Towards a new Conceptualization of Innovation in Space
Territorial Patterns of Innovation

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1. The need for a new conceptual approach in regional innovation

The importance of innovation and – in the most recent conception – of knowledge in explaining the competitiveness of economic systems has found a resurgence of interest and inspiration by policy makers over the last ten years. The Lisbon agenda, formulated by the Lisbon and Luxembourg Ministerial meetings at the beginning of the last decade (2000 and 2005), was engaging the Union to become the most competitive and dynamic knowledge-based economy in the world. The main target was to increase EU R&D intensity (over GDP) from 1.8% in the late 1990s to about 3% by 2010.

Despite these policy scopes, in 2009 R&D intensity has remained stable at the level of 1.84% of GDP and, although some EU member countries like Sweden and Finland have reached quite high R&D intensity (Sweden had already several years ago exceeded 3%), the majority of EU countries and regions is significantly below 2% (Čenys, 2009).

The idea of increasing competitiveness through knowledge and innovation has not been abandoned, and instead it has been re-launched in the Europe 2020 Strategy document, where the scope of a smart growth calls again for the achievement of 3% of the EU's GDP (public and private) to be invested in R&D/innovation, and Europe is called to become a knowledge-society, through the production and use of advanced technologies (CEC, 2010).

The scientific debate on the role of knowledge and innovation as strategic elements behind the competitiveness of regions and countries has always strongly supported this policy frame. The interpretative approach that has taken place since the 1980s stresses the importance of pervasive and horizontal functions like R&D and high education in the process of knowledge creation and innovation diffusion. "Scientific regions", hosting large and well-known scientific institutions, were studied deeply and relationships between these institutions and the industrial fabric were analyzed, with some disappointment as far as an expected but not often visible direct linkage was concerned (MacDonald, 1987; Massey et al. 1992; Monk et al., 1988; Storey and Tether, 1998). Indicators of R&D inputs (like public and private research investment and personnel) and increasingly indicators of R&D output (like patenting activities) were used in order to understand the engagement of firms and territories on knowledge, intended as a necessary long term precondition for continuing innovation (Dasgupta and Stiglitz, 1980; Antonelli, 1989; Griliches, 1990). This approach was equating knowledge and scientific research, assuming that the presence of local knowledge produced by research centres and university was a necessary and sufficient condition for increasing the innovation capacities in local firms, fed by local spillovers.

The difficulties encountered in achieving the Lisbon Agenda stimulated reflections on the need for new innovation policy style and scope by a smart group of scholars, stressing the need for replacing a thematically/regionally neutral and generic innovation policy - a "one size fits all approach" - with a policy built on smart specialization of R&D activities in different regions and on an exploitation of the advantages stemming from specialized R&D concentration (CEC, 2008; Foray, 2009).

These reflections sound rather shareable. A smart specialization is a way out of the thematically/regionally neutral and generic orientation of R&D funding investments. Core regions can be seen as the natural places for general purpose technologies, which can achieve a critical mass of scientists and knowledge able to achieve increasing returns to R&D, leaving to "peripheral" regions the role of co-inventors of applications in their technological domain (Foray, 2009). R&D funding investments become in this logic targeted in a thematic and regional sense; general purpose technological R&D investments find their most efficient destination to core regions, while R&D funding in specific innovation applications are destined to peripheral regions, each of them finding a specific role in a knowledge production hierarchy based on its comparative advantage (Pontikakis et al., 2009).

Starting from these recent reflections, some space exists for a further conceptual framework of analysis on the reasons for the failure of the Lisbon strategy and on possible new innovation policy styles. In particular, a new conceptual framework on the determinants of innovation capability at regional level is required that goes beyond some simplified assumptions that still accompany the most recent reflections. In particular, the ideas of a simple equation between knowledge and scientific research, of a simple core-periphery dichotomy in R&D activities, of the call for R&D expenditure as the only way to boost innovation processes, require some additional thinking in a new conceptual framework able to overcome these limits and to drive normative interventions towards *thematically/regionally focused innovation policies*.

Our reflections start from the assumption that the presence of advanced sectors and advanced functions like R&D and higher education are special features of only *some of the possible innovation paths* and, though relevant, cannot be considered as necessary or sufficient preconditions for innovation. Furthermore, emphasising *per se* interactive processes between the different actors of knowledge development as the crucial element in knowledge creation and diffusion is again not completely satisfactory.

Instead, all the valid scientific contributions brought about in the field of knowledge creation (Dasgupta and Stiglitz, 1980; Antonelli, 1989; Griliches, 1990) and of knowledge spillovers (Acs et al., 1994; Audretsch and Feldman, 1996; Anselin et al., 2000; Paci and Usai, 2009) can be the basis for a new conceptual framework that aims at interpreting the different patterns of territorial innovation, defined as a combination of *context conditions* and of *specific modes of performing the different phases* of the innovation process. This work is a first reflection in this direction.

The structure of the paper is as follows. In the next section the theoretical achievements in regional innovation and knowledge approaches are highlighted and the still open challenges underlined. In section 3 a new conceptual approach is presented, which tries to tackle the open challenges. Section 4 presents the possible conceptual innovation patterns. Policy implications will be presented in the last section.

2. Theoretical achievements in regional innovation approaches

Innovation diffusion at regional level attracted the interest of regional economists and geographers at the end of the 1960s, when the neoclassical paradigm that innovation is a "manna from heaven", equally distributed among firms and in space, was questioned. In these approaches, innovation is an exogenous event that propagates through specific territorial channels to generate positive impacts on a local area from outside. Analyses should therefore examine the territorial routes whereby innovation reaches a particular area: routes formalized in

models of the spatial diffusion of innovation, whose main feature consists in an epidemic approach to the diffusion. The pure likelihood of contact between people who have already adopted an innovation and its potential adopters explains innovation diffusion in this model, which implicitly assumes that every potential adopter has the same opportunity to adopt, and that spatial variations in adoption are due solely to information flows that spread territorially at different times (Hägerstrand, 1967) (Table 1). In this approach, information means innovation, and innovation means higher economic performance, in a natural and undisputed short-circuit. The role of space in this theory is that of spatial friction to information flows; the latter find their natural source in large cities and then propagates through cities at the lower level of the urban hierarchy thanks to infrastructures and economic flows.

