtechnologie   Kleine und mittlere Unternehmen   Innovative Milieus   Industriegebiete
DY N AM I C E L E M E N T S I N S P A T I A L I N N O V A T I O N P R O C E S S E S

The concept of collective learning is at the heart of the *milieu innovateur* theory. The presence of common knowledge which goes beyond the boundaries of the firm, but which remains within the spatial boundaries of the innovative milieu, gives rise to a process of cumulative local know-how. This spatial dynamic is the territorial counterpart of Dosi’s concept of the technological trajectory of a firm (Dosi, 1982). In the case of the firm, the long term permanence of the trajectory is determined by the specificities of technology which are upgraded by the evolutionary and self-reinforcing process of incremental innovation. At the spatial level, the specificity of the milieu evolves with its internal know-how and innovation potential through a process of collective learning. In the theory of the milieu, collective learning appears as intrinsic to the nature of this socio-economic entity, and characterizes its evolutionary patterns. However, within this theoretical framework ambiguities remain as to what is meant by collective learning. These are addressed in this paper.

A first element for further reflection lies in the concept of collective learning itself. 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’. Although at a first glance, this definition could be seen as providing a clarification of the concept, a closer look reveals little difference between collective learning defined in this way and more traditional concepts of learning. Evolutionary theorists define 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, 1982] exist which allow individuals to coordinate their actions in search for problem solutions’ (Dosi, 1982; Dosi et al., 1988; Nelson and Winter, 1982). The only apparent difference between these definitions lies in the ‘social’ categorization of collective learning. If this is the case, a clear meaning has to be given to ‘social’ and this is one of the objectives of this paper.

A second element which requires further consideration is the idea that collective learning is an essential feature of the milieu. This could be interpreted as a result of the conscious co-operative behaviour of local agents or as an externality, generated by the local environment, that agents feel free to exploit as they wish. The main difference in the two interpretations is that while the former implies a conscious behaviour on the part of local agents, the latter is the dynamic counterpart of Marshallian *industrial atmosphere*, a tacit economy which is external to the firm but internal to milieu requiring no conscious effort on the part of the agent. It follows from the second definition that, as it is impossible to visualize an *industrial district* without atmosphere, collective learning is intrinsic to an innovative milieu.

This paper addresses these two ambiguities within the concept of collective learning with the intention of:

- providing a more precise definition of the meaning given to collective learning with the intention of clarifying similarities with and differences from the concept of learning (second section)
- identifying a methodology to clarify the difference between the concepts of the milieu and of collective learning. This involves asking the question: can a milieu as a socio-economic entity exist without a mechanism of collective learning? (third section)

These theoretical questions have stimulated empirical analysis, the main goal of which is to investigate the role of collective learning as a vehicle for spatial transfer of knowledge. For this purpose, three Italian high technology milieux with high intensity of innovation activities have been chosen. In particular, our interest is to explore:

- the learning behaviour in the innovative activities of high technology firms. Here our interest is to explore the channels through which firms acquire knowledge, and whether these channels are similar for each type of innovation and for each type of firm in the milieu
- whether the importance of collective learning varies between process innovation, incremental product innovation and radical product innovation.


In the theory of the *milieu innovateur*, collective learning is the territorial counterpart of learning within firms – a vehicle for temporal and spatial knowledge transmission. However, collective learning remains a fluid concept. Definitions have been provided by many authors and applied to industrial economics, labour economics/industrial relations, and regional economics. But an unambiguous differentiation between collective learning and learning is still lacking.

In this section, reflections on similarities and differences between learning and collective learning are provided which may help in comparing the two. In the case of both learning and collective learning, the transmission of knowledge over time is secured by interaction among agents and by continuity through time. These guarantee the transfer of knowledge within groups of individuals, within firms and, in the case of
Spatial Transfer of Knowledge in High Technology Milieux

the milieu, across the space between firms and groups. In this respect, learning is collective because it is:

- **cumulative**, since it persists 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 new knowledge on the part of the inventor is transferred by other agents on the basis of synergy and by interactive processes, giving rise to a cumulative process of knowledge creation.

**Knowledge transfer over time: the role of continuity**

A first important vehicle for the transfer of knowledge is continuity over time, which allows the cumulation of knowledge in the form of know-how and experience. According to the traditional evolutionary school, innovation is characterized by discontinuity and breakdown of a static framework of productive processes in which technologies and information are given and perfectly known *ex ante*. Beyond the world of perfect information where uncertainty is pervasive, the probability is that entrepreneurs will base their decisions on their *existing* knowledge. This uncertainty-reducing behaviour explains the path dependent nature of the innovation and the outcome is continuity, sequentiality and cumulativity of technical, organizational and managerial knowledge. From this perspective, time is defined by the rhythm of innovation and by the pace of the learning processes which accumulate within the organization.

