A theoretical model of knowledge transfer and combination within industrial districts

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Abstract

This paper develops a model of how industrial districts (IDs) operate as self-contained, relatively impermeable cognitive systems, within which knowledge transfer and combination take place. The model, built on a qualitative meta-analysis of the empirical studies conducted in the last 15 years on Italian IDs, provides a knowledge based interpretation of IDs and a rationale to conceive IDs as local innovation systems.
The paper analyses the *mechanisms* that spread knowledge across district firms, the *enablers* of cross-firm knowledge transfer through the above described mechanisms and the *process of producing new knowledge*. The paper also interprets some typical IDs' dynamics and focuses on spin-offs as a particular form of knowledge transfer and production within districts. Moreover, it suggests that knowledge production may take place not only within districts' boundaries (combination), but also involve external sources (hybridation or contamination). Finally, it tackles the issue of how globalization impact on IDs, concentrating on the role of local public agencies as service providers to district firms.

Keywords: industrial districts, knowledge transfer, knowledge combination, spin-offs, knowledge-intensive business services.

Introduction

Industrial districts (IDs) consist of a group of interdependent, specialized firms, co-located in a given geographical area. The output, configuration of activities, and scope of functions these groups of firms perform are often so complex that they can be conceived as functional equivalents of large, vertically integrated, diversified enterprises.

This particular form of production organisation, which has developed and become particularly widespread in Italy, owes its success to the fact that, over time, IDs have managed to operate as local innovation systems, i.e. as places where, besides production, new ideas, products and processes are developed. Thus, as some recent studies suggest (Corno, Reinmoeller and Nonaka 1999; Belussi and Gottardi 2000; Rullani 2003), the conceptual categories of the economics of knowledge can help understanding the nature of industrial districts, the foundation of their competitive advantage and their evolution.

This paper works out the application of knowledge based theory (Scarbrough 2001) to IDs and proposes a model of how IDs operate as self-contained, relatively impermeable cognitive systems, within which every district firm represents a cognitive subsystem. This perspective maintains that IDs are a sort of meta-context, characterized by: a) high density of firms (and local institutions), themselves contexts in which knowledge is produced and transformed; and b) high density of inter-firm relations which allows knowledge transfer and combination.

This model sheds new light on the destinies of IDs in the global era. IDs can survive, reproduce their distinctive quality and continue to operate as local innovation systems, if they keep up their knowledge production function, i.e. if they manage to open up cognitively to the global environment, reduce their impermeability, and establish relationships with other, non local actors who possess knowledge potentially useful for competitive purposes.

Research methods and paper structure

This is a theoretical paper. It builds on a review of the literature that analyzes the evolution of industrial districts in face of globalization and draws upon a qualitative meta-analysis of the empirical studies conducted, during the last 15 years, on Italian IDs (table 1).

Table 1 approximately here

Evidence from these studies and from ongoing research by the authors is used to test the model, describing and interpreting the knowledge transfer and combination in IDs.

In the paper we develop a model of how IDs operate as self-contained, relatively impermeable cognitive systems, within which knowledge transfer and production take place. We believe this model provides a basis and a rationale to conceive IDs as local innovation systems.

Sections 3, 4, 5 and 6 present the basic research constructs of the model: a) the *mechanisms* that spread knowledge across district firms - within the ID; b) the *enabler* of cross-firm knowledge transfer; c) the *process of producing new knowledge.*

Section 7 focuses on spin-offs as a particular form of knowledge transfer and production within IDs. The knowledge production process may be contained within the boundaries of the district (combination) or it may involve external sources (hybridation or contamination). In the former case, district firms produce new knowledge combining knowledge resident in different district firms; in the latter case, district firms hybridate their specific knowledge with knowledge coming from other contexts. Section 8 explores this second mode of knowledge creation, examining the connections between IDs and the external environment.

Section 9 tackles the problem of the reproducibility of the district model in the light of the challenges brought by global competition and focuses on the role that public agencies can play, acting as a cognitive interface between IDs and the broader competitive environment. The case of CATAS (wood furniture district in North East Italy) is presented to exemplify excellence in this field.

Section 10 concludes the analysis and draws some implications.

The mechanisms of knowledge transfer among district firms

Our qualitative meta-analysis of the studies on Italian IDs (Table 1) shows that among the mechanisms that allow the inter-firm transfer of knowledge, the following are particularly important and frequent:

a. observation, aimed at imitation, of artefacts and actions;
b. interpersonal and inter-organisational relations;
c. mobility of human resources between district firms.

The observation of artefacts and actions, aimed at imitation refers in particular to innovations and to the corresponding imitations of the product. On this point it must be stressed that a determined new product is an artefact that embodies both tacit and explicit knowledge. The same remark may be made about the behaviour of an innovating firm when introducing the innovation on the market, such as communication activities and the distribution policy. The finished product and the marketing actions embody the explicit knowledge used or generated in the development process of the new product in a rather diluted form, which may be more tacit or semi-explicit. At the same time, a certain visibility is given to elements of tacit knowledge, which rise to a less tacit or semi-explicit level. Imitative observation must therefore succeed in absorbing the largest possible amount of knowledge embodied in the artefact, through a process of reverse engineering, and in the accompanying actions.

Interpersonal and inter-organisational relations are another fundamental way to transfer knowledge within IDs. The most immediate reference is to buyer-supplier relationships between firms which are connected in the productive *filière* or in a wider cluster (vertical relationships), or which give rise to horizontal agreements. It must be added that, in the logic of the network, a potential channel for knowledge transfer is also created between two firms that are not directly connected by a relationship if they keep up an exchange relationship with a third subject. In fact, each node of the district network may work as a cognitive relay. This is the case, for example, of two rival firms on the final market who share a subcontractor specialised in a production phase, a laboratory that carries out quality tests on the product, or a commercial intermediary. Lastly, the social relationships between people who work in different firms must not be overlooked, especially when these firms are not connected by organised relationships. In this way, further indirect relationships are created between the firm contexts in the district.