The idea that the spatial diffusion of innovation is influenced less by geographic distance among adopters than by economic distance has been introduced in the model of spatial innovation by economists: the amount of productive activity in an area, and its levels of income, consumption and investment, can straightforwardly explain the greater receptiveness of an adoption area (Griliches, 1957; Mansfield, 1961; Metcalfe), and empirical analyses developed more recently in different technological trajectories, namely robotics and ICTs development, witnessing the importance of the stage of economic development for interpreting technological penetration rates, speed of adoption and historic moment of first adoption (Camagni, 1985; Capello, 1988).

When a need for an endogenous approach to regional innovation was felt, the conditions for innovation creation came to the fore as a second stage of reflections. In this literature, innovation is interpreted as a production of high-tech goods or services, assuming an immediate link between invention and innovation taking place inside individual firms (or their territories) operating on advanced sectors. R&D facilities are in fact strictly linked to production facilities, while firms tend to cluster inside high-tech districts in order to take advantage of all sorts of proximity externalities. In this approach, the mere presence of high-tech sectors was a condition for a region to innovate. The spatial conditions behind local innovation were empirically identified. Externalities coming from the presence of advanced education facilities were invoked to explain innovation capacity, but international accessibility, advanced urban atmosphere, traditional industrial competencies under reorientation (Malecki, 1980; Saxenian, 1996) were also suggested.

When many knowledge-based advances were actually introduced by “traditional” sectors – such as textiles and car production – in their path towards rejuvenation, it became evident that the “sector-based” approach was not sufficient; knowledge creation became the main aspect of scientific interest. Conceptual efforts were made to explain the different regional capacities in generating knowledge.

A first wave of reflections were mainly interpreting the capacity of a region to create knowledge thanks to the presence of pervasive and horizontal functions like R&D and high education (MacDonald, 1987; Massey et al. 1992; Monk et al., 1988; Storey and Tether, 1998). The link between knowledge creation and innovation was interpreted as the result of a sort of division of labour operated between R&D/higher education facilities on the one hand and innovating firms on the other. Their interaction produced academic spin-off or knowledge spillover flowing from the former to the latter, and subject to strong distance decay effects (Acs et al., 1994; Audretsch and Feldman, 1996; Anselin et al., 2000).

At the beginning of the 1990s, knowledge creation was studied from a different perspective, mainly attributing to the cognitive capability of regions their degree of knowledge creation (Foray, 2000), stressing the role of interaction, synergy and cooperation among local actors as

the main source of collective learning processes, and therefore of knowledge creation. Areas, local milieux as they are called, were pointed to be the loci for the construction of knowledge (Camagni, 1991; Perrin, 1995; Keeble and Wilkinson, 1999 and 2000; Capello 1999; Cappellin, 2003a), thanks to network relations (long-distance, selective relationships), interaction, creativity and recombination capability, nourished by spatial proximity and atmosphere effects.

Table 1. Alternative Approaches to Knowledge and Innovation Studies

	Innovation diffusion	**Innovation creation**	**Knowledge creation**		**Knowledge diffusion**	
			Functional approach	**Cognitive approach**	**Spatial approach**	**Evolutionary approach**
Aim of the theory	Identification of the spatial channels supporting innovation diffusion	Identification of the reasons for local innovation creation	Identification of the reasons for local knowledge creation		Identification of the reasons for local knowledge diffusion	
Knowledge-innovation linkage	Information-adoption short circuit	Invention-innovation short circuit	Spin-offs, spatial spillovers	Collective learning, local synergies Entrepreneur-ship	Spin-offs, spatial spillovers	Common cognitive codes
From innovation to performance	Adoption-performance linkage	Radical innovation, Schumpeteria n profits	Technological breakthrough, royalties on patents	Continuing innovation, productivity increases	Knowledge-performance linkage	
Location regions	Regions along the urban hierarchy	Advanced regions	Scientific regions	Milieux Learning regions	Networking regions	
Role of space	Barrier to information diffusion	Proximity economies, specialisatio n advantages	Agglomeratio n economies	Uncertainty reduction, relational capital	Proximity economies	
Period	End of the 1960s and 1970s	Middle of the 1980s	End of the 1980s and 1990s	End of the 1980s and 1990s	Middle of the 1990s onward	Middle of the 2000s
Key references	Hägerstrand, 1952; Griliches, 1957; Mansfield, 1961; Metcalfe, 1981; Camagni, 1985; Capello, 1988	Malecki, 1980; Saxenian, 1996	MacDonald, 1987; Massey et al. 1992; Monk et al., 1988; Storey and Tether, 1998	Camagni, 1991; Perrin, 1995; Keeble and Wilkinson, 1999; Capello 1999; Cappellin, 2003a; Lundvall and Johnson, 1994	Acs et al., 1994; Audretsch and Feldman, 1996; Anselin et al., 2000	Boschma, 2005; Rallet and Torre, 1995; Capello, 2009

The "learning" region was also identified as the place where such cognitive processes play a crucial role, combining existing but dispersed know-how, interpretations of market needs,

information flows with intellectual artifacts such as theories and models and allowing exchange of experiences and co-operation (Lundvall and Johnson,1994).

The cognitive approach highlights an explicit link between knowledge and entrepreneurship as a link between knowledge and innovation adoption. The subsequent idea posits that investments in knowledge by incumbent firms and research organizations such as universities will generate entrepreneurial opportunities because not all of the new knowledge will be pursued and commercialized by the incumbent firms. The knowledge filter (Acs et al. 2004) refers to the extent that new knowledge remains un-commercialized by the organization creating that knowledge. It is these residual ideas that generate the opportunity for entrepreneurship. The capabilities of economic agents within the region to actually access and absorb the knowledge and ultimately utilize it to generate entrepreneurial activity are not assumed to be invariant with respect to geographic space, as has been always thought. In particular, diversified areas, in which differences among people that foster looking at and appraising a given information set differently, thereby resulting in different appraisal of any new idea, are expected to gain more from new knowledge.

