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Elements for the development of a self-sustaining model of Regional Innovation System

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On n'est curieux qu'à proportion qu'on est instruit.
Jean-Jacques Rousseau

Si è curiosi soltanto nella misura in cui si è istruiti.
Jean Jacques Rousseau

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Introduction

Foreword

The current debate regarding territorial development focuses on the central theme of innovation as the key to sustain local competitiveness and entrepreneurial growth; innovation is usually the result of ongoing and prolonged collaboration and interaction between enterprises and a variety of different actors such as customers, producers, consultants, research institutes, universities, and regulatory institutions.

In recent years, literature has highlighted the critical role played by geographical proximity and local institutional conditions (Kirat and Lung, 1999, Trippl, 2006; The IRE Working Group, 2008) for the interactions among the abovementioned actors and for the circulation of existing knowledge or the production of new knowledge and its economic exploitation.

Furthermore, regions have been recognized as the ideal geographical level (Cook and Memedovic, 2003; European Union, 2007; OECD, 2011) for the definition of effective policies to improve critical innovation interactions; as consequence, the theoretical framework of Regional Innovation System (RIS) emerged as conceptual frame of reference (The IRE Working Group, 2008).

Moreover, literature emphasized that perspectives on territorial systemic innovation - including regional innovation system one - are characterized by typical features of the complexity science, such as the emergence and self-sustainability concepts (Martin and Sunley, 2011; Lombardi, 2003; Scott, 1998; Maillat, 1998; Stahle, 2002; Metcalfe and Ramlogan, 2008; Leydesdorff and Etzkowitz, 2000; Camagni and Capello, 2012; Becattini, 2002; Leydesdorff , 2006; Foray *et al*, 2011; Cooke P., 2012).

According to this frame of reference, this work is aimed at analyzing how to model an effective system of interaction - among innovation actors - within the RIS theoretical framework and by also taking into consideration the complexity science viewpoint.

Research questions and thesis outline

The research questions we attempt to answer are:

Regional innovatio System can be looked as Self-Sustaining Complex Adaptive System (SS-CAS) ?

- Which are essential elements?
- How to model Regional innovation System as Self-Sustaining Complex Adaptive System?
- How to evaluate regional innovation capability?

In order to answer to these research questions, we firstly analyze - in part one of thesis - literature on several territorial systemic innovation perspectives, including RIS one, and on innovation capability measuring tools. With the aim to understand strenght and weakness of innovation capability measuring instruments of current literature, we also implement a measuring tool based on current literature methodologies; so, we highlight that current literature tools for the assessment of regional innovation doesn't implement the measurement of the level of regional innovation self-sustainability (i.e. the level of regional innovation cycles aimed at self-mantaining an effective regional innovation); more in depth on this point, we claim for the necessity that regional self-sustaining innovation should become the goal for any regional innovation policy and - as consequence - for any regional innovation measurement tool.

In part two of thesis - by arguing on the necessity to turn towards a new viewpoint based on the self-sustainability concept - we propose a new RIS conceptual model, based on the complexity science pillars, from which it can be possible to develop new measurement tools that are able to analyze regional systemic innovation from the point of view of the self-sustainability.

Overview

Literature has showed a rich array of theoretical frameworks on territorial systemic innovation; these framework are characterized by several common elements and by the evidence of a recurrent underlying presence for the emergence and self-sustainability concepts; scholars also highlighted the absence of an unified conceptual framework from which an universal model may emerge to guide research and policy. So, literature analysis suggests the need of adopting common elements in an unified vision.

Furthermore, scientific literature has achieved a large consensus on the fact that systemic innovation has to be viewed from a regional point of view and that it is strongly related to institutional condition and to the presence of intangible resources - such as culture, competence and knowledge - at regional level. So, in order to deal politically with systemic innovation, it can be inferred that regional government has a critical role for the development of systemic innovation of the administrative region.

Moreover, literature suggests that proximity, critical mass and critical variety of competencies relevant to explore and exploit the flow of technological opportunities are key attributes of an innovative territory.

Understanding the sources and patterns of innovative activity is the critical step for developing better policies; an answer can be provided by implementing operational models aimed at measuring innovation performance of regions.