In large enterprises, R&D functions and engineering departments play the role of information collection, its assessment and transcoding and the selection of decision-making routines thanks to the continuity of enterprises through time (Table 1). In particular, R&D functions are the stable element where knowledge is accumulated, embedded in routines of the firm and transferred as tacit knowledge in the process of searching for new technological innovations. From this process specific technological trajectories evolve. The accumulation of know-how generates irreversible patterns and choices so that more advanced methods may never become profitable because the potential adopters are locked into competencies rooted in, and reinforced by, existing technologies (Arthur, 1988, 1990).

In small firm districts, the innovation-searching function provided by R&D within the large firm is nonexistent because of diseconomies of scale and the unpredictable and relatively short life of small firms. In such productive systems, information collection and accumulation of knowledge takes place in a *socialized way* outside each firm and finds its elements of continuity in the local labour market and in the network of local customers and supplier linkages between small and medium sized enterprises (SMEs) – see Table 1 (Camagni, 1995). The labour markets of local industrial districts are traditionally stable over time and in Italy, at least, it is unusual for workers to search for jobs outside the milieu for both social and economic reasons. A strong social sense of belonging to a specific territory guarantees a very low external labour force mobility. Moreover, the high degree of sectoral and other specializations typical of such milieux limits the market for local skills outside the area and by constituting barriers to exit helps guarantee the stability of local labour markets.

A second element of continuity can be found in the stable linkages between suppliers and customers. Such relationships generate a transfer of codified and tacit knowledge between suppliers and customers which accumulates over time and defines patterns of incremental innovation that feed a specific technological trajectory. This is internal to the large firm, but in the case of the milieu the technological patterns of incremental innovations have roots outside the single firm, being the result of strong social interactions within input-output linkages amongst groups of small firms. As Aydakot, 1986, suggested, the innovation process within territorial entities such as the milieu is a process of ‘rupture/filiation’ (break and continuity). Although innovation is a break with an existing situation, creativity and innovation potential have their seeds in the local knowledge and scientific know-how acquired over time.

**Knowledge transfer in space: the role of dynamic synergies**

However, while continuity is necessary, it may not be a *sufficient* condition for learning and collective learning. A second element is required in both firms and districts to assure the transfer of cumulated knowledge: that of dynamic synergies. In large enterprises, information collection and knowledge is transferred through functional interaction amongst R&D, production, marketing and organization departments. Since most of the accumulated knowledge is tacit and based on

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**Table 1. Elements for knowledge transfer**

<table>
<thead>
<tr>
<th>Elements for knowledge transfer</th>
<th>Continuity</th>
<th>Dynamic synergies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Context</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Farms</td>
<td>R &amp; D functions</td>
<td>Functional interaction</td>
</tr>
<tr>
<td>Territory</td>
<td>Low mobility of the labour force outside the milieu</td>
<td>Tacit transfer of knowledge</td>
</tr>
<tr>
<td></td>
<td>Stable linkages with suppliers and customers</td>
<td>Labour force turnover within the milieu</td>
</tr>
<tr>
<td></td>
<td>Innovative cooperation with suppliers and customers</td>
<td>Innovative cooperation with suppliers and customers</td>
</tr>
<tr>
<td></td>
<td>Local spin-off</td>
<td>Collective learning</td>
</tr>
</tbody>
</table>
intangible assets, the preconditions for strong and innovative interaction among functions are the creation of common rules and routines, imposed by hierarchy and control, typical of a large enterprise (Nelson and Winter, 1977).

In territorial systems of small firms, an element of dynamic synergy is vital to achieve (collective) learning to guarantee the transfer of accumulated knowledge and local know–how across 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 within the milieu, 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 within small firm districts results from the different mechanisms which characterize the milieu. First of all, the typically short and often turbulent life of small firms inevitably generates labour turnover amongst highly qualified workers. Moreover, because of the localized specificity of those skills, opportunities outside the milieu are limited for the local labour force so that mobility is largely between local firms.

Intense interactions between suppliers and customers are also elements 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 result from dynamic strategies in the search for uncertainty–reducing mechanisms (sociabilization of risks, transcoding of complex information and know–how) rather than as strategies oriented towards the achievement of static efficiency by reduction of transaction costs by means of long term trusting relationships. The dynamic strategies behind these interactive linkages are the reasons for their long term permanence and strategic importance. They help define the technological trajectory of the milieu by setting in motion a positive circular relationship between the identifications of needs and the generation of new stimuli and ideas for the satisfaction of those needs which feed both process and product innovation.