Inter firm mobility of human resources is another mechanism of knowledge transfer. This is widespread not only as a human resource management practice, but also as a social phenomenon. From this perspective, people play the role of knowledge carrier in much the same way as artefacts. More specifically, the tacit knowledge acquired by a specialised operator during long experience accumulated in a firm accompanies him when he decides to change his job and may be potentially activated in the firm context that he moves to. The activation of tacit knowledge in the new context may involve exclusively the person who possesses it. Alternatively, the same knowledge is transferred to other people working in the company, through verbal communication (relations within the firm) and imitative observation. In fact, the expert worker who is observed by an apprentice while he is doing his work communicates in silence, through his actions, or he may accompany his movements with words, to favour the observer's learning process. In the case of pure observation, the observer comes into contact with the tacit knowledge of the person observed, which emerges in the actions in a semi-explicit state, in a similar way to that seen for artefacts.

The knowledge transferred through people may be tacit or codified and concern every activity in the firm's value chain (Robertson, Swan and Scarbrough 2003). It is often simple knowledge, such as a technical contrivance that allows an improvement in the performance of a machine tool. However, sometimes even bundles of quite complex knowledge are transferred, such as the codified framework of an information system with tacit tricks that enable it to work.

The causes of within-district knowledge diffusion

In this section we move from description to interpretation, and try to show the reason why the knowledge produced in each district firm may be transferred fairly easily to other firms in the same district. The aim is to explore the complexity arising from the simple fact of physical proximity.

For this purpose, it is useful to point out that three different sub-processes are involved in knowledge transfer:

a. transmission, intentional or not, of knowledge to the potential receiver;
b. receiving of knowledge by the receiver;
c. absorption of knowledge, i.e. its understanding and "metabolization" which makes it available for use.

The probability that the knowledge produced by a district firm is absorbed by others depends firstly on the degree of complexity of the knowledge, which may be defined according to the number of interdependent units of knowledge of which it is formed.

On this point we must say something about the relationship between the complexity of knowledge and its possible tacit nature. Various scholars support the hypothesis that, the greater the level of tacitness of an innovative process – that is the incidence of the tacit knowledge used or produced in the process – the more difficult it will be to imitate (Teece 1986; Reed and DeFilippi 1990; Krogh and Roos 1996). In actual fact, it is not the level of tacitness itself, but the level of complexity of the tacit knowledge which inhibits, though not necessarily prevents, imitation and more generally the transfer of knowledge.

Tacit knowledge may in fact be made explicit in different ways and in different degrees, and thus be transferred from one firm to another with the observation of the artefacts that embody that knowledge or through communication which accompanies the relationships that directly or indirectly connect the firm contexts. It has also been seen that, when tacit knowledge is embodied in persons, its transfer from one firm context to another may even come about without it being made explicit; the explicit form is involved only later, in the possible transfer between individuals within the context, through observation (of actions) and communication.

So, with Spender (1996), we define tacit knowledge as not yet explicit, admitting that the condition of tacitness does not identify a universe of knowledge destined to remain in its original state. Tacit knowledge is not therefore irremediably sticky. Instead this may be the case of very complex tacit knowledge, which is impossible or too expensive to bring to an explicit and articulated state, at least at the present time.

Returning to the theme of absorption, if the complexity of external knowledge inhibits its absorption by a district firm, this effect cannot be separated from the cognitive characteristics of the context. Precisely, with the same degree of complexity, the probability of knowledge produced in a context S (source) and transmitted outside in some form being absorbed by a context R (receiver) is all the higher, the greater the absorptive capacity of R. This capacity therefore tends to dissolve the inhibiting effect of complexity on absorption. In other words, the probability that knowledge transfers successfully is contingent on the degree of relative complexity of the knowledge, i.e. on the degree of complexity of the knowledge to be absorbed with regard to the absorptive capacity of the context that is to absorb it.

The absorptive capacity is the expression of the cognitive structure of the receiving context, i.e. of the heritage of knowledge that it has accumulated over time. Cohen and Levinthal (1990, p. 128) argue that the absorptive capacity "is largely a function of the existing endowment of prior, similar or related knowledge. At the most elemental level, this prior related knowledge includes basic skills or even a shared language but may also include knowledge of the most recent scientific or technological developments in a given field". The same authors say that the absorptive capacity is generated in a variety of ways, from investments in R&D to learning by doing developed through productive experience, as typically occurs in traditional IDs.

The concept of prior related knowledge therefore introduces a logical connection between S and R. From this point of view it may be usefully reformulated as cognitive proximity between the two contexts (Nooteboom 2000). When a firm context presents a cognitive structure very close to that of the context that generated the new knowledge, the absorptive capacity of the former is high and the transfer process under way (transmission and reception) can easily reach the final step.

In the presence of cognitive proximity, observation may become an effective mechanism for knowledge transfer. In particular, for observation with the aim of revealing the knowledge contained in a new artefact to be positively concluded, the observer or team of observers must possess basic knowledge and skills similar to those of the subject who produced the innovation.

Likewise, the reduced cognitive distance between district firms -origin and destination of knowledge- facilitates successful knowledge transfers through interorganisational relations and human resource mobility. In the opposite situation of cognitive distance, transfer is instead destined to be held up in the reception phase. In fact, as already said, knowledge is absorbed if it is available for use.

In the case of relationships a factor other than cognitive proximity plays an important role in facilitating absorption. That is the ability of the individuals to interact through communication. The presence of this resource is the necessary premise for cognitive interaction, which in turn leads to the increase of the absorptive capacity of the contexts.

Thus, cognitive interaction plays a crucial role as knowledge absorption facilitator for all the mechanisms illustrated in the previous section.

The concepts of proximity and of cognitive interaction explain why the knowledge transfer mechanisms that we have studied are particularly frequent in IDs or – more precisely – why the high frequency of transfer opportunity that occur in the local environment result in actual transfer.