Therefore, in the most recent time, the two approaches of knowledge creation were put aside, leaving space for a debate on the way knowledge spreads at the local level. Spatial proximity was at first seen as the main reason explaining the channels through which knowledge spreads around: moving in a certain sense back to the original contribution on innovation diffusion in the 1960s, the pure likelihood of contact between a knowledge creator (an R&D laboratory) and a potential recipient (a firm, a university, another R&D centre) was seen as the main vehicle for knowledge transmission, in a pure epidemic logic (Acs et al., 1994; Audretsch and Feldman, 1996; Anselin et al., 2000). The theory of technological spillovers developed in the 1990s linked the spatial concentration of innovative activities with the increasing returns that concentrated location generates on those innovative activities themselves. Cross-fertilizations, dynamic interactions between customers and suppliers, synergies between research centres and local production units occur within circumscribed geographical areas like highly-specialized metropolitan areas. They do so as the result of the rapid exchange of information and transmission of tacit knowledge made possible by face-to-face encounters. In a concentrated location, the beneficial effects of a firm's research and development activities are not confined within the boundaries of firms; they 'spill over' into the surrounding environment, to the advantage of innovative activity by other firms. A large number of empirical analyses, mainly econometric, has successfully measured the technological spillovers and the knowledge advantages enjoyed by spatially concentrated firms. Space is purely geographical in this approach, a physical distance among actors, a pure physical container of spillover effects which come about – according to the epidemiological logic adopted – simply as a result of contacts among actors, whose probability to occur enhances in a limited geographical area.

The simplicity of this approach soon became evident, and a large debate was developed on the necessity to enrich the spatial proximity with cognitive aspects, able to differentiate the absorptive capacity of different actors within a region. Knowledge creation and innovation are in fact a cumulative and localized outcome of search (Antonelli, 1989); as the result, the cognitive base of actors and organization and their potential for learning differ substantially. Different concepts of proximity, from social, to institutional, cultural and cognitive proximities, were added as interpretative elements in knowledge spillovers, enriching the conceptual tools interpreting knowledge diffusion (Boschma, 2005; Rallet and Torre, 1995; Capello, 2009).

These approaches are all interesting per se, and over time built a rich scientific apparatus on the way knowledge and innovation take place in space. Their richness is witnessed by the multiple

scientific paradigms on which they find their roots; from economic geography, to evolutionary theory of innovation, to neo-Schumpeterian theories on local development, to evolutionary geography, and enrich the understanding of local innovation processes.

However, they have one aspect in common, which represents the limits of the present scientific know-how on local knowledge and innovation. All these theories base their reflections on *one particular phase* of the innovation process, often interpreted as the crucial one, being either knowledge creation, innovation creation, innovation diffusion or knowledge diffusion. Some theories even interpret knowledge and innovation as coinciding processes, giving for granted that if knowledge is created locally, this inevitably leads to innovation, or if innovation takes place, this is due to local knowledge availability. A similar short-circuit is assumed between knowledge/innovation and performance, expecting a productivity increase in all cases in which a creative effort, a learning process, an interactive and cooperative atmosphere characterize the local economy.

Instead, factors that enhance the implementation of new knowledge can be quite different from the factors which stimulate invention and innovation. Invention, innovation and diffusion are not necessarily intertwined, even at the local level. Firms and individuals which are leading an invention are not necessarily also leaders in innovation or in the widespread diffusion of new technologies. The real world is full of examples of this kind; the fax machine, first developed in Germany, was turned into a worldwide successful product by Japanese companies. Similarly, the anti-lock brake systems (ABS) was invented by US car makers but became prominent primarily due to German automotive suppliers (Licht, 2009).

Moreover, it is by no means always the case that technological catching-up shows a positive correlation with economic convergence; the strong economic growth performance of Eastern countries up to 2008 is certainly not related to knowledge economy growth, as these countries (and their regions) have witnessed no technological catching-up in those years. Regional economic growth is weakly related to different scientific indicators, both of input (R&D) and of output (patenting activity). As a proof of what we say, a simple correlation run on a sample of 286 NUTS2 regions in Europe between regional growth in the years 2006-2008 and R&D on GDP in 2007 shows a negative (and significant) value (-0.33); the value of the R index remains negative and significant (-0.23) when the correlation is measured between regional growth in the years 2006-2008 and patents per capita in a period of 2005-2006

All this suggests that innovation can be the result of different patterns, different modes of performing each phase of the innovation process. The variety of innovation modes explains the failure of a “one size fits all” policy to innovation, like the thematically/regionally neutral and generic R&D incentives, with the expectation to develop a knowledge economy everywhere. On the contrary, innovation modes typical of each specific area have to be identified, on which ad-hoc and targeted innovation policies can be drawn.

3. Territorial patterns of innovation: a proposed definition and a framework

Our impression is that space exists for further conceptual reflections that help policy makers to draw effective policies to launch the European competitiveness based on a knowledge-economy. In particular, the paradigmatic jump in interpreting regional innovation processes lies nowadays in the capacity to build on the single approaches developed for the interpretation of knowledge and innovation a conceptual framework interpreting not a single phase of the innovation process, but the *different modes of performing the different phases of the innovation process*,

highlighting the *context conditions* (internal and external to the region) that accompany each innovation pattern. In this way, we are able to take into consideration alternative situations where innovation builds on internal knowledge, or where local creativity allows, even in front of the lack of local knowledge, an innovative application thanks to knowledge developed elsewhere and acquired via scientific linkages, or where innovation is made possible by an imitative process of innovation outside the region.

This new interpretative paradigm – the innovation patterns paradigm, stressing complex interplays between phases of the innovation process and spatial context or territorial conditions - adds two new elements with respect to the previous theoretical paradigms. First of all, it disentangles knowledge from innovation, addressing the two as different (and subsequent) phases of an innovation process, each phase calling for specific local elements for its development, and having a different natural location depending on the presence of the factors that support their development. This approach refuses the assumption of a invention-innovation short circuit taking place inside individual firms (or their territories) operating on advanced sectors, as well as an immediate interaction between R&D/higher education facilities on the one hand and innovating firms on the other, thanks to spatial proximity.

The temporal necessarily sequentiality between knowledge source and innovation, and between innovation and economic performance - we refer here to the so called "linear model of innovation" - has been heavily criticized since it is rooted in the idea that innovation can be analyzed as an "rational" and "orderly" process (Edgerton, 2004). However, we strongly believe that: i) scientific advance in many cases is a major source of innovation, fully recognizing that they are neither necessary nor sufficient conditions for innovation to take place; ii) an alternative model where "everything depends on everything else", with no specific structure of the innovative system fully and clearly specified, does not help in generating a conceptual analytical model able interpret the systemic, dynamic and interactive nature of innovation; iii) self-reinforcing feedbacks from innovation to knowledge and from economic growth to innovation and knowledge play an important role in innovation processes. The impact of science on innovation does not merely reside in the creation of new opportunities to be exploited by firms, but rather in increasing research productivity and therefore the returns to R&D, through the solution and exploitation of technical problems, elimination of research directions that have proven wrong from a scientific perspective and provision of new research technologies (Nelson, 1959; Mowery and Rosenberg, 1998; Balconi et al., 2010). We therefore strongly support the concept of a "fragmented (spatially diversified) linear model of innovation", in which the patterns of innovation are a linearization, or partial block linearization of an innovation process where feedbacks, interconnections and non-linearities, in the form of increasing returns, find a prominent role.