The movement of labour within the milieu is also facilitated by local spin-off activity defined as: (1) the start-up of a new business by an agent previously belonging to another local firm; and (2) the derivation of the business idea leading to the formation of a new firm from the previous employment of the founder (Perhankangas and Kauranen, 1996). Local milieux provide both the social and economic preconditions for spin-offs and improve the possibility of their success. From the social perspective, high trust and the common sense of belonging to the same cultural society make spinning-off an acceptable event. Economically, knowledge of potential local supplier and customer markets acquired in the previous job, a receptive local demand for particular products developed in the previous job and the presence of external economies, assure locational advantages, help profitability and thus improve the chances for survival.

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 co-operate – managerially and organizationally as well as technically – because of their organizational, institutional and cultural proximity. As the French school underlines, organizational proximity overcomes the economic separation among actors, by generating common interpretations of the reality used in formulating personal strategies and economic choices (Bell et al., 1993; Rallet, 1993). Trust among actors is another element on which dynamic synergy rests, since it helps in decreasing the risk and uncertainty accompanying inter-firm relationships (Dupuy and Gilly, 1995). Because of their common role in reducing uncertainty, power and trust are often regarded as the two main elements beyond dynamic synergies: the former in the large enterprise context, the latter in SME territorial contexts.

Collective learning as a club good
As we have seen, the crucial difference between learning and collective learning lies in the social nature of the latter process. Beyond the elements of cumulativity and of interaction, which typifies learning, collective learning has a public dimension. The mechanisms for the spatial transfer of knowledge are social because new knowledge is transferred to other agents, whatever the will of the original inventor, thanks to common technological, organizational and institutional routines and behaviours which facilitate the sharing of information and know–how. In other words, the outcome of the innovative process rapidly becomes a public good. In this way, the creative knowledge accumulates outside the firm, and becomes a club good: no rivalry exists for its use by agents belonging to the club, and external agents are barred from access. In this sense, collective learning is a typical ‘club good’ à la Buchanan, 1965, providing external economies to club members. Collective learning can therefore be defined as a dynamic process of the cumulative creation of knowledge freely transferred among economic agents whatever its origin by interactive mechanisms based on shared rules, norms, organizations and procedures.

In the case of the large enterprise, the profit of the innovation achieved via cumulative knowledge remains within the boundaries of the firm, and is explained in Schumpeterian terms as appropriated rents which reward entrepreneurial activities. Moreover, the role of profit as private remuneration serves as an incentive for further investments in knowledge, through new R&D expenditures, leading to cumulative know–how and to continuous innovative activities.

In the case of local systems of small firms, the profit
of the innovation achieved via cumulative knowledge is by definition public, since knowledge is assembled and accumulated in a socialized way through inter-SME linkages and labour force mobility. Locally accumulated knowledge is transferable through the local labour market, through SME linkages and through local spin-offs, facilitated by organizational, institutional and social proximity. The socialization of knowledge and the process for its accumulation provide the opportunity for the exploitation of this external economy, without rivalry, only by local firms. In this sense, imitation, reverse engineering, technological upgrading of product and process innovation as well as radical product innovation mainly occurs independently of the will of the original innovator (Camagni, 1995).

This dynamic externality occurs in the local environment at the same level as those more traditional elements of static efficiency, such as Marshallian industrial atmosphere and other external economies associated with a clustering of small firms. In this respect, once the appropriate conditions are met, learning and resulting innovations are independent of conscious co-operation between single actors and are not attributable to the explicit strategy of individual local firms. It is in these senses that learning is collective.

COLLECTIVE LEARNING AND THE MILIEU CONCEPT: SIMILARITIES AND DIFFERENCES

We therefore interpret collective learning as a club good, rather than the result of conscious co-operative behaviour of local agents. However, this interpretation overlaps with the definition of milieu and raises the interesting research question of whether a local area is a milieu only when collective learning processes are present.

Fig. 1 presents our framework of analysis for attempting to answer this question. In Fig. 1 different spatial systems are identified (simple geographical proximity, industrial districts and milieux) and for each the pre-conditions are indentified. Simple geographical proximity turns into a specialized area where stable inter-SME linkages and a local labour market guarantee the continuity over time of local technological and scientific know-how in the specific sectors on which the locality’s comparative advantage rests. Without these customer–supplier relationships, the locality lacks sectoral specialization and develops a diversified labour market.