Firstly, district firms may be mapped and classified according to the stages of the supply chain and the industry they operate in. Within these groups, homogeneous from the technological and productive point of view, the cognitive distance is small, since there is the maximum level of prior related knowledge of each one of them with respect to the others.

The knowledge available in the receiving context is similar to that which is to be absorbed, and, hence, cognitive proximity remains large between firms with similar outputs and technologies, while it is smaller for firms linked by supply relationships. However, the latter can leverage on a specific potential channel for knowledge transfer permanently available, the relationship itself.

As regards the second decisive factor of absorptive capacity, cognitive interaction, IDs' boundaries outline a unique and homogeneous social and cultural context, perceived and lived as a community by the people who work in the local firms and institutions. The social and cultural homogeneity comprises a series of elements which Dei Ottati (2003) sums up in the community market concept: a shared language and values, meanings, implicit rules of behaviour (habits) in common.

The community dimension works like an immaterial resource, being collective and district specific. It facilitates the establishment of conversations within the district and the district firms, and supports mutual understanding and adaptation, reducing transaction costs.

Socio-cultural homogeneity not only facilitates cognitive interaction, but also increases the probability of the events that provide grounds for it: the relationships and inter-firm mobility of people. The activation of the former is in fact more frequent in the absence of significant communication barriers. At the same time, socio-cultural homogeneity makes labor mobility less problematic (eliminating the psychological reluctance of replacing the known with the unknown).

Summing up, thanks to the reduced cognitive distance and/or the facilitated possibility of cognitive interaction, district firms have, on average, the capacity for absorbing the knowledge produced within the local system. Figure 1 summarizes the processes of within-district knowledge transfer presented in this section, highlighting also the feedback on cognitive proximity resulting from the absorption processes.

Figure 1 approximately here

As concerns IDS' evolution, the cognitive overlapping among district firms spurs the rapid diffusion, within the district, of incremental innovation generated within it. Instead, cognitive proximity hurdles radical innovation diffusion, because of the cognitive distance that separates the leading, innovating district firm from the existing stock of knowledge in the district. There is a chance that district firms may be able to respond to radical innovations introduced by the leading firm, triggering and pulling a comprehensive transformation of the district, but this event cannot be taken for granted. Indeed, as confirmed by the studies in table 1, in most IDs radical innovations and evolutionary discontinuities correspond to massive selection processes among the district firms.

Knowledge production in district firms

Our analysis of knowledge transfer processes led to emphasise homogeneity and reduced cognitive distance among district firms. Nonetheless, while cognitive proximity facilitates knowledge transfer, it is the differences between source and receiver that trigger it (Nooteboom 2000). Therefore, cognitive proximity between district firms needs to be large enough to make the transfer fluid, but not too large, otherwise it would hinder the transfer processes.

Knowledge production involves large fractions of district firm populations (Bellandi 2003), even though innovation, which is at the basis IDs' evolution, requires the existence of pioneer, leading firms, with a differential innovative capacity.

Knowledge production is not a mere function of the density of district firms or of the size of district firm population. Rather, they are contingent on two elements:

a) the division of cognitive labour between firms, i.e. the vertical and horizontal variety of product/technological specialisations within the district. The larger the division of cognitive labour, the more numerous the frontiers that are important for knowledge production, with groups of district firms concentrated on well defined product, technologies or market segments (Rullani 2003).
b) The idiosyncratic nature of knowledge production: co-located firms that share the same specialisation and deal with the same problems may work out different solutions (Maskell 2001). Apart from the relative cognitive heterogeneity of district firms, their relative small size, the characteristics of the workforce and the firm-level social systems facilitate the

decentralised production of knowledge Firstly, division of labour and organizational differentiation is not particularly accentuated within the firms; thus, the field of experience of individuals is fairly wide. Moreover, the small firm size and the informality of interpersonal relations favour the internal circulation of knowledge often resulting in collective problem solving.

Overall, IDs are local contexts where knowledge is continuously produced. This wide (multi-centred) base of knowledge creation forms the condition that feeds the transfer channels examined previously. In turn, the within-district circulation of knowledge feeds the knowledge creation processes by combination.

Knowledge combination within IDs

Knowledge transfer through observation, the mobility of the human factor and relations may result in simple knowledge replication. This happens if the transferred knowledge is used by the absorbing district firm without modifications.

Alternatively, the same mechanisms may feed the creation of new knowledge. This second result depends on the possibility of the transferred knowledge being combined with other knowledge, leading to new and original syntheses.

For example, the imitation of new products introduced by a rival firm is often only one dimension of a more complex process which leads to the creation of new knowledge. The imitating firm may possess knowledge and skills that can be applied to introduce incremental innovations, improving the performance of the imitated product. In other cases, the imitator employs what Teece (1986) calls complementary resources to innovation core competencies, for example developing some kind of technical device that improves the efficiency of the production process, or taking an original approach to marketing. We can then speak of innovative imitation, since the imitating firm is able to combine the cognitive input that it acquires (e.g. through the study of the artefact or the behaviour of the innovating firm on the market) with its own specific knowledge endowment, which is at least partly different.

Innovative imitation is a widespread phenomenon in IDs. District firms systematically monitor one another, intercept circulating information, reverse engineer products and components (as knowledge “containers”). Imitation is obviously viewed and perceived as negative by the imitated firms, but the imitation-innovation circuit is virtuous from a systemic perspective: imitating firms can contribute to innovation; imitated firms are obliged to research and innovate. Besides, the imitation-innovation cycle is a repeated game, with firms playing different roles at different times.

Knowledge transfer through human resource mobility can lead to new knowledge production, too. Moving workers activate new combinations of knowledge in the places where they go, as long as the knowledge they carry is different and can be usefully combined. Then, the ability of the incoming worker to adapt to the new context and to communicate and interact with his new colleagues is important.

