Facoltà di Economia
Università di Roma "Tor Vergata"
Anno accademico 2014/15
Secondo semestre

Corso di Laurea di II Livello
SCIENZE ECONOMICHE

Corso:

Economia Regionale

Docente
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LEZIONE 4

I FATTORI TERRITORIALI DELLA CREAZIONE DELLA CONOSCENZA

The geography of knowledge spillovers.
Conceptual issues and measurement problems
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45ª Riunione Scientifica Annuale
Alma Mater Studiorum
Universita' di Bologna
Dipartimento di Scienze Economiche
22-23 ottobre 2004

The original definition, and much of the legitimization of the LKS ("localised knowledge spillovers") concept, come from Marshall's discussion of **intra-industry economies of localisation**. According to Krugman's (1991) synthesis, we can classify them as:

1. ***Economies of specialisation*.** A localised industry can support a greater number of specialised local suppliers of industry-specific intermediate inputs and services, thus obtaining a greater variety at a lower cost.

2. *Labour market economies*. Localised industries attract and create pools of workers with similar skills, smoothing the effects of business cycle (both on unemployment and wage) through the effects of large numbers.

3. *Knowledge spillovers*. Information about novelties flows more easily among agents located within the same area, thanks to social bonds that foster reciprocal trust and frequent face-to-face contacts. Therefore, geographical clusters offer more *innovation opportunities* than scattered locations. Innovation diffusion is also faster.

Entries 1. and 2. in the list above are often referred to as "pecuniary" or "rent" externalities, as opposed to 3., which more clearly represents "technological" externalities (Scitovsky, 1954)[1]. Rent externalities allow co-localised firms to access traded inputs and labour **at a lower price** than rivals located elsewhere; as such, they pass **through market interactions**. **Technological externalities, on the contrary, materialise through non-market interactions** and, in principle, are accessible to all members of the local community.

In principle, it is then possible to **distinguish** between a **knowledge spillover** *(i.e. technological externality)* and a **pecuniary externality** (Griliches, 1992). **The former occurs when a firm derives a profit from R&D activity undertaken by other firms without sharing their cost.** It may be called also **'disembodied' knowledge spillover**. Once pieces of knowledge are created they become part of the publicly available stock of knowledge and sustain the processes of endogenous growth.

We will see that the crucial issue is to test whether these knowledge spillovers exist and which is their geographical extension.

[1] A further set of empirical literature has to do with two specific issues within **urban economics**, namely the attempts: (i) to estimate the relative importance of natural resource endowments vis a vis knowledge externalities in affecting the location of industries, (ii) **to distinguish between Marshallian externalities and more specific 'urbanisation' externalities**. Key contributions in this field have come from Glaeser et al. (1992), Ellison and Glaeser (1997, 1999), Head et al. (1996), Henderson (1999), and Black and Henderson (1999). Once again, however, the evidence on LKSs is by and large of an indirect kind (sometimes bringing back the production function tool, as in Henderson, 1999), and cannot be taken as definitive. For example, Glaeser et al. (1992; p.1151) conclude their paper by admitting that: "...our evidence on externalities is indirect, and many of our findings can be explained by a neoclassical model in which industries grow where labor is cheap and demand is high." Once again, **the econometric evidence does not necessarily suggest the existence of properly defined "spillovers", i.e. pure knowledge externalities.**

A pecuniary or rent spillovers occurs when a new or improved input is sold but the producer can not appropriate completely the increased quality of the product. This might be due to the market structure of the sector and its degree of competition and imitation. In this case some of the surplus is appropriated by the downstream producers. But this mechanism per se does not create further innovations and endogenous growth. Finally **knowledge spillovers do not exist if there is full appropriability,** i.e. the possibility to price discriminate or **an efficient property right system**.

Although we can distinguish the two spillover effects on the theoretical ground and despite the relevance of the distinction for policy purposes, when it comes to empirical studies, **the distinction between pecuniary and knowledge externalities becomes fuzzier**. In particular, studies on R&D productivity based upon Griliches' knowledge production function (KPF) may underestimate the former, and overestimate the latter, because of measurement errors (Griliches, 1992). Despite this, **in trying to explain why innovative activities appear to be strongly concentrated geographically,** and why firms located in certain areas are systematically more productive than firms located elsewhere, **users of the KPF approach have far too readily called in generic LKSs as a plausible explanation**.

Collective Learning and Relational Capital in Local Innovation Processes
Roberta Capello and Alessandra Faggian
Regional Studies, Vol. 39.1, pp. 75–87, February 2005

Geographical and relational knowledge spillovers: similarities and differences

As already noted above, the **concept of knowledge spillovers** has long been recognized as essential in studying the innovation process. Many authors address the problem. Audretsch and Vivarelli (1994), for instance, try to measure the effect of knowledge spillovers on innovation – measured in terms of new patents (using data on Italian firms) – and they find a significant effect of these spillovers on small- and medium-sized firms. The definition they use of spillovers, though, is not very wide, **including only the physical proximity (physical distance) to universities or research centres**. [2]

Autant Bernard (1999) extends the definition of spillovers also to **include the proximity of a high number of firms belonging to the same sector**. Again, as in Audretsch and Vivarelli (1994), he finds a significant positive relationship between knowledge spillovers – measured in terms of R&D expenditure and researchers of firms in the local area – and the innovative performance of firms.

[2] When dealing with knowledge spillovers, we refer to Jaffe (1989) as a seminal work, followed by, among others: Acs*et al.* (1994), dealing with the capacity of large versus small firms to exploit knowledge spillovers; Audtretsch and Feldman (1996) and Feldman and Audretsch (1999), dealing with the importance of diversified versus specialized knowledge *spillovers*; and Anselin *et al.* (2000), dealing with the definition of the physical distance over which knowledge spillovers disappear. For a recent review on the role of knowledge spillovers on regional development, see De Groot *et al.* (2001).)

Despite recognizing that proximity to universities, research centres and other firms – belonging both to the same or different sectors – in the local area is important, the phenomenon of knowledge spillovers is much more complex. A high concentration of firms belonging to the same sector in an area is not enough to explain the high innovation of the area itself. **It is necessary to define which channels convey these knowledge spillovers and allow them to spread over the territory**.

The concept of relational space, first introduced in the milieu theoretical framework, becomes crucial in this respect. [3]**Relational space is defined as the set of all relationships – market relationships, power relationships and cooperation** – established between firms, institutions and people that stem from **a strong sense of belonging** and a highly developed **capacity of cooperation** typical of culturally similar people and institutions. The concept of relational capital helps to underline the difference between the approach of two schools of thought mentioned above.

Fig. 1 underlines the comparison between the two approaches. On the one hand, **if one starts from a concept of pure physical space**, the precondition for knowledge spillovers is the **physical proximity** to firms of **the same sector** (to exploit specialization economies), to firms of **different sectors** (to exploit economies coming from diversification), and to **universities and research centres**, typical places where knowledge is produced. Physical proximity increases **the probability of contacts** between the economic actors, therefore allowing knowledge to spread more easily and produce useful **spillovers**.

[3] On the relationship between relational capital and innovation, see Camagni (1991), Keeble and Wilkinson (1999, 2000), Lawson and Lorenz (1999), and Camagni and Capello (2002). For the concept of organizational and cultural proximity, see also the French school on 'la proximite´' (e.g. Rallet, 1993).

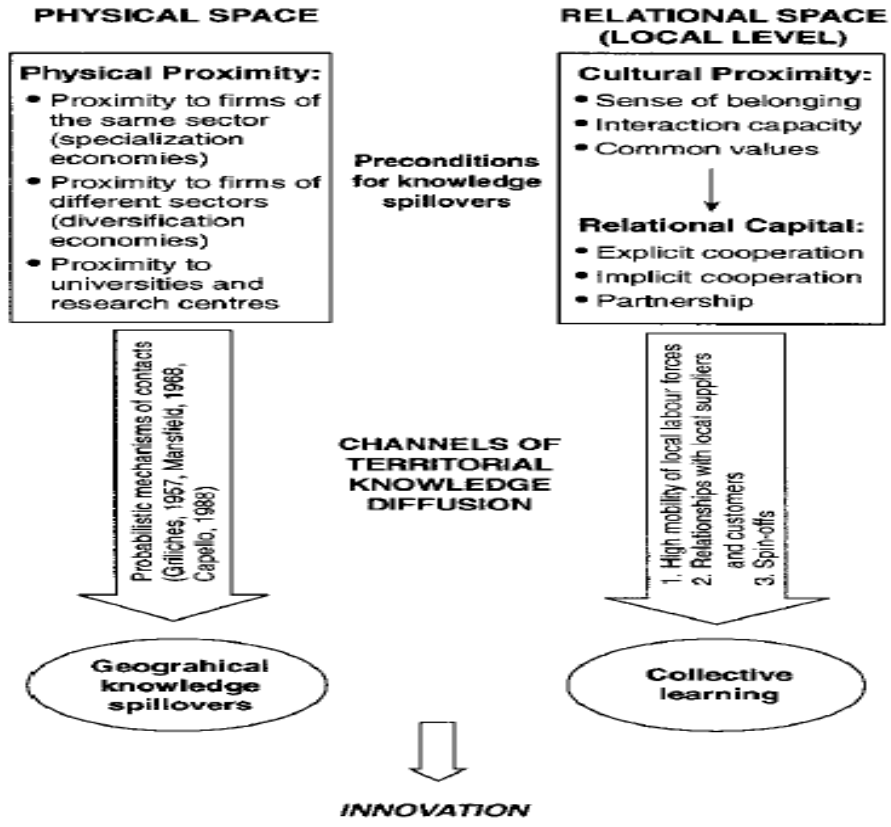

Fig. 1. Physical versus relational space

On the other hand, **if one takes into account the concept of relational space**, **the precondition for the creation of knowledge spillovers** becomes the **cultural proximity of actors**, i.e. their **sense of belonging** to the area, their capability of interacting and the **sharing of common values**. This cultural proximity is the basis for the existence of **relational capital**, which in turn is formed by the following:

- **Explicit cooperation among actors.**
- **Implicit cooperation among actors.**
- **Public and private partnership.**

Relational capital is therefore the 'substratum' of collective learning exactly like physical space is **the necessary condition for the 'traditional' knowledge spillovers**. It can be seen in Fig. 1 that the parallel between the two approaches is almost complete, but an important difference must be emphasized. **In the industrial approach, there is no clear definition of the channels through which physical proximity materializes into geographical knowledge spillovers**. All that is known is that the proximity to other firms or research centres positively influences the performance and the innovativeness of a firm, but it is not clear how this happens.

Everything is due to pure probabilistic mechanisms. Conversely, **in the regional approach**, **the channels through which the relational capital becomes collective learning** are clearly defined: .

- **High mobility of local labour force.**
- **Stable and fruitful relationships with local customers and suppliers.**
- **Spin-offs.**

Camagni (1995, p. 203) defines **collective learning** as the 'dynamic and cumulative **process of production of knowledge**, which is due to **interaction mechanisms** typical of an area characterised by **a strong sense of belonging and relational synergies'**. The internal cohesion promotes the introduction of new products or production techniques and reduces the uncertainty linked to innovations. The space is not just 'physical', it is something more. **It is a space created by men, both the result of and the precondition for collective learning**, an *active input* rather than a passive surface (Coffey and Bailly, 1996).

An Evaluation of the Effectiveness of Science Parks in Local Knowledge Creation: a Territorial Perspective
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PAPER ID: 145
To be presented at
5th Triple Helix Conference
Turin, 18th-21st May 2005

Despite recognising that proximity to universities, research centres and other firms – belonging both to the same or different sectors - is important, what emerges from a critical review of the literature is that **the explanation for the existence of knowledge spillover is left to a pure probability of contacts between economic actors, which increases in limited geographical space.**

During the seventies and eighties agglomeration economies have explained the performance of new industrial areas; **territory is in this kind of literature analysed as an active element in economic development**, being a **productive resource in itself, a source of advantages for firms**.

In more recent time, **territory has been conceived as a support to innovation activity**, being able to decrease uncertainty and risks accompanying innovative processes.

In this view, space is a complex concept, which **refers not only to geographical proximity**; space is interpreted in terms of **relational proximity**, **defined as the ability of local firms, institutions and people to put in place strong local relationships – market relationships, power relationships, cooperation**.

These relationships, alternatively called "relation capital", lay behind any process of collective learning.

The channels through which knowledge develops locally have been envisaged in:

- *the local labour market*. The local labour market plays an important role within the local production system, as the **high internal turnover of specialised labour** and the low external mobility guarantee cross-fertilisation processes for firms and professional upgrading for individuals; **a local know-how grows through a collective and socialised process**, subject, and this is the other side of the coin, to risks of isolation and lockingin, unless external energy is also captured through selected external co-operation
linkages;

- *stable linkages between suppliers and customers*. Stable input-output relationships generate a **codified and tacit transfer of knowledge between suppliers and customers**, which cumulates over time and defines patterns of incremental innovation which feed a specific technological trajectory. Also in this case, the comparison with the firms' technological trajectory is straightforward. As Aydalot suggested (1986), the innovation process in a territorial entity like the milieu is **a process of "rupture/filiation" (break and continuity):** if an innovation is a break with a preexisting situation, economic creativity and innovation potential have their seeds exactly in the local cumulated knowledge and know-how acquired over time;

- *intense innovative interactions with suppliers and customers and by mechanisms of local spin-off*. Theoretically, a spin-off is defined as a new independent firm fulfilling two criteria (Perhankangas and Kauranen, 1996; Dahlstrand A., 2000): **a) the start up of a new business by an agent previously belonging to another local firm, and** b) **the derivation of the new business idea from the previous employment of the founder.** Local milieux provide both the social and the market preconditions for this phenomenon to take place: from the social point of view, **high trust and common sense of belonging to the same cultural society** make this process acceptable6.

Collective learning is the territorial counterpart of learning in an industrial context; it is thought as the vehicle for knowledge transmission, both **in a temporal and in a spatial dimension**. In the former dimension, the transfer of knowledge is guaranteed by an element of **continuity**; in the latter by one of **interaction among agents**, which guarantees the transmission among individuals and firms and which becomes, in the case of the milieu, an element for the spatial transfer of knowledge5.

Local market conditions, like **stable interactions with suppliers** known in the previous job, **a receptive local demand of particular products** developed in the previous job, and **the presence of external economies**, assure locational advantages, guarantee the achievement of profits and thus **give rise to chances for survival on the local market**.

Beyond this set of mainly informal, "un-traded" relationships - among customers and suppliers, among private and public actors - and **a set of tacit transfers of knowledge** taking place through **the individual chains of professional mobility and inter-firm imitation processes**, **another knowledge acquisition channel has been underlined in the literature.**

More formalised, mainly trans-territorial co-operation agreements - among firms, among collective agents, among public institutions - **in the field of technological development, vocational and on-the-job training, infrastructure and services provision are important channels to achieve new knowledge.**

In trans-territorial networks, partners are single and selected economic units: enterprises, banks, research centres, training institutions, or local authorities, in which the location element is, roughly, only one co-ordinate among many serving to identify the unit itself. **At a first glance, therefore, these networks only link together different economic actors, with no necessary relation with space.**

But **when the location of a unit takes on significant meaning**, inasmuch as it reveals a set of relations, which generate territorial development and identity (e.g., Apple at Cupertino, Silicon Valley) and **when these network relations start to multiply, they do become territorial.** When carefully observed, **the identity of the local *milieu* often prevails over the identity of the individual partner**, stressing the importance of the territory: the strategic importance of links with a company in Silicon Valley resides more in the **opening of a "technological window" in Silicon Valley than in access to that specific company's know-how**.

This second kind of networks can identify a process of "learning through networking". Through **strategic alliances, non-equity agreements, technological cooperation, firms are able to capture some of the necessary assets from outside, overcoming the costs of internal development.** This model is in a sense **intermediate between internal and collective learning**, in that it opens the firm to the general context, but maintains it into a set of selected and targeted relationships. On the concept of "firms' networking" see among others Chesnais, 1989; Gordon, 1991.

International Knowledge and Innovation Networks

Knowledge Creation and Innovation in Medium-technology Clusters

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NEW HORIZONS IN REGIONAL SCIENCE

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4.6 THE LOCALIZED CHARACTER OF COGNITIVE PROCESSES

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6. The localized character of cognitive processes

The literature on cognitive economics highlights a third approach in explaining the spatial agglomeration of innovative activities, different from those indicated by the industrial economics and the regional economics literature. In fact, the spatial concentration or diffusion of innovative activities has a more fundamental reason than the existence of "localization factors" working on the attraction of innovative firms. **This reason is routed in the intrinsic spatial nature of the process of knowledge creation**. In particular, our study aims to come to a better understanding of the processes of knowledge generation, transfer and absorption within and between firms and other organisations within a region, by **focusing the attention on innovation as the result of an interactive process involving the sharing and exchanging of different forms of knowledge between regional actors**. This perspective is clearly important when analyzing the relationships between small and medium size firms in the process of innovation adoption.

In synthesis, **knowledge creation is the result of pattern making or of the classification and reclassification of exogenous stimulus**. Thus, **the process of knowledge creation has an interactive and a combinative character** and a closer geographical proximity and/or a greater cognitive proximity facilitate the interaction between various complementary actors and the combination of complementary pieces of

knowledge. **Knowledge can only develop in a localized or specific framework** and calls for a geographical and cognitive proximity of the various actors, which participate to an interactive learning process. **Knowledge creation only apparently has an a-spatial character** and cognitive sciences clarify on the base of theoretical considerations that the process of knowledge creation works in a localized framework. Thus, **the agglomeration of innovative productions can be explained on the base of the spatial or localized nature of the processes of knowledge creation.**

The analysis of the relationship between the process of cognition and space can be based on the psychological theories of those economists, who first investigated the problem of knowledge creation and who provided contributions which have later been confirmed by recent advances in neurosciences, such as neurobiology and psychology. According to cognitive theories, a brain operates, as in Smith's (1980 [1795]), Marshall's (1994) and Hayek's (1952) theories, by forming selective connections. **According to Adam Smith, it is characteristic of human nature to be uncomfortable when unable to make sense of a particular phenomenon**, especially when that phenomenon is repeated; people therefore try to invent **'connecting principles'** that will collect unexplained phenomena into categories and provide an acceptable explanation of these categories. In fact, Adam Smith pointed to the role of those "specialised philosophers and men of speculation, who are often capable of combining together the powers of the most distant and dissimilar objects" (Smith, 1776). Satisfactorily explanations are a source of positive pleasure, especially if the solution is aesthetically pleasing, and are likely to be widely adopted by those encountering such phenomena (Loasby, 2003).