If an element of institutional and social proximity is added to the specialization of a local labour market, the framework for an industrial district develops. Organizational and social proximity give a different meaning to the customer–supplier relationships and to the local labour market. The quality of the relationships improves with trust and social interactions and these set in motion informal and tacit transfers of information and know-how and other non-traded assets among local firms. From this evolves the characteristics of an industrial district on which is based static efficiency: industrial atmosphere and reduction of transaction costs. If these preconditions are absent, the specialized area become atomistically competitive.

The dynamic interpretation of the customer–supplier relationships, of the element of co-operation and continuity, leads towards a milieu, as the GREMI group has underlined since the 1980s. When co-operation and the tacit transfer of knowledge is transformed into innovative synergy and capacity, rather than simply social solidarity and interaction, a local district becomes a milieu. The milieu is characterized by collective learning, by a local labour market which local firms feed with their knowledge independently of their will, and from which they can obtain local dynamic advantages. This local cumulative and ‘socialized’ knowledge may be grasped by local actors whenever they want, and represents the source for local dynamic comparative advantage. If these dynamic synergies are not present, the district remains a local district with competitive advantage based on 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 which turns collective learning into profits. These profits are only in part remuneration for the uncertainty of the innovation process and the risk taken by the individual entrepreneur; most of them originate from the externalities grasped by the innovator. 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 exploit collective learning
- the private strategies of each local agent, willing to grasp the club good on offer for its own economic purposes.

The capacity of local firms to exploit collective learning may be interpreted in a Schumpeterian way as entrepreneurial expertise to turn knowledge, even if socialized, into a business idea. In this sense, cafeteria effects for informal exchanges of ideas among producers and customers may lead to the identification of specific needs and may be important mechanisms for building local entrepreneurial capacity.

The decision of each local actor to grasp collective learning depends upon two specific elements: (1) the type of innovation for development; and (2) the firm size. Collective learning embeds historical knowledge accumulated in the local labour market over time, which is the pre-requisite for a jump to a new technological trajectory. Radical product innovations are mainly
based on new technological knowledge and on new scientific resources which stem from an historical process of cumulative know-how. Once an agent is willing to innovate radically, it is more inclined to grasp the opportunity to exploit the local labour market, where these creative resources have been cumulated. It is also in this respect that, once local actors exploit collective learning, they participate, independently of their will, in the process of the creation of new resources, which become embedded in the local market. By contrast, incremental innovation innovations are more likely to rest on knowledge accumulated within each firm so that the innovator will be less oriented towards the exploitation of externally generated knowledge.

By a similar 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, and is less willing to participate in, or grasp the advantage of, the socialization of knowledge creation. For the opposite reasons, a small firm is more inclined to be involved in contributing to, and exploiting, collective learning once the process becomes established in the area.

Once a milieu innovateur is achieved, positive feedback from the innovative process reinforces the elements of continuity (stable labour market, stable inter-SME linkages) and of dynamic synergies (interactive mechanisms leading to innovation) (Fig. 1). However, the existence of these positive feedbacks does not guarantee the long term innovative capacity of the milieu. The continuity of cumulative knowledge may in the long run increase risk since it may drive the milieu towards an increasingly narrow specificity, and could lock the local agents into obsolete, non-competitive yet stable technological trajectories (CORIAT and Dosi, 1995;
Camagni, 1995). By these means, collective learning which is at the heart of dynamic comparative advantages of the milieu because it is a ‘barrier to entry’ to 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 accumulated, and which may contribute to the creation of collective learning, is co-operation with firms outside the milieu, which provides external energy to the local technological trajectory. External learning is therefore another important channel for an innovative milieu (Camagni, 1991).

These reflections lead to empirical questions which we investigate in the empirical part of the paper. In particular:

- do firms make selective use of collective learning? If so, we would expect different learning behaviours of local agents, depending on the kind of innovative activities and of firms’ size.
- is collective learning 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 section, we address these questions by an empirical analysis based on three Italian high-technology milieux.

Learning Behaviour in Innovative Activities: An Empirical Analysis

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 was developed and run in three high-technology milieux areas in Italy, namely Pisa, Piacenza and the north-eastern part of Milan, where high-technology firms are geographically clustered. The questionnaire covered five main themes:

- 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, labour 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, with special emphasis on 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.