Knowledge circulates in IDs through relationships. Relational contracts and collaborative arrangements, rather than market transactions, are more effective motor for knowledge creation. From this standpoint, in presence of complementary knowledge assets, the communitarian dimension that characterizes IDs on the one hand produces mutual trust and cooperation (key resources), and, on the other hand, favours the cognitive interaction between partners and, consequently, the generation of new knowledge by combination. For example, leading district firms often involve expert subcontractors or suppliers of process technologies are often involved in new product development.

Figure 2 approximately here

Figure 2 develops the model sketched in Figure 1 including the variables analysed in this section. Cognitive interaction not only facilitates knowledge transfer, but also supports knowledge combination in the production of new knowledge. Besides, the boundary between transfer and combination often tend to blur especially in the case of innovation inter-firm project teams.

Finally, it is useful to point out that the cognitive differences between district firms feed the production of new knowledge by combination. The same condition is at the basis of knowledge transfer, as seen in section 5. The two processes have different effects on the cognitive structure of IDs. In fact, while the local diffusion of knowledge increases cognitive proximity between district firms (section 4), reprocessing and original syntheses of circulating knowledge reproduce diversity.

Firm creation through spin-offs: a knowledge-based interpretation

IDs are also meta-contexts where district firms are incubators of new entrepreneurship. New firms frequently are born as spin-offs of existing firms. Spin-offs are important in generating the district identity, in generating variety and in keeping alive the imitation-innovation cycle.

Spin-offs, i.e. the creation of new firms through the break-away of human resources from existing firms, represent a particular form of knowledge transfer, which extends the set of mechanisms illustrated in section 3.

As a mechanism of knowledge transfer from an incubator firm to a newly constituted firm, spin-offs resemble all the three processes already described. It is a peculiar form of human resource mobility; the knowledge embodied in the new firm formed (via training and learning) in the original district firm, a process similar to the mechanism of imitative observation. Also in the phase of the gradual development of the entrepreneurial idea, a decisive role is played by the relationships with the future entrepreneur, both inside and outside the firm in which he operates.

Spin-offs may be: a) replicative, if the new firm replicates business and organizational models already adopted by existing district forms; b) innovative, if the new firm introduces original entrepreneurial formulas into the district,, i.e. if the transferred knowledge concerns new combinations.

Replicative spin-offs occur when the knowledge that is to be transferred is simple and when the business and organizational models are easy to replicate. This happens when:

a. the spin-off entirely replicates the value chain of the mother firm (frequent with spin-offs coming from network mother firms);
b. the spin-off replicates only part of the value chain of the mother firm (frequent with spin-offs coming from vertically integrated mother firms).

A typical example of this second case is subcontracting. Spin-offs are induced by mother firms (often as buffer against demand fluctuations), the knowledge to be transferred is simple and the business model easy to replicate.

The cognitive simplicity of firm structures which are replicated through spin-offs largely explains the frequency of this form of enterprise creation within IDs. However, the influence of the complexity factor is mitigated – at least within certain limits – by the presence of other factors, that help explaining more complex within-district spin-offs (still replicative spin-offs).

The first factor is the higher entrepreneurial propensity within IDs. Entrepreneurship is more present and diffused within IDs because in district firms, prevalently small and medium sized, entrepreneurs may be directly observed by workers and cognitive interaction between workers and entrepreneurs may be frequent.

A second factor is multiskilling and the usually broader set of competencies workers in district firms develop. This favours the circulation and combination of knowledge (cognitive gymnasiums) and supports entrepreneurship. Multiskilled workers are more likely to start their own business than narrowly specialised ones.

A third factor is external relationships. The community dimension and the permeability of the firm-level social system makes it easier to team up and put together the resources required to spin-off. External relationships, as well as intra-firm relationships, may impact on the development of an entrepreneurial project and strengthen the perception of its feasibility. Relationships cultivated over time, before spinning off, can be activated in the start-up phase, becoming part of the new firm's business model.

Overall, IDs act as incubators with high probability of spin-off start-ups. Workers operating in district firms can take advantage of knowledge transfer channels within and between district firms to spin-off and start new ventures. Workers' absorptive capacity is supported by cognitive interaction and the community dimension, which creates an invisible connection between people and firms within the district (figure 3).

Figure 3 approximately here

Social and cultural homogeneity within IDs not only facilitates cognitive interaction but also reduces barriers to establishing relationships (section 4). Besides, it increases the probability of actually starting a new firm. This high propensity to go into business on one's own, building on one's previous experience as an employee, and involving family members or even colleagues from the same mother firm, is based on values that are widely shared in the local communities of Italian IDs – in particular work, ownership and the family – which created an extended base for the social legitimisation of entrepreneurial activity, albeit launched in modest forms. In other words, the specific characterisation

which informs the community dimension in IDs makes the status of entrepreneur a highly desirable target.

To complete the picture of the factors that explain spin-offs with moderate complexity, these new firms can be founded by several people coming from the same mother firm, where they performed different jobs and acquired complementary experience. In this particular but not infrequent case, the even extended replication of the value chain is based on the variety of the human resources involved in the spin-off and on the consequent recombination of their individual knowledge and skills in the new firm.

Innovative spin-offs introduce new business and organisational models in the ID. If these spin-offs are successful, they contribute to the ID transformation and even drive the ID evolution. Again it is the coupling of transfer and combination that marks the boundary between replicative and innovative spin-offs.

A first example is when new firms are born as the result of multiple spin-offs from district mother firms. These spin-offs typically involve several persons coming from different district firms and combining diverse knowledge and skills. In this case the combination is based on the relationships between the future partners, which may or may not result from relationships between the firms to which they belonged. The maturing of the business idea by combination is favoured by the cognitive interaction between the people involved.

Letting the outside environment in: the cognitive opening up of industrial districts

Up till now the analysis of cognitive processes has been circumscribed within the boundaries of each district system. Adopting a wider perspective, it may be easily recognised that both knowledge transfer and the combination of knowledge can involve external sources. As was said in section 2, the internal-external combination is identified as hybridation. The use of an alternative term intends to point out a difference that is not banal. Indeed, the capacity to absorb external knowledge and to produce innovations based on it was important in the competitive evolution of IDs, as will be seen below.