According to Marshall and Smith the brain works by linking the idea of **an initial impression received by the body with the idea of an action which the body performs in response**, and then linking the latter with the idea of an impression that is interpreted as a consequence of that action (Marshall 1994, Raffaelli 2003, Smith 1795, Loasby, 2003). In fact the brain is a selective system and it works not according to logics and mathematical thinking, but rather according to the recognition of configurations. This pattern making activity

performs the vital function to allow to the brain to orient itself in the surrounding space: a function which is crucial for survival and has been developed through human evolution. In fact, cognitive activity seems necessarily represent the result of a reaction to the stimulus coming from the local environment. Connections clearly imply a spatial framework and proximity enhance connections. The spatial dimension of the process of cognition is also clarified by the fact that the local environment and the aim to respond to new needs and to solve the problems of local users are the most important stimulus to innovate for the firms. Cognition and innovation are related to the stimulus of a problem emerging in a specific field or to the opportunity to satisfy an emerging demand in a specific market (Gallouj and Weinstein, 1997). The local environment is the source of challenges and risks for the individual actor and it is related to the national and international economy. Firms should respond to the new needs and demand (as indicated in the TKM approach to be illustrated below) in local markets and aim to solve problems of local users. The strength of the stimulus and the possibility to perceive it depends on the spatial accessibility (as in the TKM approach). Moreover, cognitive proximity and a low geographical and cognitive distance facilitate the identification of weak signals and enhance collaborations.

A second key concept in the process of cognition is that of routines and path dependence (Loasby, 2001, 2002). According to Marshall, over time the brain may develop a range of closely connected impressions and actions, which we might call routines. In fact, the application of solutions or the repetition of new actions develops new connections between different parts of the brain (Marshall 1920, p. 252), which gradually take over the maintenance of these activities, leaving the conscious brain activity free for new initiatives, including those which utilise these now-automatic connections. According to Rizzello (2003), "neurognosis" indicates that when an organism faces new information, its capacity to give significance to this information depends on its previously stored experience and on its neurognostic structures. Thus, human brain and mind evolve by following a path, that strongly depends on pre-existing structures, as it adapts to external challenges while searching to maintain consistency and integrity. That implies time irreversibility and that experience matters.This concept implies that spatial and cognitive proximity are a key condition in order to promote

frequent and strong connections between different actors. Activities are mostly strongly linked or embedded in their local environment. Firms and actors respond by aiming to survive and to preserve the integrity of the local environment. That process explains the "receptivity" to external stimulus by local actors (as in the TKM approach). In particular, **external stimulus should be compatible with the internal integrity of the local production system and should lead to a gradual process of adaptation**. In fact, firms and actors respond and adapt in order to survive and to preserve the identity and integrity of the local environment facing the threats of external competition. The process of knowledge creation in a given location is characterized by switching costs and rigidities, inertia or stickiness and it evolves according specific paths.

The concepts of local endogenous development and of complex adaptive systems imply some form of immobility of resources and of internal integration and coherence, as it is implied by the neurognosis concept. The territory represents a resource in economic development and it is characterized also by a specific identity (as in the TKM approach), which increases internal cohesion and synergy, but it may also determine a form of spatial dependence, as the specific characteristics of the local selection environment may create obstacles and lead to lock-in effects. For example, in local industrial clusters (Steiner, 1998) specialized in medium technology sectors, knowledge creation is tightly related to the sectoral specialization, the industrial culture and know-how existing in the innovation systems to be considered. These factors may facilitate the early identification or the design of new patterns, combining previously existing ideas and pieces of information and knowledge. At the same time, however, they also constrain the discovery of new pattern in the attempt to insure the consistency and compatibility with existing solutions causing path-dependency and in some cases "lock-in" effects.

A third concept elaborated by cognitive theories is that of "exaptation" (Rizzello, 2003). While new knowledge, which is corroborated by apparently successful application, is consolidated into new routines, if directed action fails to achieve its objective, the recognition of failure leads either to a modification of existing routines or to experimentation resulting in new routines. Thus, knowledge that is already organized into

routines facilitates the creation of new knowledge especially that which builds on the old. That introduces imagination and the possibility of trial and error within the mind, as in modern practices of research and development. Problems in the economy require combinations of routines and novelty, and these combinations are themselves modified by evolutionary processes of trial and error. This sequence of creativity against a background of routines, leading to new routines which provide a more advanced basis for further creativity, is a dialectical process. Each resource, instead of constituting a well-defined input into one or more production functions, is a multi-specific asset, the potential uses of which have to be discovered, invented, or imagined. It is indeed a most important characteristic of knowledge that it can be reused, but in a way that is not simply deducible from current uses. As indicated by Rizzello (2003), "exaptation" is the phenomenon through which previous neuronal structures built and developed to solve problems of interpretation of external world effectively reveal their capacity to co-opt new configurations and functions when individual faces new problems. In fact, new neuronal structures emerge from old one, in order to give significance to the sensorial data. Coase (1992) explained the firm as a set of incompletely-specified contracts, which provided resources to be deployed at some date yet to be chose and within domain that could be broadly envisaged, thus avoiding the cost and time of making the necessary arrangements at that date. It is an investment in creating capabilities that provide options. A Coasean firm is a combination of purpose and capabilities which retain sufficient degrees of freedom to allow people to take decisions that may make a difference.

The concept of exaptation is tightly related to that of creativity and to variations. In fact, the growth of knowledge is always at the margin (Loasby, 2003). The generation of variety across organisations is a natural consequence, as imperfect specification is a condition of those experiments at the margin on which Marshall relied for the variations, that were a chief cause of progress (Marshall 1920, p. 355). In particular, a movement is easiest to adjacent states, but typically there are many states that are adjacent to each current position, so that even individuals or organisations with identical current positions may develop in different ways. In practice, individuals and firms will not have identical positions, even those with similar experiences and engaged in similar businesses, and this increases the potential for variation, as Marshall noted. Marshall believed that this

process tended to result in ever greater differentiation of function, matched by closer co-ordination (Marshall 1920, p. 241). The concept of specialization is related to the division of labour and Adam Smith suggested that the most fundamental aspect of the division of labour is the division of knowledge (Metcalfe and Ramlogan, 2005) as: 'each individual becomes more expert in his own peculiar branch, more work is done upon the whole, and the quantity of science is considerably increased by it' (Smith, 1776). According to Marshall and Hayek, the same stimulus may generate a variety of responses due to the differences in initial perceptions and the selective connections which are due to the reinforcement of what appears to work (Loasby, 2003). According to Hayek, any impulse is a 'representation', which is itself interpreted in terms of the relationships which have already been established within the brain (Hayek,1952). Similarly spatial dependence is related to the fact that **the same external stimulus may lead to different "creative" responses according to the casual combination of the actors** involved in the process of interactive learning or the connections established with them, as it characteristic of a complex, adaptive system (Metcalfe and Ramlogan, 2005).

Clearly space matters in the process of knowledge creation. Innovation requires the search and the integration of complementary resources and capabilities and that is enhanced by the existence of network relations with other local actors. In fact, Hayek argues that instead of direct connections between particular stimuli and particular sensory qualities, the effect that is produced by any stimulus depends, on the location of this impulse in relation to other impulses within the network of connections (Hayek, 1952). In a spatial perspective, tacit knowledge explains why clusters are faster in adoption innovation. It is perhaps because of this double threat to initiative and variety that Marshall was so impressed with the virtues of an industrial district, which seemed to ensure the automatic organization (Marshall 1919, p. 600) of highly specialised activities while facilitating both the generation and the active discussion of novel ideas, including ideas for constructing new patterns of relationships between firms. The spatial dimension of these concepts elaborated by the cognitive economics literature is indicated by the fact that reconversion of existing capabilities to new uses is possible only within a limited domain and it implies geographical or cognitive proximity, as firms initially look for the support of local suppliers and for the demand of local customers.

However, inventions and innovations increasingly are the result not of individual creative activity but of a collective process of searching and learning. Innovation requires the sharing of tacit knowledge, which is more ambiguous, redundant and fungible than codified knowledge, but it requires direct personal contacts. Complex adaptive systems (Holland 2002) are highly innovative and are also necessarily localized in geographical space. In particular, regional innovation systems (RIS) can be interpreted as evolutionary networks made by interacting brains, which thorough explicit collaboration or through spontaneous market selection generate systemic innovation. Network externalities emerge in a territorial framework and local networks facilitate interaction and flows of information and knowledge. Interactive learning is the key process in knowledge creation and the links and the frequency of the contacts are constrained by spatial distance. The process of interactive learning within a regional innovation system leads not only to imitation, but also to an increasing specialization and differentiation of the individual pre-existing firms into new productions and to the spin-offs of new firms. Thus, creativity is enhanced and limited by local capabilities (as in the TKM approach).