In a period of a month, 863 high technology firms were interviewed and a database was constructed of binary (yes, no) or discrete (a qualitative judgement) variables. The methodology we use to describe learning behaviour for innovative activities is cluster analysis. However, prior to this behavioural analysis, we used factor analysis to explore whether it was possible to identify phenomena to which groups of variables from amongst the considerable number in the data set might be related. The basic assumption of factor analysis is that underlying dimensions, or factors, can be used to explain complex phenomena. The goal of factor analysis is thus to identify the not-directly-observable factors based on a set of observable variables, reducing their number without losing too much of their explanatory power. From our questionnaire, many variables could be used to describe:

(1) Firms’ characteristics, in terms of:
- growth, size, and innovative activity
- relationships with suppliers, in terms of the role played by suppliers in the innovative activity of the firm, and whether organizational and institutional proximity matters
- relationships with customers, as in the case of suppliers

(2) Local area characteristics, in terms of:
- district locational advantages, like industrial atmosphere, stable labour market, cultural proximity with the labour force
- the 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 enabled us to identify for each group of characteristics a smaller number of ‘derived’ factors to represent the groups of related explanatory variables from the questionnaire. 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 (Tables 2–6).

In the case of firms’ characteristics (Table 2)10 three main principal factors are significant and meaningful, explain 67% of total sample variance and can be readily interpreted from an economic point of view. A first factor, labelled DININ, represents highly innovative firms with increasing turnover. A second factor, labelled SMIN, can be interpreted as a size and product innovation factor: firms of small size with breakthrough innovation. A third factor in this area, labelled PRO-
Table 2. Factor analysis for the structural characteristics of firms

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

Note: Values in the table represent the factor loading of each variable on each of the factors.

CIN, represents firms characterized by high levels of process innovation.

In the area of suppliers’ relationships, the results lead to three main factors (Table 3) 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 organizational proximity (ISTORGPROS), while the third represents the importance of local suppliers in the innovative process of firms (PRELOCS). These factors load on 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 organizational proximities with suppliers.

In the area of customers’ relationships, similar results are achieved (Table 4). Four main factors emerge, explaining 79% of the total sample. In order of importance, these are: institutional and organizational proximity with customers (ISTORGPROC); the technological proximity of customers (TECH-PROC); the presence of local customers which stimulates innovative activities (PRELOCC); and the role of standard contracts with customers in innovative activities (STANDCONC). 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 5). Four main factors are identified, explaining 67% of the total sample variance: cultural proximity with the labour force (labelled CULTPRO); proximity to the original firm (ORFIRPRO); stable local labour market (STABMKT); and industrial atmosphere (INDATM). Also in these results, the economic interpretation is simple: the industrial district’s locational efficiency (reduction of transaction 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) 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 embedded 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, the results are quite satisfactory at both the statistical and economic level; four factors are achieved (Table 6). A first factor represents learning external to the district (LEXDIS): scientists and technicians coming from other firms in the area and informal mechanisms of hiring. The second factor

Table 3. Factor analysis on suppliers relationships

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

Note: Values in the table represent the factor loading of each variable on each of the factors.
### Table 4. Factor analysis on customers relationships

<table>
<thead>
<tr>
<th>Variables</th>
<th>ISTORGPROC</th>
<th>TECHPROC</th>
<th>PRELOCC</th>
<th>STANDCONC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard supply contract</td>
<td>0·27</td>
<td>−0·63</td>
<td>−0·07</td>
<td>0·56</td>
</tr>
<tr>
<td>Contract based on technical standard</td>
<td>−0·1</td>
<td>0·11</td>
<td>0·007</td>
<td>0·87</td>
</tr>
<tr>
<td>More than 75% of suppliers are local</td>
<td>0·13</td>
<td>0·05</td>
<td>0·84</td>
<td>−0·30</td>
</tr>
<tr>
<td>Very important role played by suppliers in technical innovative processes</td>
<td>0·18</td>
<td>0·11</td>
<td>0·83</td>
<td>0·28</td>
</tr>
<tr>
<td>Common approach with suppliers to institutional aspects</td>
<td>0·89</td>
<td>0·23</td>
<td>0·24</td>
<td>−0·05</td>
</tr>
<tr>
<td>Common approach with suppliers to technical aspects</td>
<td>0·37</td>
<td>0·79</td>
<td>0·09</td>
<td>0·023</td>
</tr>
<tr>
<td>Common approach with suppliers to organizational aspects</td>
<td>0·92</td>
<td>0·28</td>
<td>0·14</td>
<td>−0·007</td>
</tr>
<tr>
<td>Complementary knowledge</td>
<td>0·41</td>
<td>0·75</td>
<td>0·04</td>
<td>0·14</td>
</tr>
<tr>
<td>High trustworthiness in co-operation</td>
<td>0·30</td>
<td>0·5</td>
<td>0·37</td>
<td>0·32</td>
</tr>
</tbody>
</table>

Explained variance by each factor (in %)  
Share of total explained variance: 79%