Secondly, the concept of "patterns of innovation" calls for the identification of the context conditions, both internal and external to the region, that support the different innovation phases; these context conditions become integral part in the definition of a *territorial pattern of innovation*. In this sense, the approach does not look for the territorial capabilities that allow territories (in general) to exploit innovation and knowledge, like the presence of human capital. The conceptual framework looks for the *territorial specificities (context conditions)* that are behind *different modes of performing the different phases of the innovation process* and that become integral parts of a territorial pattern of innovation.

An integrated conceptual framework like this one identifies the local conditions that guarantee: a) the shift from local knowledge to innovation; b) the acquisition of external knowledge to innovate locally; c) the acquisition of external innovation for imitation with different degrees of

creativity. It builds on both the different modes of performing innovation and the context conditions that guarantee the different phases of the innovation process is the way forward. The conceptual effort rests therefore in the identification of the combination of context conditions that accompany each phase of the innovation process, and give rise to alternative patterns of innovation.

A territorial pattern of innovation is therefore defined as a combination of *context conditions* and of *specific modes of performing the different phases* of the innovation process.

Basic elements of a territorial pattern of innovation are:

1) agents: regions. In a territorial pattern of innovation the agents are identified in regions as collective actors, when innovation and knowledge processes take place across regions. Local firms and non-corporate entities are instead the referent agents, when intra-regional flows of innovation and knowledge are taken into account;
2) phases of innovation process: knowledge/innovation/performance. An innovation pattern conceptualizes the innovation process as starting from a knowledge source, which is transmitted to other agents (locally or among regions) and turned into an innovative application. When innovation has taken place, this leads to increasing productivity and economic performance;
3) territorial conditions for local interaction: as the evolutionary theory of innovation has stated since the 1980s, firms do not innovate in isolation, so that innovation must be seen as a collective process involving other firms as well as a number of other non-corporate entities, such as universities, research centres, government agencies etc. (Dosi, 1982; Nelson and Winter, 1977 and 1982). The behavior and specific nature of these agents and, more importantly, of the relationships among them, have a critical influence on the way an innovation process works and performs. The mechanisms that facilitate the interaction among firms and non-corporate agencies at the local level, are looked for in our approach in the *territorial conditions* of the local area. The capacity of actors to interact, to cooperate, to share a path towards innovation is in our approach embedded in the socio-economic context of a region, that generates and supports collective learning processes at the local level, or allows interactive effects to take place between two socio-economic contexts that share common social values, a similar scientific background and a shared cognitive base. These reflections have been developed in the neo-Schumpeterian regional innovation theories that highlight space as a source of dynamic externalities, a generator of collective learning that reduces uncertainty and risks associated to innovation processes;
4) territorial conditions for knowledge and innovation diffusion between regions: more importantly, a territorial pattern of innovation highlights especially the conditions that guarantee a region to interact with other regions, attracting knowledge and innovation not present locally. In line with the evolutionary economic geography theory, that uses interdisciplinary insights from social, cultural and political sciences to explain interaction in innovation processes, these conditions cannot be looked for only in spatial proximity, and call for a wider interpretative base for knowledge spillovers. If a spatial perspective can be accepted to explain knowledge flows inside a region, with clear distant decay effects, their application at the inter-regional level loses any conceptual meaning, and is merely confined to a gravity type approach. Instead, a wider use of the “proximity effects”, like cultural and cognitive proximity advantages, may be extremely useful to understand the interaction among regions. The networking approach that explains innovation through the long-distance cooperation between different places finds explanations in the cognitive and social nature of the different areas.

4. Different kinds of territorial patterns of innovation

4.1. Differentiated patterns of innovation

A territorial pattern of innovation is made of a combination of *territorial specificities (context conditions)* that are behind *different modes of performing the different phases of the innovation process*. Among all possible combinations, the most interesting ones are the following:

Table 2. Characteristics of the different innovation patterns

Innovation patterns Characteristics	*Endogenous innovation pattern in a scientific network*	*Creative application pattern*	*Imitative innovation pattern*
Knowledge/technology	Basic, general purpose technologies	Applied technologies	Creative imitation
Innovative model	Supply-driven	Supply-driven	Supply-driven
Role of the region in the innovation process	Active role	Active role	Passive role
Outcome of the interregional cooperation	Knowledge creation	Creative innovation adoption	Innovation diffusion
Territorial pre-conditions behind the inter-regional flows of knowledge and innovation	Territorial receptivity	Territorial creativity	Territorial attractiveness
Natural regional context associated to the innovation pattern	Metropolitan regions	Second ranked urban regions	Catching-up regions
Innovation policy aims	Maximum return to R&D investment	Maximum return to co-inventing applications	Maximum return to imitation

- an endogenous innovation pattern in a scientific network, where the local conditions are all present to support the creation of knowledge, its local diffusion and transformation into innovation and its widespread local adoption so that higher growth rates can be achieved. Given the complex nature of knowledge nowadays, this pattern is expected to show a tight interplay in the creation of knowledge with other regions, and therefore being in an international scientific network;
- a creative application pattern, characterized by the presence of creative actors interested and curious enough to look for knowledge, lacking inside the region, in the external world, and creative enough to apply external knowledge to local innovation needs;
- an imitative innovation pattern, where the actors base their innovation capacity on imitative processes, that can take place with different degrees of creativity in the adaptation of an already existing innovation.

Each territorial pattern of innovation is characterized by different innovative models, different roles of the regions in the innovative process, different outcome from interregional cooperation,

require different territorial preconditions to take place and therefore have natural places where they may take place (Table 2). Finally, each of them have specific innovation policy aims (Table 2), as explicitly mentioned in the following sections.

4.2. An endogenous innovation pattern in a scientific network

A first and straightforward territorial pattern of innovation is an endogenous one referring to a situation in which a region is endowed of local conditions for knowledge creation and for turning knowledge into innovation, so to guarantee a productivity increase and regional growth. This model relies on specific *internal context conditions* that explain knowledge creation and diffusion, as well as innovation by looking at the internal structural conditions of a region, have been widely analyzed by the literature.