Publications with information and statistical evaluations on the innovative capability of the EU regions have been characterized for the adoption of specific performance indicators and for the implementation of a composite indicator aimed at measuring the multidimensional concept of regional innovation. But - to date - regional innovation scoreboards are all characterized by a certain grade of methodological weakness because of the absence of a conceptual framework beyond; only few different tools (Triple Helix tool and Innovation Pattern tool) have referred to a conceptual model; so, only few other different tools have developed an operational model not methodologically so weak as the scoreboards one. But scoreboards are useful tools because they let to measure the level of local resources and competencies; so, it should be necessary to develop methodologically stronger scoreboard.

More generally, in all current measuring tool there isn't the measurement of the self-sustainability concept, i.e. there isn't the measurement of the level of self-catalytic innovation cycles; but, we argue that implementation of the self-sustainability state should be the goal of any regional innovation policy; so, with this aim we have analyzed the features of several RIS literature framework with the objective to develop a Self-Sustaining conceptual model.

Regional Innovation Systems (RISs) are complex systems resulting from the integration of a territorially embedded institutional infrastructure and a production system. The RIS framework defines innovation as a cumulative and not-linear systemic process resulting from the formal and informal, voluntary and involuntary interactions among innovation actors. The main idea in the RIS approach is that interactions between different local actors that have good reasons to interact - such as small and large firms, manufacturing and service companies, industries and universities, private and public agencies - should foster local learning processes.

By now, due to the territorial dimension of innovation processes, to the importance of local institutional conditions and – still - to the systemic character of the cooperation and the mutual learning among the innovation actors, Regional Innovation System is considered the most adequate framework to define the best policies for improving the innovative capability of a territory.

But, also the RIS approach - like others theoretical frameworks on systemic regional innovation - "suffers from the absence of an unified conceptual framework from which a universal, albeit very broad, model may emerge to guide research and policy” (Doloreux D. and Parto S., 2004).

Several conceptualizations on systemic territorial innovation, including RIS one, argued that: a) systemic territorial innovation is constituted by a set of connected or interdependent innovation actors, with the capacity to alter or change learning from experience; b) the system as a whole is characterized by the emergence and self-sustainability concepts.

But last two points are typical features of the complexity science; so, according to Cooke (2012), we argue that a Regional Innovation System should be considered as a Complex Learning System.

Doloreux and Parto (2004) have highlighted that to “engineer” the RIS it is necessary to specify what the institutions are and how they interact in different systems, at different scales, or at different levels; so, in order to give a contribution to “engineer” the RIS and also to fill the literature gap about the absence of an unified conceptual framework on regional systemic innovation, we suggest some further ideas - on RIS as complex learning system - by adopting some interpretations on complex phenomenologies of chemistry and evolutionary biology:

1. With defined conditions of regional framework there are defined relational barriers (namely cognitive, organizational, social, institutional) among innovation actors. The presence of catalysts – which have the function to promote connections among other actors of innovation - let the development of "activated network " among innovation actors involved in the network.

2. The conditions of regional framework are determined by choices of the governor; these choices continually change because of a continuous feedback cycle between top-down policies of the governor and bottom-up answers of the other innovation actors; therefore, we suggest to use the concept of "artificial" - within the RIS framework - with the aim to underline that framework conditions (defined by the governor choiches) determine virtuosity, or viciousness, of the abovementioned feedback cycle.

3. The evolutionary growth of the innovative regional capability requires cooperation of several producers of innovation in a self-catalityc system as the hypercyclic one.

4. RIS is a complex adaptive system that lives on the edge of chaos in a state of Self-Organized Criticality. The level of Regional Innovation Value Criticality (RIIC) is the key parameter; when the "envirovmental" conditions are stable (namely, when there is absence of critical perturbations), the level of Regional Innovation Value Criticality is in the homeostatic equilibrium; with critical perturbations there is the development of an omeoretic step in which the level of RIIC changes suddenly; such omeroretic phase persists until the achievement of a new homeostatic equilibrium (with the related stabilization of the RIIIC level); more in general, the level of Regional Innovation Value Criticality (RIIC) is in a metastable equilibrium; this state depends on conditions of framework; such RIIC level, therefore, continually can grow, or decrease, depending - respectively - on virtuous pertubations, or vicious, operated by the "artificial-

emergent" feedback cycle; as consequence, the synergistic effects of top-down policies and bottom-up answered can lead to catastrophic bifurcations that represent the key alternatives of the evolutionary path; "artificial-emergent" feedback cycles belonging to the virtuous type depend on governor policy; in other words, the governor can push the RIS in the choice of the best path in every catastrophic bifurcation (the verb "to push" is consistent with idea that virtuosity, or viciousness, of the above mentioned feedback cycles is determined by governor choiches); therefore, virtuous cycles create the evolutionary path. On the contrary, with "artificial-emergent" feedback cycles belonging to viciousness type, the level of Regional Innovation Value Criticality decrease. Ideally, by always promoting choice of the best path - namely by pushing the system in an effective evolutionary path - governor fosters a continuous increase of the level of Regional Innovation Value Criticality.