Besides the acquisition by district firms of codified knowledge available in various forms (from technical-scientific and managerial literature to patents), the observation of how the absorption in the district of knowledge generated outside it comes about enables us to recognise further, distinct methods:

a. the recruiting of human resources outside the district, used by the district firms to acquire new knowledge, or knowledge that is not yet present internally and at local level;
b. the relationships between the district firms and sources outside the district that supply raw materials, technologies and services, upstream from the supply chain, and with industrial and commercial customers downstream;
c. the imitative observation of innovations introduced by external competitors. This method of knowledge transfer may also lead, as we know, to the development of original innovation in the presence of a fertile combination with the heritage of knowledge possessed by the district follower;
d. the professional experiences acquired outside by persons who broke away from the local context for a certain time and then returned to use their acquired knowledge in the creation of a new firm;
e. the creation of firms by involving entrepreneurial resources from both inside and outside the district. This method may also have the form of a multiple spin-off in which the subjects carrying complementary knowledge are at least partly external;
f. lastly, an important role of cognitive connection between the district and the external environment may be played by determined local institutions, such as banks, training bodies or business service centres.

Sometimes, some form of cognitive permeability to the environment that surrounds the local context is decisive in the generative phase of the district system, or in its evolution. The cases listed below give an efficacious illustration of this statement.

Among the external professional experiences that have had a decisive impact on the origin of an industrial district we must certainly recall that which preceded the foundation, in 1891, of the Voltan shoe factory in the Brenta area, where numerous small craft workshops were already operating. The fundamental element in the conception of the new firm was the period that its founder had spent in the United States, where he came in contact with the shoe industry which at that time was at the most advanced level in the world. The knowledge acquired abroad enabled Giovanni Luigi Voltan to create a firm with a productive and commercial formula that was completely unknown to the local craftsmen.

In a short space of time the new firm became one of the principal Italian firms in the sector and, at the same time, the model for other manufacturers in the Brenta area to follow. The Voltan shoe factory also played a direct role in the transition from craft area to industrial district. In the Twenties and the Thirties, numerous employees branched off and set up firms of their own, often working in the start-up phase as subcontractors for the parent firm (Fontana, 1998; Belussi 2000).

In the case illustrated we find all the typical mechanisms of intra-district knowledge transfer, similarly to the spin-offs examined in the previous section. Now, however, the mobility of human resources, observation and relationships are projected outside the boundaries of the local environment.

As regards the observation of the innovations developed outside the district context, from the point of view of evolution the imitations that lead the way to further important innovative processes are the most important. For example, a similar event marks the beginning of the "plastic revolution" in the sports footwear district of Asolo and Montebelluna. The first ski boot made entirely of plastic was manufactured in the United States by Bob Lange in 1966. Nordica was the first district firm to believe in the new technology, which it managed to perfect by replacing the original method with a more efficient process. A fundamental element for the success of the project was the collaboration with an expert craftsman in the district and with two firms located in the Veneto region but outside the district, the first of which made machines for the shoe industry while the second operated in the sector of plastic for industrial processing (Codara and Morato 2002). This case therefore represents the combination of two of the methods in the list.

The innovation brought about by Nordica was then imitated by the main firms in the district. Instead, as regards the small local manufacturers, in many cases the threat of being overwhelmed by change stimulated them to convert to specialised activities in the new filière, or to concentrate on finished products other than ski boots, such as après-ski and other types of sports footwear.

The example described is also interesting because it suggests that radical innovations represent opportunities to rejuvenate the district. The advent of plastic as a new material for ski boots led to a drastic conversion of production technologies, the development of new channels of supply, and a reconstruction of the base of technical skills necessary to support the new production process. Only one firm immediately seized the opportunity offered by the new technology and made the necessary investments, tackling the complexity implied in the discontinuity of change. However, in a relatively short space of time the knowledge produced by the pioneer spread to the local production network, triggering the longest development phase in the history of the district (Corò, Gurisatti and Rossi 1998).

As we have mentioned, a further form of cognitive permeability to the external environment is the creation of "mixed" firms in comparison with the origin of the entrepreneurial factor. A famous case is Luxottica, in the Belluno eyewear district. The firm, now a world leader in its sector, was founded in 1961 as a subcontracting firm by a minor entrepreneur from Lombardy, Leonardo Del Vecchio. Two local entrepreneurs took part in the venture, who at that time were running a company that made frames for sunglasses, for which Del Vecchio worked in Milan as a subcontractor supplying small metal parts (Brunetti and Camuffo 2000).

A more recent mode of cognitive permeability to the external environment derives from the interest of large multinational groups in Italian IDs. The investments made by external firms have assumed the form of the creation of new ventures or the purchase of existing firms.

Contrary to some pessimistic forecasts (Amin 1993), the entry of multinationals in the IDs did not trigger a process of disintegration of these systems. In fact, the investments of external operators generally represent the recognition of the elective presence in a specific district context of knowledge, skills and relationships that are important for the competitive advantage in the reference sector. This presence of strategic assets is the main factor of attraction for multinationals.

On this basis the acquired or created firm does not become an extraneous body within the district, but rather introduces a fine element of connection with the external environment into the traditional scheme of knowledge production and circulation within the district. On the whole, these investments opened up a new channel for knowledge transfer from the outside to the inside of the local context and increased the opportunities for cognitive hybridation.

Consistent with the interpretation proposed is, for example, the presence of numerous multinationals in the sports shoe district of Asolo and Montebelluna (Corò and Grandinetti 2001) and in the biomedical district of Mirandola (Biggiero 2002).

The role of KIBS (knowledge-intensive business services) in IDs evolution

The acquisition of external knowledge has certainly played a role in the formation and evolution of IDs, even though these systems have founded their competitive advantage on cognitive processes that are largely immersed in the local context.