For example, the development of the thought of individual scientists has been affected by their respective local cultural environment. The various schools of thought are often related to specific cities or countries and not only to an historical period. Moreover, learning together is often a characteristics of the professional communities and know-how is often collective and localized. In fact, the urbanization economies and the Jacobs externalities (Jacobs, 1969), related to the diversity of metropolitan areas, or the localization economies, related to the specialization of industrial clusters, allow to easily identify local complementary capabilities in the process of innovation. The concentration of firms in large metropolitan areas facilitates innovation, both because this concentration decreases transaction costs between the actors (Cappellin, 1988) and because this diversity enhances business opportunities and entrepreneurship capabilities, due to the high diversity of origins, sectors, competencies existing in these areas and the easy access to a wide scope of new emerging needs and complementary resources.

Table 1: The spatial/localized dimension of cognitive processes
(adapted from the original)

Components of the cognitive processes	Territorial factors and processes
1. According to cognitive theories, knowledge creation is the result of pattern making or of the classification and reclassification of exogenous stimulus	1. Cognition and innovation are related to the stimulus of a problem emerging in a specific field or to the opportunity to satisfy an emerging demand in a specific market. Spatial and cognitive proximity are a key condition in order to promote frequent and strong connections between different actors.
2. The capacity of an organism facing new information to give significance to this information depends on its previously stored experience and on its neurognostic structures. Firms and actors respond and adapt in order to survive and to preserve the identity and integrity of the local environment facing the threats of external competition. The human brain and mind evolve by following a path, that strongly depends on these neurognostic structures.	2. The image of the external world is shared by the members of a group and leads to a common identity or culture. Complex adaptive systems (CAS) are highly innovative and are also localized in geographical space. The territory is characterized by a specific identity, which increases internal cohesion and synergy, but it may also determine obstacles and lead to lock-in effects.

3. The same stimulus may generate a variety of responses due to the differences in initial perceptions and the selective connections which are due to the reinforcement of what appears to work.	3. Local networks facilitate interaction and flows of information and knowledge. The process of interactive learning within a regional innovation system leads to an increasing specialization and differentiation of the firms into new productions. Thus, creativity is enhanced and limited by local capabilities.
4. ”Exaptation” is the phenomenon through which previous neuronal structures built and developed to solve problems of interpretation of external world effectively reveal their capacity to co-opt new configurations and functions when individual faces new problems.	4. The reconversion of existing capabilities to new uses is possible only within a limited domain and it implies geographical or cognitive proximity.
5. Over time the brain may develop a range of closely connected impressions and actions, which we might call routines. Following rules and codifying them in institutions is an “economic way” to act successfully.	5. Institutions are linked to territorial sovereignty and political participation and to local history, common culture, place identity, values, norms, visions, trust.

A further key concept in cognitive theories, when applied to the analysis of the economy, is the concept of institutions. Smith’s, Marshall’s and Hayek’s psychological systems rely on routines and institutions which economise on cognition. Institutions play a key role in the process of knowledge creation. Rules and organic institutions standardize the world and in so doing they simplify the ambit in which humans use their limited

cognitive capabilities. In fact, routines facilitate the connections and create free time to be devoted to the explicit thinking on innovation (Hayek,1952). Thus, following rules and codifying them in institutions is an “economic way” to act successfully. The routines and institutions within Smiths, Marshalls and Hayeks psychological systems allow to focus attention on the issues for which they are inadequate at any particular time. According to Loasby (200, 2002, 2003), the maintenance of stable baselines within particular domains is a prime function of formal organisations, and the appropriateness of the baseline is a major determinant of organisational success or failure. Order makes room for creativity, which is stabilised in a new order which combines newly-established expectations and beliefs into a patterned performance. Thus, in the brain conscious attention is reserved for problem-solving or the introduction of novelty. Cognitive processes indicate an evolutionary sequence made by variety generation, selection, and the preservation of selected variants in the form of modified or novel routines and institutions (Loasby 2003).

The spatial dimension of the concept of institutions is clarified by the fact that coordination by institutions is a necessary process when knowledge is spatially dispersed between different actors and for solving the problems of information asymmetries. Moreover, it is impossible to refer to institutions without considering the territory, on which they exercise their power, the geographical or sectoral borders with respect to other institutions and to the political participation by the people living or working in a given area. In fact, institutions are linked to the concept of territorial sovereignty and to the concept of legitimacy, which implies a local constituency. The spatial dimension of institutions is clearly indicated by their relations to local history, to the memory of centuries of interdependence between local actors, to the existence of a common culture, to the distinctive characteristics of the individual places and the existence of a place identity, to common visions of the future, common values, specific norms and routines and reciprocal trust. The process of economic development in specific regions depends on the existence of “intermediate institutions” and on the local “social capital” (Coleman, 1988; Scott, 2000; Maskell, 1999; Ferlie, 2003; Sorensen, 2003) and they facilitate the connections and decrease the cognitive distance between the local actors. In particular, strategic dedicated organizations

and institutions seems to be required for the management of knowledge and innovation networks of SMEs in intermediate technology sectors within a given territory (as in the TKM approach)**.**

The focus on the specific phases of the cognitive process, highlighted by the cognitive economics literature, allows to identify their tight correspondence with specific territorial factors and process and the role of space and geographical distance on the creation of ideas and new knowledge (table 5). Moreover, the theoretical concepts indicated above correspond to a large extent to **the various phases of the "territorial knowledge management" approach, to be illustrated later in this chapter (Cappellin 2003b, 2007).** In particular, the concept of connections corresponds to that of **external stimulus**. The concept of neurognosis corresponds to those of **receptivity and of common identity**. The concepts of exaptation and variation correspond to the concepts of **creativity** and of **interactive learning within a local network**. The concept of institutions is clearly related to the concept of **governance** of knowledge and innovation networks.

Thus, the previous analysis highlights that **space is relevant not only in order to examine the process of territorial diffusion of innovation** or to **examine the impact of innovation on the structure of the territory and on regional disparities**. On the contrary, the focus on the localized dimension of cognitive processes allows to highlight that **space and the territory affect the process of knowledge creation**. In fact, that is **the fundamental reason of the spatial agglomeration of innovative activities, which are based on the knowledge creation processes occurring in specific geographical areas**. The specific characteristics of these areas, both the central and most developed areas and also the peripheral and less developed area, **lead to different characteristics of the processes of knowledge creation in these individual areas and that affects the innovation and the competitiveness of local firms**. Therefore, the relationships between the space economy and knowledge are clarified not only by the uneven spatial diffusion of different types of knowledge, such as codified and tacit knowledge, or analytic, synthetic and symbolic knowledge, or by the existence of urbanization or localization economies explaining the agglomeration of innovative activities in specific

geographical areas. On the contrary, what seems more relevant is the role that space is directly playing on the process of cognition or on the generation of knowledge and innovation.

In conclusion, it is possible to **underline the difference between a temporal or evolutionary perspective and a spatial or territorial perspective in the analysis of the knowledge creation process**. **In a temporal perspective**, individuals classify new stimulus and associate pattern of stimulus to patterns of response on **the base of the success in previous experience**. The exchange of ideas, information and knowledge activate a creative process of re-elaboration of the own knowledge and of increasing specialization by **connecting existing elements in new ways within the mind of the considered person**. **A spatial perspective** to the analysis of the innovation process **introduces also the interaction between various local and external actors**, as a new element with respect the combination of different pieces of knowledge within an individual mind or firm, as indicated by a functional or temporal perspective. Knowledge creation is the result not only of the combination of a new stimulus with the individual previous experience, but also of the **combination of different competencies between the various actors, who are interacting in a learning process occurring within a given network or local area.**

That explains the different spatial pattern of creativity and the effect of lock-in. In fact, **in a spatial perspective, the same stimulus may determine a different pattern of response in each regional innovation system according to the different form of the network of local actors**, as the way an innovation system is responding to an external stimulus depends **not only on the existing individual capabilities of the actors**, who interact in the learning process, **but also on the level of integration and the forms of the links, which have been built between them**. Not only the plurality of the individuals allows a plurality of responses, as an individual combines the stimulus with its own experiences, but also **the stimulus to an individual actor may be combined with the different complementary competencies of the various actors, who are directly or indirectly linked to him. That leads to differences in the pattern of innovation within diversified communities or systems of SMEs.**

The increasing integration within a regional innovation system is leading to an increasing specialization of the various local actors. In particular, the knowledge which is shared between the various actors usually has a different meaning for the donor and the receiver, as is significance depends on its combination with their respective specific internal capabilities. **This increased knowledge is leading them to specialize in order to perform a specific or rather unique function within an innovation network.** Thus, the processes of the interaction between regional actors and of the combination of different pieces of knowledge, specific of different scientific or production fields are related to **the process of adaptation, greater specialization, selection and greater integration of the actors within a knowledge and innovation network.** These processes in a local production system of SMEs occur in a rather informal or automatic way, rather than being planned by a superior coordinating authority, such as within an individual large firm.