Knowledge creation is in general dependent on an urban environment, where material and non-material elements supporting scientific knowledge find a natural location. Table 3 summarizes the main elements that have been underlined as the sources of knowledge creation, being material and non-material, stemming from indivisibility and synergies, i.e. from agglomeration and proximity, the two elements characterizing urban environments:

- urban size per se (McCann, 2004), especially concerning the creation of large human capital pools and wide labour markets (Lucas, 1988; Glaeser, 1998);
- diversity, concerning the variety of activities and the possibility for specializations in thin sub-sectors and specific productions, thanks to the size of the overall urban market (Jacobs, 1969 and 1984; Quigley, 1998);
- contacts and interaction, allowing face-to-face encounters reducing transaction costs (Scott and Angel, 1987; Storper and Scott, 1995);
- synergies, thanks to proximity, complementarity and trust (Camagni, 1991 and 1999); in more formalized models, these same effects stem from complexity of the urban system and synergetics (Haken, 1993);
- reduction of risk of unemployment for households, thanks to the thick and diverse urban labour market (Veltz, 1993);

Table 3. Urban elements and knowledge creation

Sources of urban increasing returns	*Indivisibility (agglomeration)*	*Synergy (proximity)*
Types of elements supporting knowledge		
Material elements	- Fixed social capital; - High level functions	- City as a node of national and international transport networks;
Non-material elements	- Large markets of inputs; - large market of qualified human capital; - diversified productive systems; - creative capital accumulation.	- High availability of information; - transcoding system of knowledge and information; - R&D and higher education integration.

- trans-territorial linkages, emerging from the international gateway role of large cities, particularly crucial in a globalising world (Sassen, 1994).

The literature has not confined itself to the identification of territorial elements of knowledge creation. Reflections on the *territorial elements* that explain the capacity of a region to use its knowledge for innovative activities have been put forward. In particular, creativity and recombination capability to translate scientific, basic or applied knowledge into innovative application, require a relational space, where functional and hierachical, economic and social interactions are embedded into geographical space. Geographical proximity (agglomeration economies, district economies) and cognitive proximity (shared behavioural codes, common culture, mutual trust and sense of belonging) guarantee the *socio-economic and geographical substrate* on which collective learning processes can be incorporated, mainly due to two main processes (Camagni and Capello, 2002):

- the huge mobility of professionals and skilled labour – between firms but internally to the local labour market defined by the district or the city, where this mobility is maximal), and
- the intense co-operative relations among local actors, and in particular customer-supplier relationships in production, design, research, and finally knowledge creation.

The translation of knowledge into innovation is facilitated by interaction and co-operation, by the reduction of uncertainty (especially concerning the behaviour of competitors and partners), of information asymmetries (thus reducing mutual suspicion among partners) and of probability of opportunistic behaviour under the threat of social sanctioning (Camagni, 1991 and 2004), all elements that are confirmed by many regional economics schools (Bellet et al., 1993; Rallet and Torre, 1995; Cappellin, 2003b).

The foregoing concerning the role of territorial variables and the centrality of local conditions should not be taken as suggesting a return to an anti-historical localism or territorial autarchy. On the contrary, local *milieux* should be perfectly accessible, open and receptive to external flows of information, knowledge, technologies, organisational and cognitive models, and always be ready to recombine local knowledge and external knowledge anew. What is really meant by referring to the importance of local territories is the fact that, while some relevant production factors like financial capital, general information, consolidated technologies and codified knowledge are readily available virtually everywhere nowadays, the ability to organise these "pervasive" factors into continuously innovative production processes and products is by no means pervasive and generalised, but exists selectively only in some places where tacit knowledge is continuously created, exchanged and utilized and business ideas find their way to real markets (Camagni and Capello, 2009).

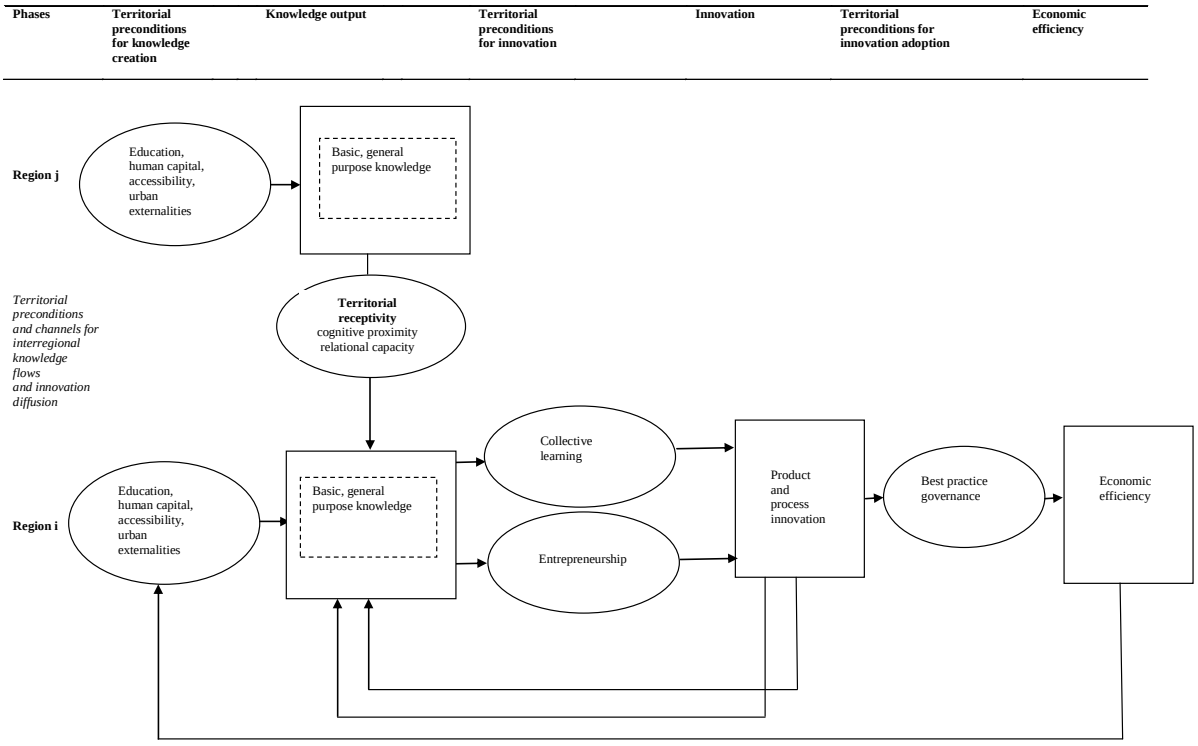
In this respect, the knowledge filter theory of entrepreneurship, put forward by Acs and Audretsch, provides an explicit link between knowledge and entrepreneurship within the spatial context, where entrepreneurs are interpreted as the innovative adopters of new knowledge. This theory posits that investments in knowledge by incumbent firms and research organizations such as universities will generate entrepreneurial (innovation) opportunities because not all of the new knowledge will be pursued and commercialized by the incumbent firms. The knowledge filter (Acs et al. 2004) refers to the extent that new knowledge remains un-commercialized by the organization creating that knowledge. These residual ideas are those that generate the opportunity for entrepreneurship. The interesting aspect of this theory is that the capabilities of economic agents within the region to actually access and absorb the knowledge and ultimately utilize it to generate entrepreneurial activity is no longer assumed to be invariant with respect to geographic space, as has been always thought. In particular, diversified areas, in which differences among people that foster looking at and appraising a given information set

differently, thereby resulting in different appraisal of any new idea, are expected to gain more from new knowledge.