Nevertheless, in the last fifteen years the respective competitive scenario has changed, in relation to the growing globalisation of economic processes. This phenomenon appears, in a cognitive analysis perspective, as a gradual worldwide extension of the base on which take place the processes of production, circulation and use of important knowledge for the competitive advantage of the firms. From this standpoint, district systems must have a higher level of cognitive opening towards the external environment (Becattini and Rullani 1996; Zeleny 1999).

An important role in supporting the evolutionary paths of IDs may be played by the local institutional actors and policy makers. For this purpose, the actions that these subjects take must be oriented to supporting the innovation and internationalisation processes of the district firms, at the same time encouraging the creation and strengthening of the local relationships which have a specific impact in the reproduction of IDs as local innovation systems.

In particular, special mention must be made of the public or mixed (private and public) agencies that provide services to the firms in a district in fields such as technological transfer, product and process innovations, the quality of products and business systems, collective marketing.

The structures of this type fall within the category of the actors of change of IDs in the extent in which they operate as *knowledge-intensive business services* (KIBS). Precisely, in the evolutionary perspective that we are sketching in the final sections of our paper, a KIBS acts as a cognitive interface between the district context and the wider competitive environment, integrating the knowledge generated in the former with the knowledge circulating outside it (Becattini and Rullani, 1996).

KIBS are immersed in the district and come in contact with local firms, acquiring a high level of awareness of their manner of operation, the innovation processes they develop and the corresponding needs of information and knowledge. But, thanks to the relationships established outside the district – customers or institutions located in other regions and countries- they also have unprecedented (for the district) absorptive capacity as regards external knowledge. The reworking and innovative hybridation of the knowledge acquired through connections inside and outside the district allow the production and transfer, incorporated in the services provided and through the relationships with district customers, of knowledge which otherwise would scarcely be at the disposal of the great majority of firms in the district.

Development agencies and service centres have been formed in many Italian IDs with mixed results. Those that are effective, like CATAS in the chair district in Friuli (Camuffo and Grandinetti, 2005), play the role of local/global cognitive interface Among the positive examples we can certainly mention.

CATAS was founded in 1969 as a special company of the Udine Chamber of Commerce with the task of carrying out quality controls on the district products (wooden chairs) and more generally in the sector of wooden furniture. The start-up of the laboratory was fairly long. In fact, between the Sixties and Seventies, the demand for services concerning quality was very limited within the district. Consequently, in the first stage of its life the centre was engaged in informing potential customers and increasing their awareness, thus succeeding in creating the bases – in terms of socialising with the language and contents of the product quality – necessary to make its offer of services understandable and attractive.

The volume of activity steadily increased during the last decade, up to as many as 23,585 tests carried out in 2004. In parallel, the number of customers (affiliated firms) grew to 1,092 at the end of 2004. CATAS has also diversified geographically moving beyond the boundaries of the Manzano chair district and opening a branch in Lissone, Lomabrdy, located in the important furniture district of Brianza (1997).

The technologies, as welll as the scope and quality of services offered by CATAS have also systematically improved. Currently, CATAS's laboratories can run 824 different technical tests concerning the quality of finished products, components, materials (paint, glue, plastics, fabrics, etc.). Quality tests are complemented by other services: technical documentation, technical consulting, seminars and training courses, product quality certification.

CATAS has also connected with similar institutions operating in other countries. It participates in EURIFI (European Association of Research Institutes for Furniture), which connects European institutions that deal with technology, innovation and quality in the furniture industry. This network facilitates benchmarking, and identifies shared laboratory routines and test methods. CATAS has recently started to do technology transfer. In 2003 it opened, in collaboration with the Area Science

Park[1], the Wood & Furniture Centre, already engaged in various R&D projects and providing consulting for companies.

Summarizing, CATAS has a vast and complex system of relationships, schematically represented in figure 4, which nurture knowledge accumulation within the district and between the district and the external environment, and leads to effective performance.

The Centre's excellence legitimises its role of local/global cognitive interface among firms and institutions, beyond the district boundaries.

Figure 4 approximately here

Implications and directions for future research

After briefly recalling the distinctive features that characterize IDs as a particular form of production organisation and the main transformations they have undergone over time, this paper has developed a model of how IDs operate as self-contained, relatively impermeable cognitive systems, within which knowledge transfer and production take place. This model provides a basis and a rationale to conceive IDs as local innovation systems. The model comprises the following three research constructs: a) the *mechanisms* that spread knowledge across district firms - within the ID; b) the *enabler* of cross-firm knowledge transfer through the above described mechanisms; c) the *process of producing new knowledge*, as a phenomenon that widely involves the population of district firms and is also supported by the combination of the knowledge circulating in the local context with other knowledge, present in the firms receiving knowledge.

The theoretical contribution of the paper is an original model of how IDs work as local innovation systems thanks to knowledge transfer within IDs (between district firms) and with the external environments The paper has provided a fresh interpretation of some typical ID dynamics (e.g. interfirm labor mobility) and focused on spin-offs as a particular form of knowledge transfer and production. It suggests that knowledge production may take place within the district boundaries (combination) or it may involve external sources (hybridation or contamination). In the former case, district firms produce new knowledge combining knowledge resident in different district firms; in the latter case, district firms hybridate their specific knowledge with knowledge coming from other contexts. The paper explores this second mode of knowledge creation, too, examining the connections between the district context and the external environment. Finally, still from the cognitive perspective, the paper has tackled the issue of how globalization impact on IDs, concentrating on the role of local public agencies as service providers to district firms. Future research could apply this framework to study real cases and interpret IDs dynamics (crisis, growth, diversification, etc.). The model could also be used as a diagnostic tool for local industrial policy.

[1] The Area Science Park is based in Trieste and is one of the principal scientific and technological parks in Europe. It is managed by a Consortium, the members of which include the Universities of Trieste and Udine, the National Council for Scientific Research, the Region of Friuli-Venezia Giulia and other institutions.