Moreover, **cognitive theories explain that the building of mental frameworks, connections or routines in our mind is leading to link in a automatic way pattern of stimulus with pattern of responses.** This combination of the external stimulus with the previous individual knowledge **is leading to the phenomenon of "path dependence".** Similarly, **in a spatial perspective, the success in solving previous problems is leading to strengthen the particular links between some specific actors and to create soft infrastructures, such as routines, norms, intermediate institutions, trust, common identity and sense of place belonging, facilitating the future interactions between these same actors.** In other words, the external stimulus may lead to combine the individual competencies of an actor with the competencies of other selected actors in the same local community and **that may lead to "embeddedness" or to "spatial dependence". In a functional perspective, a lock-in effect may be the result of the lack of capability by an actor** to perceive and to adapt to a new stimulus, which is too different from his individual capabilities. However, **in a spatial perspective, a lock-in effect may also be the result of the exclusion of some external actors,** who appear too different, and a too strong internal homogeneity within a local innovation system may hinder the receptivity to diversity and the interaction with external actors. Thus, **we may conclude that the time and the space dimensions are**

both relevant in the process of innovation. While the "evolutive approach" clarifies the "path dependent" character of the innovation process, a "network approach" clarifies the "spatially embedded" character of the innovation process, as this latter depends on the interaction between various local actors within a collective learning process.

International Knowledge and Innovation Networks

Knowledge Creation and Innovation in Medium-technology Clusters

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NEW HORIZONS IN REGIONAL SCIENCE

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4.19 THE APPROACH OF TERRITORIAL KNOWLEDGE MANAGEMENT

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KEY POINTS

"Territorial Knowledge Management" (TKM) is an operational framework, which aims to organize the cognitive relationships between the firms in the process of innovation within a local network of cluster (Cappellin, 2003b, 2007; Harmaakorpi and Melkas, 2005; Wink, 2003). TKM shall serve to facilitate the flows of tacit and codified knowledge.

Therefore, TKM represents a new approach to the local innovation policies.

More generally, TKM aims to facilitate the process of interactive learning through the governance of the cognitive relationships in a network of local actors.

The models of knowledge management are not capable to identify neither how the new knowledge is being created nor how from this knowledge value may be created. Thus, Territorial Knowledge Management follows a cognitive rather than an accounting approach and its aim is to explain the key factors leading to the creation of knowledge and how the firms may create value from knowledge through innovation.

The framework of TKM is rather general and it can be applied to different types of networks and different types of knowledge flows

In particular, TKM aims to:

a) promote the creation of the "territorial knowledge capital" (TKC);
b) textract the value of territorial knowledge capital through the enhancement of innovation;
c) guide the creation of new formal and informal institutions, infrastructures, norms, rules and routines;
d) provide a quantitative accounting framework to measure the local strengths and weaknesses in the perspective of the knowledge economy.

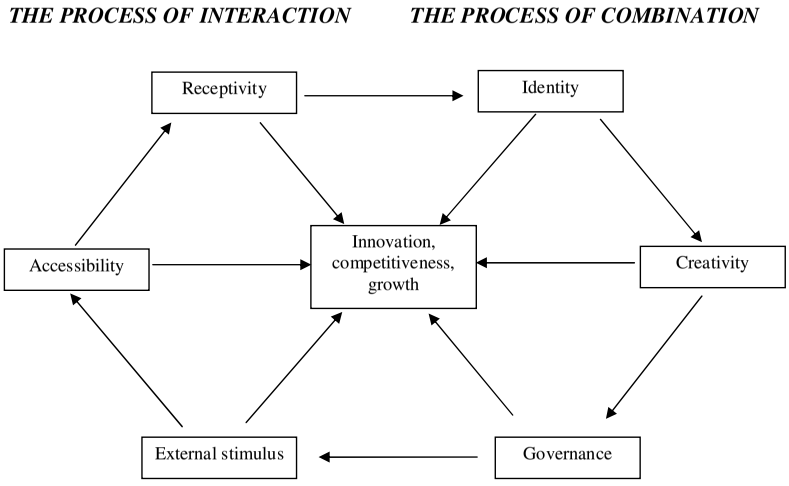

Figure 10: Territorial Knowledge Management as a framework for the governance of regional knowledge networks

The approach of Territorial Knowledge Management is based on the concepts of cognitive economics, such as the concepts of networking and integration, interactive learning and knowledge creation. This approach highlights (Cappellin, 2007) that there are six dimensions or drivers, which represent key necessary conditions for the development of interactive learning processes within a network and the creation of new tacit and codified knowledge:

- external stimulus,
- accessibility,
- receptivity,
- identity,
- creativity,
- governance.

These six factors allow to focus the various policy instruments for the governance of the learning networks in a regional innovation system on a limited number of dimensions, which are tightly related to the factors of the processes of knowledge creation according to the literature in cognitive economics.

While these three factors: external stimulus, accessibility and receptivity, are key factors in promoting interactive relationships or the connectivity between the local actors, the territorial knowledge management framework indicates three other factors, which are crucial in promoting the original re-combination of previous knowledge modules, leading to knowledge creation and innovation.

The approach of TKM represents a theoretical and operative framework based on the concepts of cognitive economics and focusing on the factors leading to knowledge creation. That allows to enlarge the factors traditionally considered in innovation policies, such as technology transfers, R&D investment and labour training, and to consider also other factors, which enhance the process of interactive learning within knowledge and innovation networks in the various regions. This approach is especially suitable in the case of networks of SMEs in intermediate technology sectors. However, it is also useful in regions specialised in high tech o in low tech sectors, where knowledge creation is still, together with others, a key factor of international competitiveness. Table 12 illustrates that the TKM approach can be flexible enough to consider the differences and specific characteristics of three different types of regions and sector specialization.

Table 12: Policy areas according to the Territorial Knowledge Management approach in selected knowledge and innovation networks

	Type of knowledge and innovation network		
Characteristics and factors	**Ecological networks**	**Identity networks**	**Strategy networks**
a) regions, sectors and firms	Peripheral regions Low tech sectors Traditional SMEs	Industrial clusters Medium-tech sectors Innovative SMEs	Urban areas High tech sectors Large enterprises
b) knowledge base	Symbolic/synthetic Knowledge	Synthetic/symbolic knowledge	Analytical/ synthetic knowledge
c) knowledge interaction	Knowledge spill-over	Interactive learning	KM and R&D Joint projects

1. Innovation stimulus	Cost competition in the global market	Customer needs and high supply chain integration	Product innovation in specialized markets and technology push
2. Accessibility	Low international accessibility - low local accessibility	Low international accessibility - high local accessibility	High international accessibility - low local accessibility
3. Receptivity	Low qualification of human resources	Specialized skilled workers	High internal sectoral diversity
4. Identity	Fragmentation and external dependence	High local embeddedness and local identity	Low cognitive proximity and common identity
5. Creativity	Technology adoption	Networking and interactive learning	High investments In R&D
6. Governance	Public infrastructures and finance and deregulation	Multi-level governance at the regional level and bridging institutions	National industrial strategies and firms alliances in specific fields

In fact, many innovations in medium-tech sectors have to integrate science-driven (analytical knowledge) or creative (symbolic knowledge) elements, which characterize either high tech or low tech activities, which may be concentrated in the same region or geographical cluster. In fact, integrated innovations not only require connections between medium and high technologies, but also the comprehension of innovation processes in high-tech and in low-tech sectors. Technologies like the development of composites as new materials are a typical example, where knowledge from high technologies have to be connected with medium-technology productions (where the new materials are used, such as aeronautics and car industry) and low-technology productions (where the new materials are integrated, such as textile).

4.20 THE INNOVATION PROCESS IN MEDIUM-TECH SECTORS

PAGES 172-174

KEY POINTS

Major factors of weakness of clusters specialized in medium tech sectors are: 1) a low international accessibility, 2) lack of creativity and product innovation instead of the hitherto focus on process innovation, 3) need for formal instruments of governance of knowledge relations to enhance the emergence of more formal cooperation between the firms. Innovation policies in the modern industrial clusters specialized in medium technology sectors should take into account the nature of their knowledge base mainly consisting of synthetic and symbolic knowledge and the form of their knowledge interaction characterized by interactive learning processes.

4.21 THE INNOVATION PROCESS IN HIGH-TECH SECTORS

PAGES 174-176

KEY POINTS

Clusters specialized in high tech sectors indicate different key problems, such as: 1) a low local embeddedness of large firms, 2) problems in combining R&D activities or analytical and symbolic knowledge, which are science and technology driven, with creativity, which is driven by the users' needs and the demand, 3) the need to avoid a too high concentration in large firms and to promote spin offs and the participation also by SMEs and other social partners in strategic decision making. These clusters can be mostly found in central and metropolitan urban areas. Innovation policies in central urban areas should take into account the nature of their knowledge base consisting of analytical and synthetic knowledge, and the form of the knowledge interaction characterized by knowledge flows coordinated by knowledge management and joint R&D projects. Knowledge networks in these areas are characterized by links between large firms and research institutions and by professional networks within knowledge intensive business services.

4.22 THE INNOVATION PROCESS IN LOW-TECH SECTORS

PAGES 176-178

KEY POINTS

Clusters specialized in low tech sectors are characterized by various weaknesses, such as: 1) too low international accessibility, 2) the lack of receptivity and qualified skills, 3) the lack of identity and fragmentation in decision-making. These clusters are typically located in less developed and peripheral areas being dependent on public subsidisation and so far exclusively on cost advantages. Innovation policies in the less developed peripheral areas specialised in low tech sectors should take into account the nature of their knowledge base, mainly consisting of symbolic or creativity based knowledge and sometimes synthetic or engineering based knowledge, and the form of knowledge interaction in these regions, characterized by automatic knowledge spill-over based on geographical proximity.