Notwithstanding the internal capacities to generate knowledge, given the complex and systemic nature of knowledge and innovation, in most cases regions reinforce and complement its internal knowledge with external one, through diffusive, mostly un-intentional, knowledge patterns based on spatial proximity ("spatial linkages"), subject to strong distance decay effects, and/or through intentional relations based on a-spatial networks or non-spatially mediated channels ("a-spatial linkages") that may take place both at short and long distances based on the organization of different forms of transfer and exchange of information and knowledge than the pure spatial proximity.

An innovation pattern of this kind can be labeled "*endogenous innovation pattern in a scientific network*" (Figure 1). In front of a territorial pattern of innovation of this kind, the natural innovation policy aim is the achievement of the maximum return to R&D investments. An aim like this calls for the importance of a specialization in R&D at European level, that guarantees the achievement of a critical mass of researchers, equipments and R&D resources; this critical mass is interpreted as fundamental in order to achieve the desired goal, for the research work to become effective and to achieve an acceptable research performance (Table 2).

Figure 1. Endogenous innovative pattern in a scientific network



Based on the indivisibility rule associated to research activities in general, and to general purpose technologies in particular, the idea of a smart specialization in R&D activity has pervaded the innovation economic debate, calling for an European Research Area allowing agglomeration processes to occur, giving rise to centres of excellence. This can only be done within an integrated research space in which knowledge is exchanged within a solid and efficient network among centres of excellence, that become regions specialized in the basic inventions. Regions showing "an endogenous innovation pattern in a scientific network" can

become one of these centres; the specialization of each centre in general purpose technology research activities can become a policy mission.

The innovative model in this territorial innovation pattern is a typical supply-driven model; from scientific activities, from an invention, a subsequent co-invention of applications leads to a number of innovations mainly brought about by inventors and co-inventors of applications.

The conditions for a region to acquire knowledge from outside its boundaries can be regarded as *territorial receptivity* (Table 4), broadly defined as the capability of the region to interpret and use external knowledge for complementary research and science advances, or more generally absorptive capacity of a region à la Cohen and Levinthal (1990). More specifically, receptivity is made of different aspects, according to the nature of knowledge, and its diffusion. If a modern view of knowledge is adopted, learning and interaction processes are put at the forefront, and knowledge is considered as complex semi-public or co-operative. Its diffusion is subject to strong spatial barriers and follows widely unpredictable creative processes. Knowledge creation and learning often depend on combining diverse, complementary capabilities of heterogeneous agents.

Table 4. Preconditions for interregional exchange of knowledge and innovation

	Territorial Receptivity	*Territorial Creativity*	*Territorial Attractiveness*
Preconditions to receive	Relational capacity	Openness to innovation	Limited labour costs
Preconditions to exchange	Social proximity Cognitive proximity	Technological proximity	Income differentials
Channels for exchange	Scientific networks Co-patenting Migration of inventors	Participation in industrial associations	Foreign direct investments

Given these characteristics, receptivity is first of all dependent on a *relational capability* required to guarantee that a region is in general made of individuals, firms and institutions oriented towards a cooperative and synergic attitude, nourished by trust and sense of belonging, in order to guarantee collective and interactive learning processes.

Moreover, spatial proximity facilitates the overcome of spatial friction, and the exchange of knowledge, mainly tacit knowledge, seems to be subject of strong distance decay effects. *Spatial proximity* to a region may therefore be another component of receptivity. However, this kind of proximity is not enough. Complexity of science and knowledge evolution, together with bounded rationality which generates cognitive constraints of actors, leads economic agents to search in close proximity to their existing knowledge base, which provides opportunities and sets constraints for further improvement (Boschma, 2005). Knowledge evolution therefore takes place in a cumulative way, localized around a technological paradigm, in cooperation among actors with a strong complementarity within a set of shared competences. For this reason, a third component of territorial receptivity is *cognitive proximity* among regions, necessary for a region to acquire knowledge from another one, to understand and use it in a creative way (Table 4).

All these features are more easily to be found in metropolitan areas. They are the main sites of innovative activity, the 'incubators' of new knowledge: cities are the principal centres of research, given their large pools of expertise, and the availability of advanced services (finance

and insurance) ready to carry the risk of any innovative activity. The fuel for a continuing knowledge and innovation process in cities lies in the density of external, particularly international linkages maintained and developed by individuals, groups, associations, firms and institutions, what is increasingly called relational capital (Camagni, 1999) coupled with a large diversity of competences on which complementary knowledge can find a common cognitive sphere.