5. The critical variety of innovation actors is a necessary requirement, but not a sufficient one for the development of Self-Sustaining Regional Innovation; indeed, in addition to the critical variety it is necessary the development of a critical number of interactions among the actors of innovation.

6. The self-catalytic cycles - joined between them in a giant cluster - are developed when ratio between the number of interactions (number of cords) and the total number of actors (knots) go over a certain threshold. This phenomenon can represent a criterion to discriminate between a self-catalytic RIS (when a specific threshold is surpassed) and not (when the relevant threshold isn't surpassed). In fact, by operazionalizing the above phenomenon we can numerically estimate the level of Regional Innovation Value Criticality; from the methodological point of view - as argued before - to achieve this objective it is necessary - first of all - to evaluate if critical variety of innovation actors is satisfied by the region in observation; in absence of such critical variety there can't be systemic innovation (therefore, in last case, estimating of the RIIC has no sense); if the requirement of the critical variety of innovation actors is

satisfied for the region in observation, we can determine the Regional Innovation Value Criticality - in analogy to the quantity of sand (by the unity of time) that falls from the dish in the Bak experiment - as number of effective interaction by the time considered. We can also estimate the condition with respect to the target of systemic self-catalysis state; such condition is evaluable by using the following formula:

$$C_{SS} = I_e / I_t$$

where

C_{SS} = condition with respect to the target of systemic self-catalytic state;

I_e = number of effective interaction by the time considered (level of current RIIC);

I_t = number of Kauffmann's threshold interactions by the time considered (level of RIIC threshold);

7. The Regional Innovation System is characterized by the presence of social hypercycles, namely by the presence of homeostatic cycles of social cohesion in a well-working state or in a bad-working one; these homeostatic cycles self-sustain itself and break itself with the coming of critical perturbations.

Furthermore, we have defined three blocks on which to build a new unified conceptual framework: the first block is constituted by the presence of heterogeneous key actors that interact in a networked complex learning system; the second block is represented by the networked system of relationships among all key actors involved in innovation processes; the third block is constituted by the presence of a complex learning system, that is a system in which a “social synergy” exists and value is added to the knowledge creation process.

Summarizing, literature analysis on regional systemic innovation let us to find several pillars on which we can define a new RIS conceptual model. So, based on the building blocks above mentioned, on the suggestions from models of Chemistry and Biology, and on the Schwandt's learning system model, we argue that an unified conceptual framework, useful to analyze the performance and the level of RIS self-sustainability, should be characterized by the following subsystems: the producers of knowledge (explorers), the producers of market value (exploiters), the mediators of innovation (catalysts) and the creator of framework and rules (governor).

Hence, in our hypothesis these four actors have to interact with each other and with external actors (namely with the explorers, exploiters, catalysts and governors not belonging to the same administrative region) through a systemic collaboration network (Fig.1); each actor interacts with the others providing them with different contents. The explorers give knowledge (namely new ideas, methodology, products, processes, problem solving, competences and so on). The exploiters, namely the firms, provide the network with economic value. The role of catalysts is to give links and, finally, the governor provides the system with the formal and informal framework of rules.