Cappellin, R. (2009), The governance of regional knowledge networks, *Scienze Regionali,* 9, 3, 5-42.

2. The process of interactive learning in knowledge and innovation networks

According the indications of the literature on cognitive economics (Loasby, 2002 and 2003; Egidi and Rizzello, 2003; Rizzello, 1999, 2003; Metcalfe and Ramlogan, 2005), **knowledge creation is the result of a process of pattern making or of the classification and reclassification of external stimulus**. In particular, the innovation process in SMEs and in medium technology sectors has a gradual character and it is driven by **an intensive interaction between the suppliers and the customers and other actors**. This **process of interactive learning** (Lundvall and Johnson, 1994; Foray and Lundvall, 1996; Lawson and Lorenz, 1999) leads to **the development of "tacit" knowledge** which is represented by a complex set of capabilities, which are localized or idiosyncratic and can not easily be transferred (Nonaka and Konno, 1998; Howells, 2002; Wink, 2003; Cappellin, 2003b, 2004a, Cappellin and Wink, 2009). As the process of knowledge creation has an interactive and a combinative character, **a closer geographical proximity and/or a greater cognitive proximity facilitate the interactions** between various complementary actors and the combination of complementary pieces of knowledge.

Knowledge which we now have on the processes of the human mind and brain according to a scientific interdisciplinary perspective helps in explaining the relationships between economic and social actors in the processes of innovation. The mind is a process and not an organism. **We are networks in connexion with a world of networks** (Castells, 2009). **The mind proceeds by networking patterns**, which are stored in our brain, **with models of our sensorial experience,** which we derive from the contact established with our past, present and also future experience, as indicated by our **forecasts of the consequences of given signals**. (Damasio, 1999).

Knowledge sciences show that improvements in the human knowledge base are possible only when **outside stimuli reach the individual's cognitive system and they are integrated and processed within this latter**. In fact, the models of neural networks indicate that the creation of knowledge is the result of an adaptive learning or searching process, which leads to **new synaptic connections of various nodes**. First, the joint impulses or signals coming from other firms or actors **should overcome a certain threshold of intensity**: a condition facilitated by **the existence of common standards of communication and routines.**

Any new stimulus from outside of the cognitive system is then analyzed to determine whether **it fits into the already existing cognitive system, categories, experiences, and cultural values**. In the positive case, an interactive process begins, leading to **the search for consistency and compatibility**. On the other hand, if the stimulus is not compatible with the individual cognitive system, **it is rejected**.

In particular, **a cognitive blockade or lock-in effect may be determined by a too low accessibility or by a too low receptivity**. The accessibility is affected by the existence of infrastructures and institutions that may decrease the distance between any two nodes. On the other hand, **the receptivity is mainly related to the scope of the diversified knowledge available to the actor** or the firm considered because that allows it to identify useful forms of complementarity in the relations with other actors or firms.

Thus, **the external stimulus should be compatible with the internal integrity or "neurognosis"** (Rizzello, 2003) of the local production system and **that leads to a gradual process of adaptation**. In fact, **the aim to preserve the personal identity in the case of an individual actor** and also to **ensure the survival of the organization or the local economy** facing external competition may represent **a powerful challenge leading to innovation.**

In fact, the compatibility with other actors and the success in the adaptation leads to the creation of new connections or to **the reinforcement of existing connections through the development of appropriate routines and institutions** (Hayek, 1937; Nelson and Winter, 1982), which **allows the saving of the limited cognitive capacity of individuals** and organizations and facilitates the process of reciprocal integration (Loasby, 2003). When the same circuit is repeatedly activated, **the synapses of the neurons in the circuit become stronger, till the circuit becomes permanent. The consciousness of oneself, which we may call personal identity**, emerges from the need to integrate the largest number of **mental patterns coming from the perception with the patterns stored in the memory**. **Newly-created knowledge must be gradually consolidated into routines in order to permit further creativity** (Loasby, 2007).

On the other hand, **our brain through the mirror neurons** (Rizzolatti and Craighero, 2004) **is capable to represent the actions of other individuals**, when a person sees another person experiencing an emotion. **That activates the processes of imitation, identification or refusal, empathy and trust and it is the basic mechanism leading to cooperation between humans**. We may also say that **the identity of himself is transformed into a sense of common belonging or to a collective identity.**

Creativity is based on the integration of various abstract logical concepts and of various economic actors with different and complementary knowledge and competencies. Learning is the process whereby previous existing knowledge is selected and is viewed in a new perspective and existing knowledge may be reconverted to satisfy new emerging needs.

That also leads to a process of differentiation between the knowledge nodes, enhancing complementarity and cooperation. The differences between the various actors and firms in a knowledge economy and their interdisciplinary integration are part of an evolutionary process, as the different technical competencies are not static but rather in continuous evolution.

This model of cognition based on interactive learning is clearly incompatible with the competitive or free market approach of standard economics. First, as **theories of rational choice equilibrium consider knowledge as exogenous**, they assume that cognition does not have opportunity costs and they do not provide an economic interpretation of its origin. Second because **the cognitive model is based on the human capability of pattern making** and on **the assumption of the fragmented nature of the knowledge distribution and on selected connections** between a limited number of actors and **that contrasts with the perfect diffusion of information**, which characterizes **the hypothesis of rational expectations**. Third because, in the model of interactive learning, **the relationships between the various economic actors are not based on competition and exclusion**, but on the **identification of common aims, complementarity and cooperation.**

On the other hand, **this model of cognition is also incompatible with a hierarchical planning approach**, based on top down decisions, since **knowledge is not a public good** to be produced by public research institutions, **but it is the result of the interaction between various private, collective and public actors**. The cognitive model does not aim to **indicate "what to do" or to "pick the winners", but it rather aims to indicate "how to do"** and to **enhance the various factors and phases, which have been identified in the process of cognition or knowledge creation** and innovation. Therefore, there is **an isomorphism between the patterns of cognition and the models of regulation** of the relationships between economic actors and we may state that both **the process of creation of new knowledge and the relationships of cooperation,** or of power or of competition between economic agents **are all based on the neural networks of our brain.**

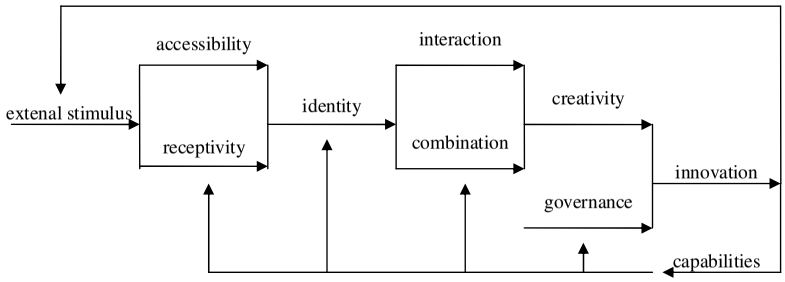

Figure 1: The process of interactive learning and innovation

On the basis of these principles, the model of **"territorial knowledge management" (TKM)** identifies **a logical and temporal sequence between six phases and factors in the process of interactive learning and of innovation** (Cappellin 2003b and 2007; Cappellin and Wink 2009): external stimulus, accessibility, receptivity, identity, creativity and governance, as indicated in figure 1. While **these concepts have individually been extensively described in the economic literature, they have not been linked before between them in a coherent model, based on the**

literature on cognitive sciences. In fact, the external "stimulus" induced by the opportunities of the demand or the pressure of competition or the change in technologies (Kline and Rosenberg, 1986; Fagerberg, 2005) determines a tension leading to the search for a solution of the problems of the firms. This searching process is facilitated by a lower geographical and/or institutional distance or an higher "accessibility" to potential complementary partners (Karlsson, 1997; Howells, 2002; Boschma, 2005; Simmie, 2005; Torre and Rallet, 2005). It also requires a low cognitive distance or an appropriate "receptivity" (Cohen and Levinthal, 1990; Antonelli, 2005) or absorption capacity of these latter.

The creation and strengthening of a common "identity", made by common values, a sense of common belonging, trust relatioships and social or relational capital (Capello, 1999; Crevoisier and Camagni, 2000; Nooteboom, 2002; Capello and Faggian, 2005), is the prerequisite for the cooperation between firms and the search for joint solutions. These new solutions are the result of "creativity" (Florida, 1995; Cappellin, 2003a; Wink, 2007) or of the capability to originally combine different and complementary pieces of knowledge and to interact in the collective learning process between the various local actors (Morgan, 1997; Maillat and Kebir, 1999; Geenhuizen and Nijkamp, 2006). Then, these new ideas can be translated into economic innovations only when appropriate organizations and institutions, or the "governance" (Powell, 1990; Cooke and Morgan, 1998), promotes the commitment of appropriate real resources and of financial funds and the integration of the new ideas with complementary production capabilities.