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Table 1. Empirical studies on Italian industrial districts

Industrial district	*Product specialisation*	*Empirical studies*
Asolo and Montebeluna	Footwear	Corò, Gurisatti and Rossi 1998; Codara and Morato 2002
Belluno	Eyewear	Camuffo 2003; Nassimbeni 2003
Brescia	Hosiery machinery	Lissoni 2001; Lissoni and Pagani 2003
Carpi	Knitwear	Bursi 1989
Conegliano	Household appliances	Soli 1998
Fabriano	Hoods	Bellagamba 2002
Livenza	Furniture	Guerra 1998
Manzano	Chairs and furniture	Grandinetti 2003; Camuffo and Grandinetti 2005
Mirandola	Disposables and medical appliances	Biggiero 2002; Lipparini and Lomi 2002; Sammarra 2003
Murge	Upholstered furniture	Albino, Garavelli and Schiuma 1999; Belussi 1999
Prato	Textiles	Dei Ottati 1995; Bellandi 2003
Pesaro	Furniture	Bocconcelli and Tunisini 2001; Zagnoli 2001
Riviera del Brenta	Shoes	Fontana 1998; Belussi 2000
Sassuolo	Ceramic tiles	Porter 1990; Bursi 1997; Marchi 1999

Figure 1. Knowledge transfer within industrial districts

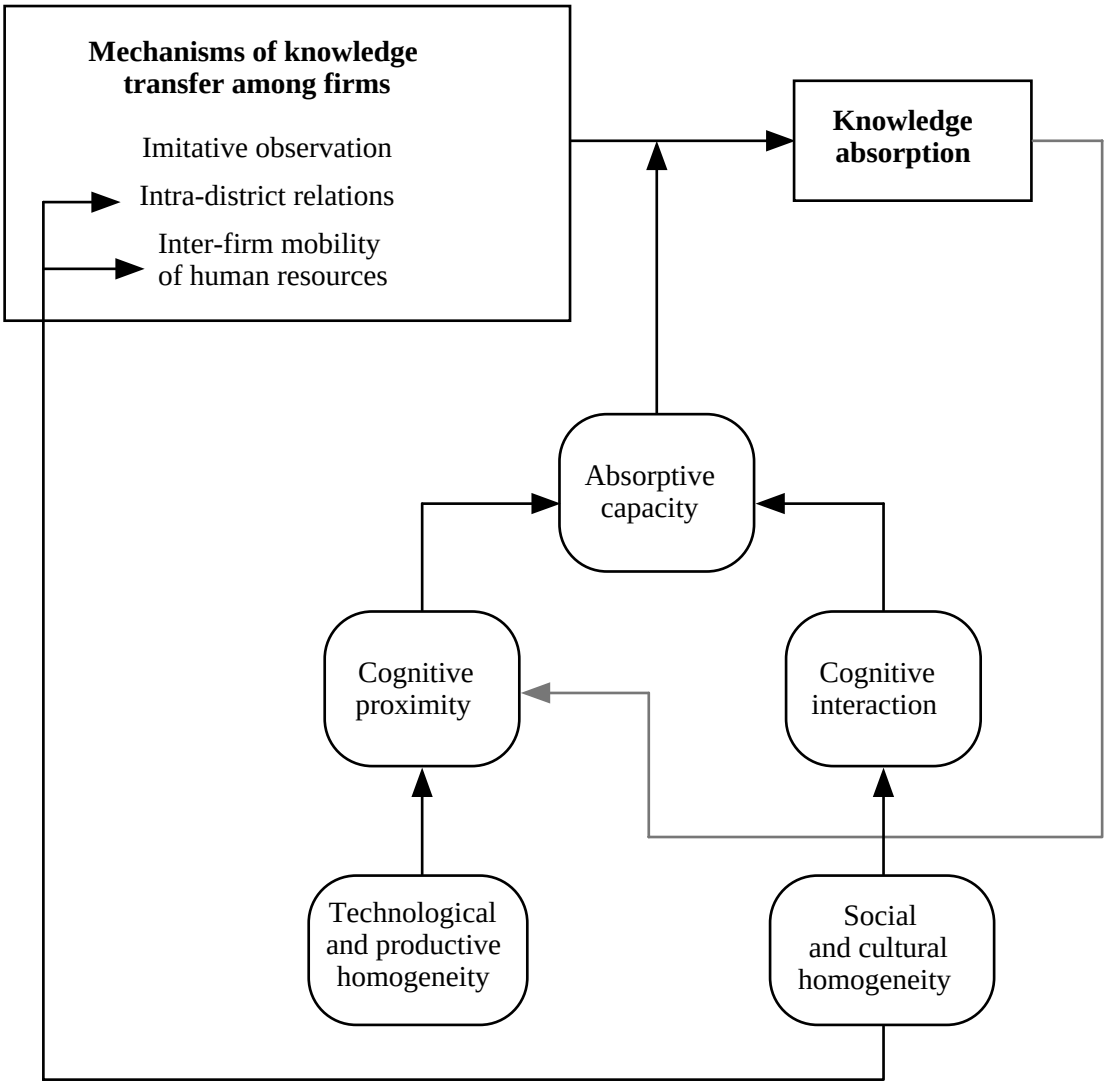

Figure 2. Knowledge transfer and knowledge combination within industrial districts