**Note:** Values in the table represent the factor loading of each variable on each of the factors.

### Table 5. Factor analysis for the location advantages

<table>
<thead>
<tr>
<th>Variables</th>
<th>CULTPRO</th>
<th>ORFIRPRO</th>
<th>STABMKT</th>
<th>INDATM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proximity to motorways and airports</td>
<td>−0·02</td>
<td>−0·63</td>
<td>0·27</td>
<td>0·06</td>
</tr>
<tr>
<td>Cultural and industrial atmosphere</td>
<td>0·29</td>
<td>0·26</td>
<td>−0·06</td>
<td>0·84</td>
</tr>
<tr>
<td>Lower production costs</td>
<td>−0·12</td>
<td>0·35</td>
<td>−0·64</td>
<td>−0·02</td>
</tr>
<tr>
<td>Common culture</td>
<td>0·81</td>
<td>−0·02</td>
<td>0·15</td>
<td>−0·10</td>
</tr>
<tr>
<td>Common technical background</td>
<td>0·81</td>
<td>0·03</td>
<td>−0·27</td>
<td>0·21</td>
</tr>
<tr>
<td>Stable local labour force</td>
<td>−0·11</td>
<td>0·08</td>
<td>0·80</td>
<td>−0·07</td>
</tr>
<tr>
<td>Very important role played by the local market in providing high quality labour force</td>
<td>0·49</td>
<td>0·18</td>
<td>0·44</td>
<td>0·17</td>
</tr>
<tr>
<td>Proximity to the original firm</td>
<td>0·34</td>
<td>0·50</td>
<td>−0·06</td>
<td>−0·64</td>
</tr>
<tr>
<td>Proximity to the residential place</td>
<td>0·03</td>
<td>0·81</td>
<td>0·20</td>
<td>0·19</td>
</tr>
</tbody>
</table>

Explained variance by each factor (in %)  
Share of total explained variance: 67%

**Note:** Values in the table represent the factor loading of each variable on each of the factors.

### Table 6. Channels of knowledge acquisition

<table>
<thead>
<tr>
<th>Variables</th>
<th>LEXDIS</th>
<th>INLEAR</th>
<th>TURN</th>
<th>SPIN</th>
</tr>
</thead>
<tbody>
<tr>
<td>The firm is the result of a spin-off</td>
<td>−0·12</td>
<td>−0·06</td>
<td>−0·15</td>
<td>0·74</td>
</tr>
<tr>
<td>Firm’s technicians and scientists were previously employed in firms outside the milieu</td>
<td>0·54</td>
<td>−0·41</td>
<td>−0·26</td>
<td>−0·25</td>
</tr>
<tr>
<td>Firm’s technicians and scientists were previously employed in local firms</td>
<td>−0·73</td>
<td>−0·29</td>
<td>−0·09</td>
<td>0·31</td>
</tr>
<tr>
<td>Firm’s technicians and scientists were previously employed in local research centres</td>
<td>0·47</td>
<td>0·39</td>
<td>0·05</td>
<td>0·46</td>
</tr>
<tr>
<td>Firm’s technicians and scientists were previously employed in external research centres</td>
<td>0·02</td>
<td>0·09</td>
<td>−0·12</td>
<td>−0·62</td>
</tr>
<tr>
<td>Firm’s technicians and scientists had their training within the firm</td>
<td>0·21</td>
<td>0·75</td>
<td>−0·10</td>
<td>−0·23</td>
</tr>
<tr>
<td>Firm’s technicians and scientists had their training outside the firm</td>
<td>−0·13</td>
<td>−0·85</td>
<td>−0·17</td>
<td>0·005</td>
</tr>
<tr>
<td>More than 50% of firm’s labour force has been recruited by the firm in last 5 years</td>
<td>0·19</td>
<td>0·28</td>
<td>0·81</td>
<td>0·18</td>
</tr>
<tr>
<td>More than 50% of firm’s labour force has left the firm in the last 5 years</td>
<td>−0·11</td>
<td>−0·11</td>
<td>0·89</td>
<td>−0·15</td>
</tr>
<tr>
<td>Importance of recruiting technicians through informal channels</td>
<td>0·51</td>
<td>0·08</td>
<td>0·02</td>
<td>0·11</td>
</tr>
<tr>
<td>Importance of recruiting scientists through informal channels</td>
<td>0·75</td>
<td>0·11</td>
<td>0·01</td>
<td>−0·07</td>
</tr>
</tbody>
</table>

Explained variance by each factor (%)  
Share of total explained variance: 62%

**Note:** Values in the table represent the factor loading of each variable on each of the factors.
represents learning internal to the firm (INLEAR) being composed of an emerging variable representing the number of technicians and scientists that have trained in local firms. 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 (SPIN) represents the new firm spin-off mechanism.