For example, **this model indicates that the cooperation between two firms and the development of a process of interactive learning between them** require an external factor or problem, which stimulates them to the change. Second, the firms should be close each other and be capable to overcome external obstacles, such as geographic distance and also differences in the language and the institutional environment of the respective region or country. Third, each firm should be receptive and capable to understand the needs of his potential partner. Fourth, the firms should identify common medium or long terms aims and they should develop a relationship of trust and of common belonging, such as in a regional community or in ad hoc groups and joint ventures. Fifth, the firms should invest and combine the respective knowledge resources and capabilities through a tight interaction aiming to the discovery of innovative solutions of the considered problems. Finally, the firms should negotiate and agree an organizational or contractual mechanism, identify precise objectives, define policy instruments and devote financial resources in order to put ideas into practice.

Thus, the stimulus to change and innovation within firms is not only determined by **the pressure of competition, the need to increase productivity and reduce costs, or the opportunity created by the supply of modern technologies and the use of modern equipments**. On the contrary, especially for SMEs in medium technology sectors and also for SMEs in service sectors the most important factor is represented by **the identification of new markets, the aim to adapt to changes in the demand and the opportunity to satisfy new users needs**. The desired outcomes are not just the increase of productivity indicators, often interpreted as a disjoint result, but rather **the speed of a continuous process of innovation,** where each change is the evolution of previous changes. **Entrepreneurship and governance, through public-private partnership**, are required to organize the joint effort of different actors and firms. The focus shifts **from stimulating competition between the local actors to governance or to promote connectivity and iterative processes** of reciprocal adaptation and selection of the best productive combinations.

3. The cumulative character of the process of knowledge creation

The innovation processes have a dynamic character, as it is indicated by the fact that the previous innovation are the base of the following innovation according to a trial and error process of learning. In particular, as indicated in figure 1, the model of TKM highlights the cumulative nature of the processes of interactive learning and adoption of innovation, as the various phases indicated above feedback on each other. In fact, innovation enhances a process of learning and it is leading to the development of the internal capabilities of the individual actors and that is affecting the future evolution path of the innovation system considered. For example, the new knowledge created and the experience accumulated in the previous periods may lead to the building of interfaces facilitating the accessibility to the other actors, to the improvement of the receptivity of the various actors to new ideas and of their capability to understand the emerging needs of potential users, to the strengthening of the sense of common belonging, to the improvement of capability in joint learning and in combining previous respective knowledge and also to the improvement of the organizational and entrepreneurial capabilities.

Moreover, the dynamic and cumulative nature of innovation and learning is demonstrated by the fact that the innovation of a firm is going to change the external selection environment for other firms and it may represent the stimulus to innovation for them, as indicated in figure 1. In fact, the last innovator may set some new initial conditions for a new round of innovation among the firms which are downhill or uphill in the innovation cycle (Cappellin, 2009). Each firm in turn uses the contributions previously elaborated by other firms and at the same time it may assume the lead of the innovation effort, performing the role of the key innovator and providing an original opportunity both for the other follower firms in the supply chain, who will continue the innovation effort, and for the competitors, who will imitate and improve his original solutions. The almost spontaneous coordination between the firms in an innovation network allows an high flexibility and to rapidly change the direction of the innovation effort, reacting to new opportunities or challenges.

In fact, like a school of fish moves in a coordinated manner and it may suddenly change its direction and also its speed, many firms and actors participate within a network to the process of innovation, performing specific tasks and introducing innovation in their respective field of activity. They procure innovative products/services from supplier firms and provide innovative products/services to client firms. Inputs sources are complementary between themselves and on the other hand clients of the products are fungible between themselves. The selection of suppliers and that of possible clients is related to their respective waiting and searching times and is affected by the scanning costs and switching costs (Cappellin, 2009).

The speed of the innovation process is determined by the speed through which the firm is capable to orient itself and to select between the possible suppliers and between the possible clients. This speed and the time lags between the innovation of a firm with respect to the innovation in the other cooperating firms, which have previously innovated or which will use the results of its innovation, depends on the adaptive and strategic behaviours of each firm and on various types of costs and factors, such as the adjustment or switching costs (Cappellin, 1983b) from one technological solution to a new solution and the transaction costs (Williamson, 1981), which affect the coordination of a firm with the other firms. In particular, these costs can be related to various factors, such as: the geographical distance and the cognitive distance between the partners, the transaction costs in the

negotiation process, the receptivity of each partners, the memory of previous experience, the reciprocal learning costs, the trust relationships, the risk of opportunistic behaviours by the partners and by the asymmetry of information, the different preference for the future and novelty, the risk aversion and also the existence of specialized services and bridging institutions.

Thus, in a dynamic environment the creation of value and of new knowledge depends on the integration of the knowledge acquired from many firms and the speed of innovation depends on the interaction between a plurality of actors. Innovation requires flexible forms of cooperation between many different private and public, regional and international actors, such as large firms, SMEs suppliers, knowledge intensive services, higher education and research institutions, financial intermediaries, public administration and many other partners such as professional association and media. Innovation requires the combination of different competencies within a process of collective learning, as firms must cooperate to increase and diversify their knowledge base.

Networks are characterized by lower adjustment or switching costs (Cappellin, 1983b) in the choice of new possible partners and of new technological solutions and also imply less transaction costs (Williamson, 1981; Cappellin, 1988) with other actors in inter-firm relationships than a competitive market made by isolated producers and users. While competition (i.e. free market) and monopoly (i.e. hierarchy) are static models of regulation, networks allow the regulation (i.e. governance) of the dynamic processes of iterative adaptation, specialization and selection both within individual firms and at the aggregate level between the different firms.

4. The role of institutions in knowledge networks.

Due to their flexibility, networks represent the most effective form of organization to promote a fast speed of innovation. In fact, the major advantage of the network model of organization is to insure to the firms a faster access to a wide scope of complementary competencies existing in other firms and to remove the barriers, which are hindering to operate into new products, processes and markets and could lead to a lock-in situation. Through network integration, firms are capable to decrease the resources and time for adopting an innovation, with respect to the situation where they would be required to internally develop these capabilities. Weak ties or indirect links can easily be transformed into strong ties or direct links (Granovetter, 1973), when the need to respond to external opportunities and threats make that necessary. Within networks, firms can easily change the level of cooperation with previous partners, as implicit or informal contracts can more easily be adapted than explicit or formal contracts. This high flexibility is a key competitive factor in a dynamic market, where innovation has to be adopted faster than competitors.

In this respect, institutions play a key role in the process of knowledge creation. In general, rules, procedures, organizational forms, norms, routines constitute the foundation of organizational behaviour. Rules and organic institutions standardize the world and in so doing they simplify the ambit in which humans use their limited cognitive capabilities. In fact, routines facilitate the connections and create free time to be devoted to the explicit thinking on innovation (Hayek,1952).

According to Loasby (2003), the maintenance of stable baselines within particular domains is a prime function of formal organisations, and the appropriateness of the baseline is a major determinant of organisational success or failure. The stability of the networks is insured by the existence of adequate hard and soft infrastructures representing a public good and being not only created by the individual actors themselves but also by the public authorities.

Moreover cognitive processes indicate an evolutionary sequence made by variety generation, selection, and the preservation of selected variants in the form of modified or novel routines and institutions (Loasby, 2003). The role of institutions is that to create new routines or baseline, which insure the adaptability of connections between actors (Hayek, 1952). The existence of a well-developed institutional system, made by various structures and infrastructures facilitates the relationships and decrease the transaction costs. Cognitive theories underline that the creation of new connections or the reinforcement of existing connections implies the compatibility with other actors, the success in the adaptation and the development of appropriate routines and institutions. Therefore, a central concern of policy should be the creation of institutions, which may enhance the connectivity of knowledge.

In particular, a rather diversified typology of institutions play a leading role in defining a long term strategy of innovation of medium technology sectors within the different regions (Cappellin and Wink 2009). These institutions represent the "social capital" of these regions and play the role of immaterial infrastructures, which organize the knowledge flows between various firms. Moreover, institutional solutions to overcome lack of resources by SMEs are regionally specific and influenced by long-term historical and cultural heritage within the region.

Regional knowldege and innovation networks lead the various actors to invest in the creation or strengthening of soft and hard infrastructures and routines linking them. That makes the relationships between firms more intense or increases the speed of the flows between the firms. The capability of the individual firm to orient itself between the various suppliers and the possible users of its own products depends on the existence of institutions and organizations, which stimulate the reciprocal trust and limit the risk of unfair behaviours, and of specialized professional services (KIBS), which perform the function of bridging institutions or of immaterial infrastructures between the various firms. In fact, the speed of decision and coordination in a network depends to a large extent on the actor who performs the function of leader and is capable to orient the other actors.

From an institutional perspective, networks are models of governance of the relationships between various actors, characterized by feedbacks in the flows of information and by incremental and cumulative processes of interactive learning and evolution. Networks are a form of learning organization, which insures a greater overall dynamic efficiency.