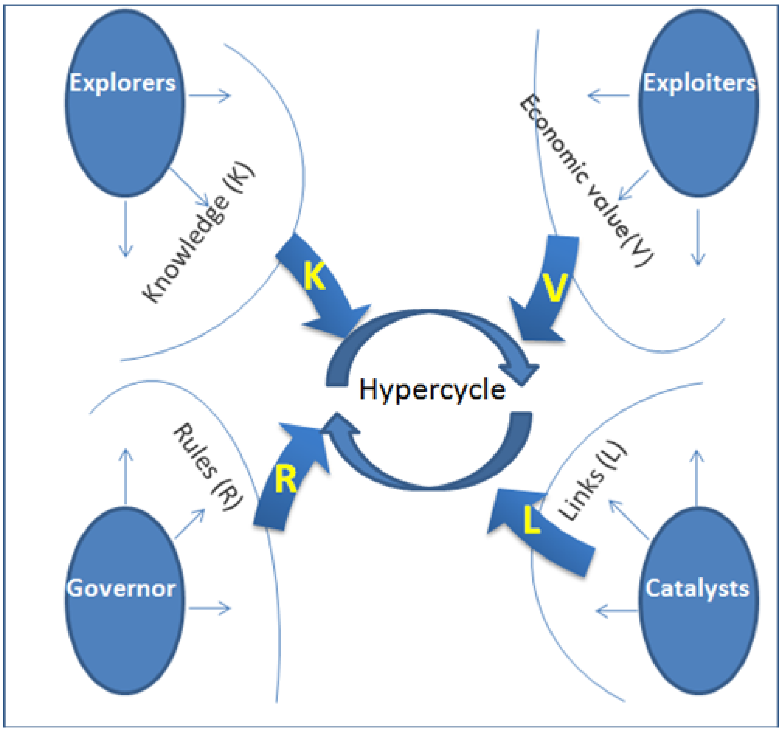


Fig. 1: RIS as self-sustaining ecology of regional innovation

Our proposed model conceptualizes the idea of global emergent competences arising from an hypercycle of self-sustaining interactions of new sources and new opportunities (to be exploited) among the innovation actors; so, within our conceptualization, RIS should be viewed as regional ecology of self-sustaining innovation by adopting the concept of "ecology of innovation" proposed by David and Metclaf (2007).

The fusion of innovation ecology perspective with innovation system perspective claims for the combination of emergent innovation strategies with planned innovation strategies. But, by evocating further concepts of evolutionary biology, we also introduces the term "artificial" with the aim to highlight the significance of the governor; in fact, notwithstanding the continuous cycle of feedback between the top-down (that is, artificial) environmental pressures of the governor and the bottom-up (emergent) environmental answers of the exploiters, explorers and catalyst, the framework conditions - defined by the governor- determine the direction of the feedback cycle, namely determine the virtuosity or the viciousness of the abovementioned cycle. So, we conclude that an effective Regional Innovation System should be viewed as **Regional Artificial Ecosystem of Self-Sustaining Innovation** where the self-sustainability represents the key concept because it focuses on the self-development of innovation over time. Within our new RIS conceptualization, the Regional Innovation Value Criticality is the numerical key becuse its numerical determination let to understand if the system is in the self-sustaining state, or not.

Part I - Measuring the Regional Innovation

Chapter 1

Background

1.1 Innovation as driving force of economic growth

Historically, studies on economical growth look at innovation as engine of development.

Innovation is not the develoment of new products or new production processes only, but it is a larger idea that - as outlined from Schumpeter J.A. (1934) - is extended to research of new markets (commercial innovation), to finding of new sources of raw materials (innovation in the supplies) and to reorganization of the industrial structure.

Schumpeter has been first one who examined innovation in a systematic way; but - historically - other significant scholars had focused on innovation before: also Adam Smith - in *"the wealth of Nations"* (1776) - studied effect of technological progress on work productivity, specialization and occupation. Subsequently, Marx provided contributions to such argumentation; indeed, he underlined that innovation is a social process and not individual one: in Marx'view the story of inventions is not story of inventors only, but it is story of connections and conflicts existing between groups and classes of economical subjects; summarizing on last point, Hansen (1921) argued that Marx conceived of social processes not in economic but in technological terms.

From second post war period, articulated analysis on role of innovation have tooken great vitality, and new theories have emerged.

Endogenous growth theory argued that economic growth is an endogenous outcome of economic system; in this theory the human capital, investments in research and development and research infrastructures have a significant role for growth process (Romer P. M., 1994).

Tight bounded to endogenous growth theory, the evolutionary theory - based on evolutionary models - was also developed (Nelson R.R. and Winter S.G. , 1982); this theory focused on knowledge, on dynamic processes linked to research and innovation, and on the idea that learning firms are owner of knowledge and specific skills. The evolutionary theory looked at enterprises as heterogeneous agents that learn and interact in uncertain and changing environments

So, according to economic studies of last decades, innovation has to be analyzed with a systemic approach and it is correlated to productive performance, enterprise competitiveness and - more in general - to economic development of the society; more on last point, as also recognized from politics, innovation is a key driving force for the long-term economic growth. (European Commission, 2009; OECD, 2010).