In the second stage of the analysis, cluster analysis was deployed and, for this purpose, the factors identified were used rather than the original variables. In statistical terms, cluster analysis groups firms according to their degree of vicinity to the main underlying factors which characterize the economic structure and the local relationships of the sample (RABELLOTTI, 1997). Cluster analysis is therefore the methodology used to identify different learning behaviours with respect to different innovative activities and goals of firms.

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

Learning behaviours in innovative activities: empirical results

The research hypothesis we are seeking to explore is that collective learning may be interpreted as a local external economy, similar to other local externalities, which is likely to be be exploited by smaller sized and more innovative firms. 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 above, we expect collective learning behaviours to be pursued by, and important to, smaller firms and firms which have more breakthrough innovation; in both cases, collective learning is a substitute for learning within the firm which is more typical of large enterprises.

The results of our cluster analysis are presented in Table 7. Three main clusters explain the learning behaviours of the firms in our sample:

- a first cluster depicts a milieu with a networking behaviour: the learning in this group of firms is based primarily on know-how external to the local area. This cluster is characterized 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 advantages of these firms. These firms add to traditional static locational advantages acquisition of know-how and learning from outside the district. It is probable that the innovative activities of these firms are rooted in external linkages.
- a second cluster shows a sub-system of autonomous firms within the milieu: learning is in fact based on firms’ internal competencies. Firms belonging to this cluster are specialized in process innovation. For these firms, as expected, the main channels of learning are: (1) learning within the firm; and (2) technological proximity with customers and suppliers.
- a third cluster depicts a pure milieu behaviour where the learning stems from socialized mechanisms of spatial transfer of knowledge, i.e. from collective learning. The smallest

Table 7. Results from the cluster analysis on learning behaviour

<table>
<thead>
<tr>
<th>Factors</th>
<th>Cluster 1</th>
<th>Cluster 2</th>
<th>Cluster 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dynamic and innovative firms</td>
<td>0.127</td>
<td>-1.32</td>
<td>-0.24</td>
</tr>
<tr>
<td>Industrial atmosphere</td>
<td>0.047</td>
<td>-0.33</td>
<td>-0.48</td>
</tr>
<tr>
<td>Cultural proximity</td>
<td>0.010</td>
<td>-0.039</td>
<td>-0.20</td>
</tr>
<tr>
<td>Learning external to the milieu</td>
<td>0.02</td>
<td>0.23</td>
<td>0.18</td>
</tr>
<tr>
<td>Process innovative firms</td>
<td>-0.01</td>
<td>0.92</td>
<td>-0.46</td>
</tr>
<tr>
<td>Proximity to the mother firm</td>
<td>0.009</td>
<td>0.55</td>
<td>-0.18</td>
</tr>
<tr>
<td>Learning internal to the firm</td>
<td>-0.05</td>
<td>0.51</td>
<td>0.28</td>
</tr>
<tr>
<td>Presence of local innovative customers</td>
<td>0.039</td>
<td>0.17</td>
<td>1.53</td>
</tr>
<tr>
<td>Technological proximity with customers</td>
<td>0.009</td>
<td>0.15</td>
<td>-0.64</td>
</tr>
<tr>
<td>Technological proximity with suppliers</td>
<td>-0.0009</td>
<td>-0.35</td>
<td>0.89</td>
</tr>
<tr>
<td>Smallest and most innovative firms</td>
<td>-0.014</td>
<td>0.30</td>
<td>0.33</td>
</tr>
<tr>
<td>Market stability</td>
<td>-0.021</td>
<td>-0.18</td>
<td>0.41</td>
</tr>
<tr>
<td>High labour force turnover</td>
<td>-0.0027</td>
<td>-0.039</td>
<td>0.02</td>
</tr>
<tr>
<td>Spin-off</td>
<td>0.02</td>
<td>-0.52</td>
<td>0.63</td>
</tr>
<tr>
<td>Standard contracts with customers</td>
<td>-0.005</td>
<td>0.29</td>
<td>0.68</td>
</tr>
<tr>
<td>Institutional and organizational proximity with customers</td>
<td>-0.059</td>
<td>0.42</td>
<td>0.61</td>
</tr>
<tr>
<td>Presence of local innovative suppliers</td>
<td>-0.03</td>
<td>0.18</td>
<td>0.47</td>
</tr>
<tr>
<td>Institutional and organizational proximity with suppliers</td>
<td>-0.03</td>
<td>0.18</td>
<td>0.47</td>
</tr>
</tbody>
</table>

Notes: 1. Values in the table represent the average value of each variable for each group of firms.
2. Italics indicates main variables characterizing each cluster.
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 embedded in organizational and industrial proximity; and informal contracts with customers.