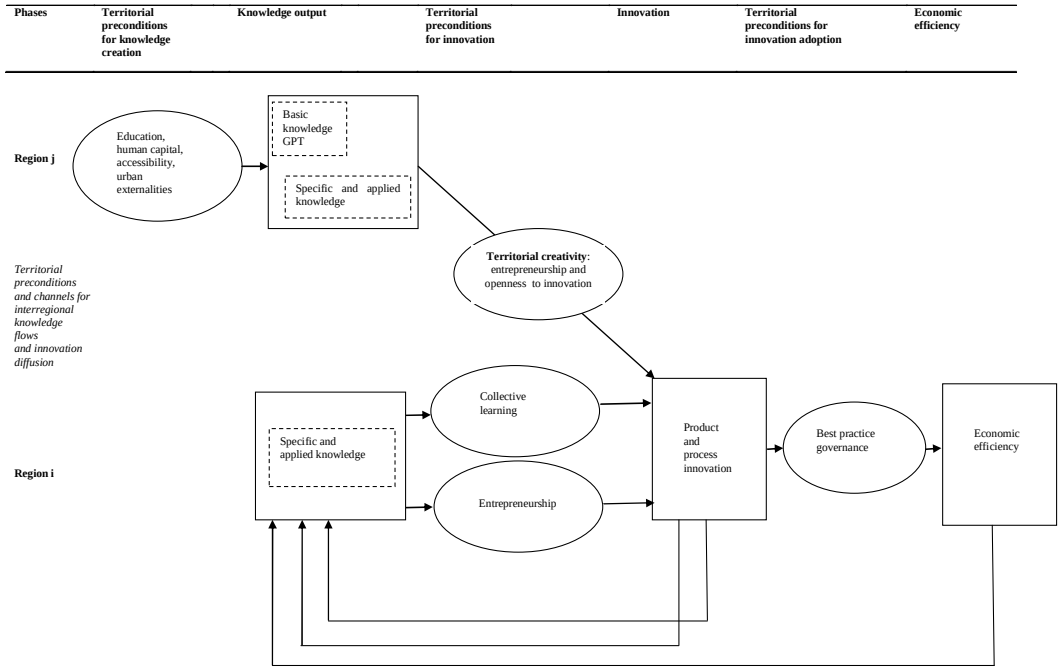
4.3. Creative application pattern

The reality shows also that some regions are late comers and mainly users of general purpose, basic technologies; experience shows that being a latecomer in core technologies has serious implications, that last for long, and are difficult to reverse. Foremost, technological leaders are facilitated to expand into new science and technology fields and create conditions for reiterating such processes in further emerging science and technology area.

However reality is full of examples in which invention and innovation are not intertwined. Factors that enhance the implementation of new knowledge can be quite different from the factors which stimulate invention and innovation. Invention, innovation and diffusion are not necessarily intertwined, even at the local level.

The linkage between basic knowledge and innovation is therefore in many cases not so evident, and many regions exist in which innovation takes place on the basis of basic knowledge acquired from outside and of specific know-how in local, application sectors. In this case, innovation activity finds its roots in a merging of general purpose technology knowledge, coming from networking with leading regions, with local specialized knowledge in the region (Figure 2). In this pattern, a particular case is the investments in the "co-invention of applications" that is development of the applications in one or several important domains of the regional economy, without embarking in expensive basic R&D activities with insufficient critical mass of human and financial resources (Foray, 2009; Foray et al., 2009).

Figure 2. Creative application pattern



In this innovation pattern, regions have to succeed in developing an original and unique knowledge domain, based on its productive vocations; therefore regions have to discover the research and innovation areas in which they can hope to excel. This discovery comes from firms, that have to achieve combinations between technologies and various elements of the value chain, and construct very different and unpredicted specific niche competitive advantage. In this sense, this innovation pattern is supply driven, in that it depends on the creativity and recombination capability of potential innovating firms, that - thanks to their internal specific knowledge - identify a gap in a possible application of general purpose technologies, and put their creative effort in order to overcome such a gap.

This does not necessary mean that regions have to specialize in one or a few knowledge domains. In an innovation pattern like this the evolutionary trajectories of innovation can either be specialized, can progress by means of the evolution of "platforms" that combine many technologies, but can also be the result of differentiated technological fields in which local firms operate. The common features of all these possible forms in which this innovation pattern can take place is that the move from invention to innovation resides in creativity, recombination capability, ability to identify at the same time new needs and the right basic technology of local actors, ability to recombine local knowledge and external knowledge anew. In this sense, the innovation process is the result of an active role of collective actors of a region, especially potential innovators/adopters, which leads to innovation creation, despite the lack of ability in knowledge creation.

The maximum return to R&D investments is not the natural policy aim of this pattern; the innovation policy aim in this case can be seen as the maximum return to co-inventing application (the typical Schumpeterian profits), which deeply depends on the ability of regions to change rapidly in response to external stimuli (such as the emergence of a new technology). In other words, it depends on the ability to promote "shifting" from old to new uses.

The networking activity between scientific core regions in which basic knowledge is created and co-innovating application regions finds an economic rational in the dynamic feed-back loops that link invention to application. Invention gives rise to the co-invention of application which in their turns, increase the return on sub-sequent inventions. When this virtuous cycle takes place, a long-term dynamic develops, consisting of large scale investments in R&D whose social and private marginal rates of returns achieve high levels. Myriads of economically important innovations result from the co-invention of applications, and the size of application co-invention increases the size of the general technology market and improves the economic return on invention activities relating to it (Foray, 2009).

The territorial conditions for this innovation pattern to occur are linked to the concept of *territorial creativity*. This is made of entrepreneurs able to actually access and absorb the knowledge produced in the world and ultimately utilize it to invent co-applications; this can more easily happen in a context open to innovation, which nourishes itself of external knowledge useful for its local purposes and needs. The probability to interact in this kind of innovative pattern is between regions with a similar technological vocation. Participation to industrial associations and / or the exploitation of external experts represent the channel through which the flow of knowledge comes into the region (Table 4).

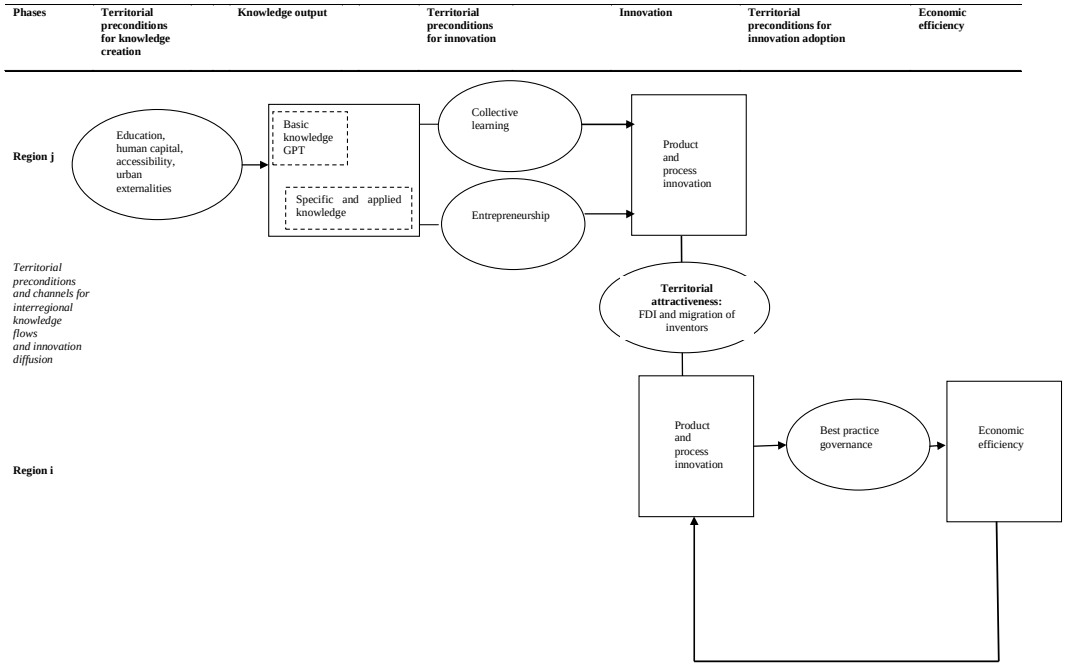
Regions in which this innovation pattern finds a natural location are the second ranked urban regions, characterized by high accessibility to metropolitan leading regions, with a local labour