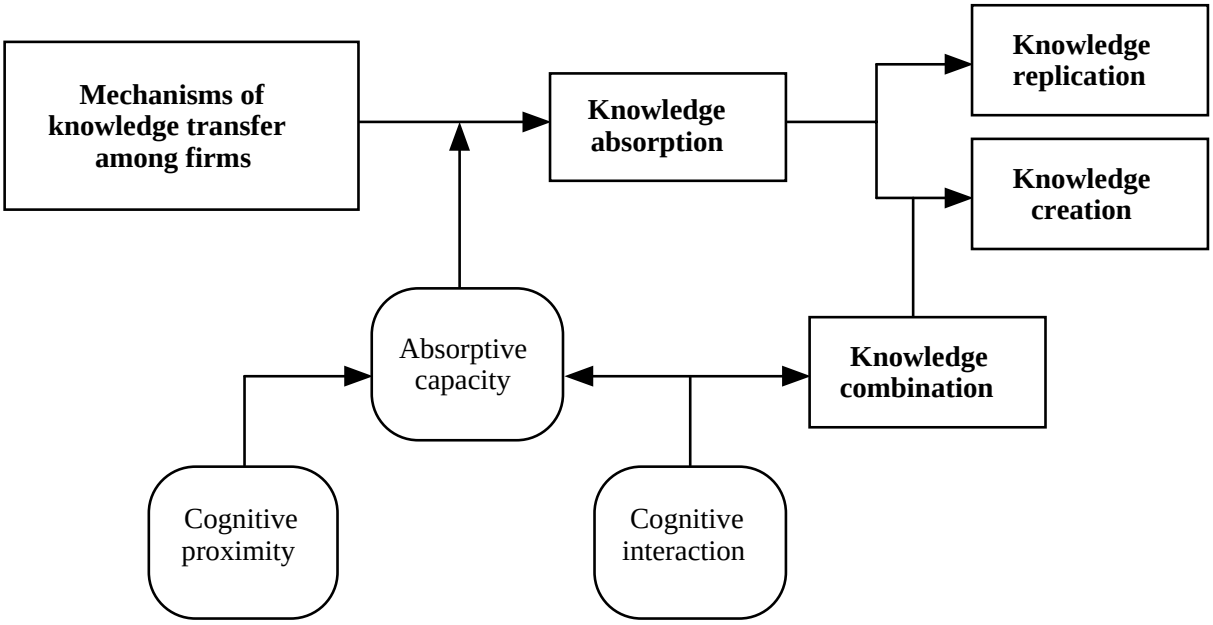

Figure 3. Enterprise creation through spin-off: a knowledge-based interpretation

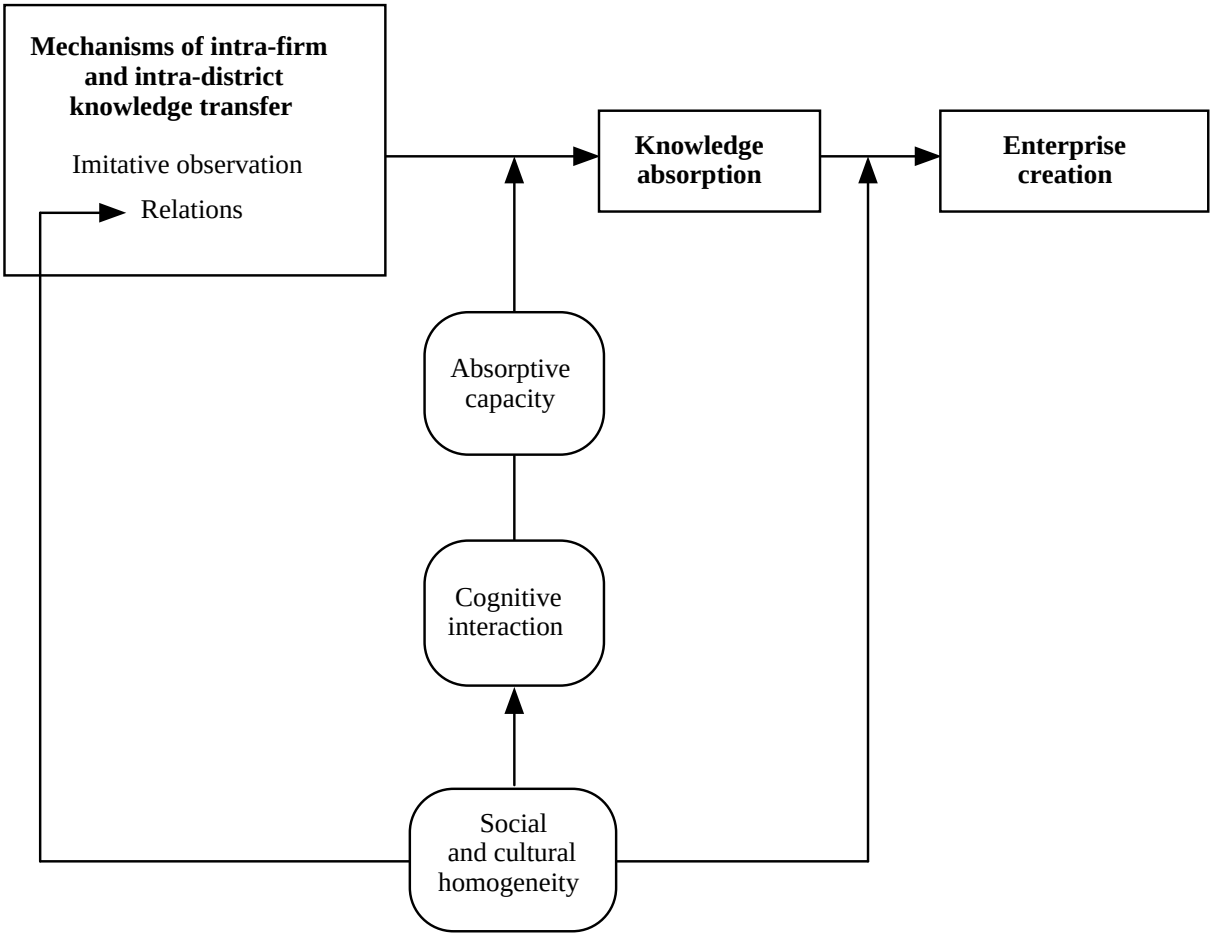

Figure 4. CATAS: a case of knowledge-intensive business service