These results support our theoretical expectations. The learning mechanisms even within a milieu seem to be correlated with two main elements: (1) the kind of innovative activity a firm has to face; and (2) the size of the firm. Collective learning is, as expected, linked more with small firms and with radical product innovations. Process innovation, on the contrary, seems to require mostly internal knowledge, accumulated by the firm, but with some technological proximity to suppliers and customers.

Other important aspects of our conceptual framework are underlined in these empirical results. Collective learning plays a crucial role when both the continuity element and the dynamic synergy element are present; low mobility of the labour force outside the milieu is associated with a high turnover of the labour force within the milieu. The dynamic synergies among suppliers and customers, empirically measured as the importance of local suppliers and customers in the innovative process of the firm, are associated with the institutional and organizational proximities, what we identified as pre-conditions for the constitution of a milieu (see Fig. 1).

Another consideration stems from the empirical analysis. Learning from outside the local area seems to be useful in two cases: first of all, as a channel through which a local district may obtain innovative impetuses and resources, when its competitive advantage is based on static elements; and secondly, it is important in the innovative milieu itself, since it may avoid collective learning mechanisms which lock the milieu into trajectories that in the long run may turn out to be inferior.

An interesting and meaningful result is the distribution of the sample of firms among the three statistical clusters obtained: more than 87% of our sample firms belong to the first cluster; 8% to the second; and the remaining 5% to the third. In these Italian local systems, the prevailing spatial elements are those of the local industrial district system, rather than of innovative milieux. Although this may seem a surprising result, it is in line with what has already been suggested by previous analyses on Italian high technology milieux (CAMAGNI, 1996): spatial preconditions for the development of local high technology milieux in Italy exist only in a limited way. The behavioural analysis run in this study confirms that high technology local systems seem to be more oriented towards the exploitation of static efficiency elements, typical of a traditional local industrial district, rather than towards the exploitation of dynamic elements, like collective learning.

Collective learning as a determinant of innovative activities in high technology 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 milieu. 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 8):

- radical innovation activity by the smallest firms depends significantly on both the turnover of the labour force within the firm, and spin-off mechanisms; both describe mechanisms of tacit transfer of knowledge, accumulated by the firm, but with some technological proximity to suppliers and customers.
- 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 represents one of the traditional locational advantages of local districts.

Table 8. Results from regression analyses

<table>
<thead>
<tr>
<th>Independent variables</th>
<th>DININ</th>
<th>SMIN</th>
<th>PROGIN</th>
</tr>
</thead>
<tbody>
<tr>
<td>Turnover</td>
<td>0.666</td>
<td></td>
<td>−0.19</td>
</tr>
<tr>
<td>(2.33)</td>
<td></td>
<td>(2.025)</td>
<td></td>
</tr>
<tr>
<td>Cultural proximity</td>
<td>0.465</td>
<td></td>
<td>−0.21</td>
</tr>
<tr>
<td>(2.339)</td>
<td></td>
<td>(2.025)</td>
<td></td>
</tr>
<tr>
<td>Spin-off</td>
<td>0.655</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(3.219)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

CONCLUDING REMARKS

Collective learning is a central concept underlying modern theories of the dynamics of spatial production systems. However, ambiguities exist in the definition of collective learning and in its interpretation within spatial theories.

Concerning the first aspect, the distinction between learning and collective learning requires more consideration. 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...
Acknowledgements — The empirical analysis is the result of the participation of the author in the Italian group and in a project on Networks, Collective Learning and R&D in Regionally Clustered High Technology SMEs, chaired by David Keeble of the University of Cambridge. The author would like to acknowledge Alessio Campoccia for his help in data collection.

NOTES
3. The word ‘social’ has to be interpreted with the meaning of a situation of shared resources, shared costs or shared revenue, in which the public nature of collective property is the result of both a conscious as well as an unconscious behaviour of agents. In the case of collective learning, the public nature of learning and of knowledge is the result of an unconscious behaviour of local firms, as extensively explained in the paper.
4. See note 2 for bibliographical references on the milieu innovateur or innovative milieu theory.
7. See note 1 for key references.
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, 1999.
10. For the complete statistical results see Table 2 which also contains each factor explanation of sample variance.
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).

REFERENCES
Spatial Transfer of Knowledge in High Technology Milieux


Lazaric N. and Lorenz E. (1996) Trust and organizational learning during inter-firm co-operation, Université de Compiegne (available from the authors).