market fed by human capital in general formed in first ranking urban areas. But it is also the case of highly specialized areas, like local districts, where specialized knowledge cumulates over time and where the needs of technological jumps are often solved by merging specific local competences with new basic knowledge from outside through what has been labeled trans-territorial networking (Camagni, 1991). In the milieu innovation theory, these networking capabilities have always been thought of as a way to feed local specialized knowledge with technological novelties at the frontier, to jump on a new technological paradigm, something impossible to achieve only by cumulating specialized technological knowledge inside the area. This latter bears the inevitable risk to lock the area into a technological pattern, with no possible way out.

4.4. Imitative innovation pattern

Another innovation pattern which can be envisaged is an imitative innovation pattern, a situation in which a region innovates since it receives innovation from outside. This is more an adoption innovation pattern, where the technological developments at the local level are the result of a passive attitude - in terms of invention, knowledge creation and innovation generation – of a region, which is fed by external actors of innovation already developed elsewhere (Figure 3).

Figure 3. Imitative innovation pattern



This imitative pattern is not necessarily the less productive and efficient innovation pattern; regions can be creative and fast in the imitation phase, by deepening and improving productivity in existing uses, by adapting existing uses to the specific local needs, by adjusting products to local market interests, by forging innovation processes on local productive needs. Regions can also be more passive and imitate innovation from outside as conceived elsewhere.

Especially in the latter case, the right innovation policy for this pattern has nothing to do with the efficiency in R&D activities, or in supporting co-inventing applications. In this case policy actions have to be devoted to achieve the maximum return to imitation, and this aim is achieved through a creative adaptation of already existing innovation, i.e. through adoption processes driven by creative ideas on the way already existing innovation can be adopted to reply to local needs.

Channels through which innovation is acquired from outside the areas are in fact foreign direct investments (Table 4); product, process, managerial, organizational innovation embedded in large multinationals can be the channel through which innovation is brought into catching-up regions. One of the traditional channels through which external innovation penetrates an area is through foreign direct investments. *Territorial attractiveness* is the precondition for regions to acquire external innovation; a large final market (market seeking) and/or labour cost competitiveness (efficiency seeking) are the preconditions to become attractive areas for FDI (Dunning, 2001 and 2009; Cantwell, 2009). Regions exchanging innovation through FDI are regions with strong income differentials.

Imitative innovation patters are typical of Eastern countries that have, over the last two decades, shown a decisive economic performance, mainly based on foreign direct investments, and all the innovative capacity brought about by multinationals. The efficiency of this innovation pattern can be high, giving rise to strong positive feed-back loops from growth to innovation through higher financial resources to invest in the innovation process. The high rate of growth can produce higher living standards and higher quality of life in these countries. The ways through which innovation is attracted from outside the region may evolve in a second stage towards other channels like mobility of inventors, that find their determinants in economic growth potentials, in expected high wages and in high quality of life potential.

5. Conclusions and policy implications

The main idea put forward in this work is that the pathways towards innovation and modernization are differentiated among regions according to local specificities, and these differentiation explains why a single overall strategy is likely to be unfit to provide the right stimuli and incentives in the different contexts.

The paper departs from the idea that R&D equals knowledge and that knowledge equals innovation. The distinction between the process of invention in general purpose, basic technology, pervading horizontally different sectors once invention is turned into an innovation, and the process of inventing an application of a basic knowledge in a specific sector, innovating in new products and new market niches is vital to understand the present patterns of innovation. This becomes even more important if we think that the factors that stimulate new knowledge, invention, innovation and innovation diffusion differ; invention and innovation are not necessarily intertwined and this gives rise even at the local level to very different and multi-faced situations; some regions have the capacity to go through all phases of the “linear model”, from knowledge creation to innovation and growth, with all feed-backs that can be foreseen from growth to knowledge and innovation. Other regions reinforce this “linear model”, exchanging knowledge with other regions gaining complementary assets through a scientific network. There is however a completely different situation in which regions innovate by combining their creative thinking with basic knowledge cumulated in other regions, developing co-inventing applications. Finally, another territorial innovation pattern can be identified by a

situation in which regions innovate that to a creative imitation of innovation developed elsewhere.

All these innovation patterns are the result of specific context conditions that support an innovation pattern more than another. Territorial receptivity is necessary to enter scientific networks, defined as the capacity of a region to understand knowledge coming from outside: cognitive proximity, intended à la Boschma as the presence in a region of complementary knowledge within shared competences with another region. Territorial creativity is a sine qua non for a region to exploit external knowledge in order to launch internal innovation processes, driven by an entrepreneurial process of discovery. Territorial attractiveness is the local condition for imitating innovation from outside.

More importantly, what emerges clearly from this approach is that each territorial innovation pattern calls for specific ad-hoc innovation policy goals: the maximum return to R&D investment can be the right goal for a region specialized in knowledge creation, but cannot be at the same time the right policy goal for regions that innovate by exploiting external knowledge, or for regions that imitate innovation processes. For the former, the ad-hoc policy goal is the maximum return to co-inventing applications, which happens when the region promotes changes in response to external stimuli (such as the emergence of a new technology). A maximum return to imitation, pushing towards a creative imitation, is instead the right policy aim for regions that rely on external innovation processes. Each region has to succeed in discovering its territorial innovation pattern, and only through the awareness of the original and unique territorial innovation pattern a region can hope to excel in exploiting innovation efficiency.

There is no pattern that is by definition superior to the other in terms of efficiency and effectiveness of innovation on growth; on the contrary, each territorial pattern may provide an efficient use of research and innovation activities generating growth. But this impression has to be proved empirically.

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