5. A comparison between the cognitive model and the linear model of innovation

According to a methodological perspective, the cognitive model of innovation illustrated above is different from the linear model of innovation, which supposes a logical and temporal sequence between basic research, applied research, development, production, marketing and diffusion. In particular, this traditional model leads to overlook various important types of knowledge different from the analytical or codified knowledge (Asheim, Boschma and Cooke, 2007), such as synthetic or engineering based knowledge and symbolic or creativity based knowledge and also managerial and institutional knowledge or capabilities. Further limits of the linear model are that it considers only the internal process of innovation within the individual firm or the in-house R&D activity rather than the case of interacting firms and that it focuses on the process of the transfer of knowledge from research to innovation rather than explaining the process of the generation of knowledge. In fact, while a linear approach aims to promote transfers of information and modern technology or to provide customized expertise to the individual firms, a systemic approach (Lundvall, 1992; Antonelli, 2005) focuses on promoting knowledge networks and cooperation between the various local and external firms and actors in the regional innovation systems and on the development of their internal capabilities. This cognitive model is also different from the "chain linked model" (Kline and Rosenberg, 1986), which envisages a tight relation or feedback within an individual firm between production activities and those of commercialization and research. On the contrary, the cognitive model highlights the interaction between different firms and actors, and it has a systemic nature.

The six driving factors of the Territorial Knowledge Management are compatible but clearly different from the four factors of **the Porter's diamond of competitiveness and productivity in a cluster** (Porter, 1998; Martin and Sunley, 2003): **firm strategy and rivalry (the nature and intensity of local competition); factor input conditions (the cost and quality of inputs); demand conditions (the sophistication of local customers); and related and supporting industries (the local extent and sophistication of suppliers and related industries).** In fact, these four factors are related to the concepts of identity, external stimulus, and accessibility indicated by the territorial knowledge model. But, they seem to indicate **the effects of the local business environment on the geographical location of firms in a cluster**, rather than to consider explicitly **the internal factors affecting the behaviours of firms and other regional and external actors in the processes of knowledge creation and innovation**, such as the concepts of **receptivity, creativity and governance**.

Finally, the cognitive model seems appropriate to explain innovation in SMEs of medium technology sectors and in service activities, but it may be useful also in highlighting **some characteristics of R&D activities**. Cognitive theories, which focus on the process of generation of knowledge, explain that **knowledge and innovation are the result of an interacting learning process occurring in a network made by various actors and allow to identify different phases or factors of this process**. In particular, a systemic or cognitive model underlines the importance for innovation of **three general concepts: connectivity, creativity and speed of change** (Cappellin, 2003a, 2009; Cappellin and Wink, 2009), **which apply also to the high technology sectors**. Thus, this model of innovation highlights the **tight technological interdependence existing between the medium technology industrial sectors and the high technology industrial sectors**.

Moreover, even in the high technology sectors, **the process of knowledge creation has recently changed**. In fact, according to a cognitive perspective, **R&D activity should not be considered as a black box** transforming inputs into outputs or R&D funds into patents and publications. On the contrary, **tacit knowledge of the individual researchers**, **interactive learning within research teams, networks of extensive and systematic international cooperative relationships** and concepts such as: **trust, identity, leadership and social capital** seem to be key characteristics also of **scientific communities and knowledge organizations,** such as scientific associations and journals, and of R&D activities within universities and firms.

In conclusion, a radical shift of perspective is needed from a traditional paradigm based on the concepts of technologies, R&D expenditure, rational process of optimization of the individual firms, market competitions between firms and resistance or receptivity of labour to the new technologies. On the contrary, innovation processes can be interpreted according to a new paradigm focused on the processes of knowledge creation, interactive learning, iterative adaptation and selection within innovation networks, and focused on the development of the internal creativity and entrepreneurial capabilities of firms and actors.

6. The spatial dimension of the learning process and territorial knowledge management

Clearly space and territory matter in the processes of cognition and generation of knowledge. Cognitive processes have a localized dimension and the innovation process have a "territorially embedded" character and that favours the spatial agglomeration of innovative activities. In this perspective it may be useful a distinction which is related to the three well known concepts of **"polarised region", "homogenous region" and "planning region",** which respectively focus on the concepts of tight flows, of place identity and of common institutions. **First, if interactive learning** is the key process in knowledge creation, then it is clear that **the links and the frequency of the contacts between the nodes of the network are constrained by the spatial and/or cognitive distance**.

Second, **knowledge is the result** not only of the combination of a new stimulus with the individual previous experience, which characterized the personal identity, but also **of the combination of different competencies between the various actors, who are interacting in a learning process occurring within a given geographical and sectoral cluster or network, which has a collective identity.** Thus, in a spatial perspective, the same stimulus may determine a **different pattern of response in each regional innovation system according to the different characteristics of the network of the local actors**. Regions are characterized by **different place identities and by a different homogeneity or internal diversity and complementarity between the local actors**, leading to **trust, common identity and sense of place belonging, and that may facilitate or hinder innovation.**

Finally, the success in solving previous problems is leading to strengthen particular links between some local specific actors and to **create soft infrastructures, such as routines, norms, organizations, intermediate institutions and public institutions, which will facilitate the future interactions** between these same actors in the region considered. Therefore, **the policy networks of regional actors and the institutional thickness of a region may enhance the speed of innovation.**

Moreover, different types of networks exist. **Territorial networks may be classified into three types of networks: "ecological networks", "identity networks" and "strategic networks", having different characteristics** (Cappellin, 2003b, 2007). 'Ecology networks', such as "Third Italy" industrial districts in the late 60'ties and early 70'ties, are characterised by **strong unintended interactions between various actors and facilitate various forms of traded and un-traded technological interdependencies or technology spill-over**, as it occurs in geographical agglomerations. 'Identity networks', such as "Third Italy" industrial districts in the late 90'ties, are based on **the sense of identity and common belonging and on the existence of trust relationships and specialised intermediate institutions ("social capital").** 'Strategy networks', such as metropolitan areas and some industrial clusters in various European countries during the 2000'ties, are based on **intended relationships and cooperative agreements between firms** and other organisations. This typology differs in some respects from similar typologies (Gordon and MacCan, 2000; Cooke, Heidenreich and Braczyk, 2003; Asheim and Coenen, 2005; Tödtling and Trippl, 2005).

Therefore, regional production systems may evolve from the form of a simple agglomeration of similar SMEs, such as in so called "ecological networks", to the form of communities characterized by intense processes of interactive learning, such as in so called "identity networks", and then they may finally evolve to the form of "strategy networks", characterized by an explicit governance of knowledge interactions between the various firms. In particular, the six phases of the process of knowledge creation and of interactive learning illustrated above in **the approach of "Territorial Knowledge Management" allow to identify the objectives or priorities of the innovation policies in different types of region.**

Thus, major factors of weakness of the "identity networks", such as clusters specialized in medium tech sectors seem to be: 1) a **low international accessibility, 2) the relative lack of creativity** and of major product innovation instead of the hitherto focus on process innovation in traditional productions, **3) the need for formal instruments of governance of knowledge relations** to enhance the emergence of more formal cooperation between the firms. Moreover, innovation policies in the modern industrial clusters specialized in medium technology sectors should also take into account the nature of their knowledge base mainly consisting of synthetic and symbolic knowledge (Asheim, Boschma and Cooke, 2007)and the form of their knowledge interaction characterized by interactive learning processes.

On the other hand, clusters specialized in high tech sectors indicate different key problems, such as: **1) a low local embeddedness of large firms**, **2) problems in combining R&D activities or analytical and synthetic knowledge,** which are science and technology driven, with symbolic knowledge and creativity, which is driven by the users' needs and the demand, **3) the need to avoid a too high concentration in large firms and to promote spin offs** and the participation also by SMEs and other social partners in strategic decision making. These clusters can be mostly found in central and metropolitan urban areas. Innovation policies in these areas should take into account the nature of their knowledge base consisting of analytical and synthetic knowledge, and the form of the knowledge interaction characterized by knowledge flows coordinated by knowledge management and joint R&D projects. Knowledge networks in these areas are characterized by links between large firms and research institutions and by professional networks and knowledge intensive business services.

Finally, clusters specialized in low tech sectors are characterized by various weaknesses, such as: 1) too low international accessibility, 2) the lack of receptivity and qualified skills, 3) the lack of identity and fragmentation in decision-making. These clusters are typically located in less developed and peripheral areas, so far exclusively compete on cost advantages and to a large extent are dependent on public subsidisation. Innovation policies in the less developed peripheral areas specialised in low tech sectors should take into account the nature of their knowledge base, mainly consisting of symbolic or creativity based knowledge and sometimes synthetic or engineering based knowledge, and the form of knowledge interaction in these regions, characterized by automatic knowledge spill-over based on geographical proximity.

Therefore, according to the territorial knowledge management approach and a cognitive perspective, **innovation policies does not only consist in the financing with public resources the private R&D investment**, but they should **facilitate the accessibility between the actors, stimulate their internal capabilities, increase their receptivity, promote a sense of belonging to the same community and the identification of common aims, facilitate the relationships with different and complementary both regional and external actors for the creation of new firms and productions and accelerates the sequential and cumulative process of trial and error between the innovation of different firms.** For these reasons, cluster policies require new forms of regulation of the relationships between the various local actors and also the identification or creation of new organizations and institutions. The multiplication of players, the management of the knowledge relationships between them and the variety of the layers of negotiation: international, national, and local (Cappellin, 1997, 2005), **demand a different model of regulation, called "multi-level governance", based on organisational structures of interaction and partnership.**