1.2 Territorial innovation models

In the last years it has been sustained the need of geographical proximity among innovation actors as a fundamental element for the development of systemic innovation; indeed, as highlighted by Boschma R.A. (2005), geographical proximity of innovation agents is a necessary prerequisite for innovation because it facilitates interpersonal contacts, information exchange and trust; accordingly, Kirat and Lung (1999) argued that geographical proximity promotes collective learning processes

On the basis of these argumentations, several territorial conceptualizations on systemic innovation - aimed at understanding and analyzing innovation processes - were carried out. Accordingly, section 1.2.1 examines main theoretical frameworks - occurred over time - through which territorial systemic innovation has been studied.

Our idea is that a well-working theoretical framework of territorial systemic innovation should include concepts of emergence (i.e. it should create new system states deriving from feedback loops among innovation actors) and self-sustainability (i.e. it should have innovation self-reproductive capability); section 1.2.2 is aimed at investigating how emergence and self-sustainability concepts have been dealt in theoretical frameworks of section 1.2.1.

1.2.1 Theoretical framework

Moluaert and Sekia (2003) have analyzed approaches such as Milieux Innovateurs, Industrial Districts, Localized Production Systems, New Industrial Spaces, Cluster of Innovation, Regional Innovation Systems, Learning Region. Pilotti et al (2013) have examined Industrial Districts, New Industrial spaces, Local Production Systems, Milieux Innovateurs, Innovation Systems, Learning region, Value Ecologies. By taking a cue from the above studies and by following a sort of literature evolutionary pattern, this section reviews main[1] theoretical frameworks – occurred over time - on territorial systemic innovation; so it reviews Industrial Districts, Local Production Systems (including Territorial Clusters), New Industrial Spaces, Milieux Innovateurs, Innovation Systems, Learning Region, Triple Helix, Innovation Ecology, Smart Specialization and Innovation Patterns.

[1] Literature shows many other - less debated - theoretical frameworks, more or less associated with forms of territorial systemic innovation, as well as territorial production system, local industrial fabric, localized industrial system, productive meso-system, localized production and innovation system, technological district, localized ecosystem (Maillat D., 1998, p.114)

The above conceptualizations are each an attempt to clarify key elements and properties of territorial systemic innovation from each specific point of view; common ground is the recognition of the significance, for innovation, of the geographical proximity and – more in general – of the proximity concept; indeed, geographical proximity helps exchange of key elements of innovative activities such as tacit knowledge and grey knowledge (Asheim and Gertler, 2005; Iandoli and Zollo, 2008), and facilitates interpersonal contacts, interactive and collective learning (Kirat & Lung, 1999), most likely – according to Boschma R.A., (2005) - by strengthening the proximity in its broader meaning, that is most likely also by getting stronger the other dimensions of proximity as well as cognitive proximity (the sharing of a common knowledge and competence base), as organizational proximity (the sharing of a common capacity to coordinate and exchange the knowledge), as social proximity (the sharing of social ties of friendship and trust), and as institutional proximity (the sharing of the same institutional rules of the game like a set of cultural habits and values).

Before starting with the analysis, we claim for revisiting some terms used by literature on this topic; indeed, when we deal with innovation at systemic level, without referring to any specific theoretical framework, we will use the words "systemic innovation" instead of "innovation system" or "system of innovation" in order to avoid ambiguity; indeed, in our opinion such a quibble is necessary because terms such as "innovation system" or as "system of innovation" are commonly used by literature for identifying a specific theoretical framework (Regional Innovation System). On the second hand, we highlight that literature of systemic innovation shows a certain grade of confusion on the use of the "model" term; indeed, Moulaert & Sekia (2003) and Todtling F. & Trippl M. (2005) referred to the "model" term as an illustration of the building blocks of a systemic innovation conceptualization. Thus, we claim for using "theoretical framework" or "conceptual model" when we deal with an illustration of a systemic innovation conceptualization, and we claim for using " operational model" when we deal with operationalization of a conceptual model or, more pecisely, when we deal with operazionalization of relationships among variables that are able to express the system behaviour.

The Industrial District (ID) notion was introduced by A. Marshall (1891); this scholar was first one that clarified why advantages result from geographical concentration of a great number of small firms belonging to the same productive sector. In the Marshall view the industrial district results effective because of several positive network externalities.

Marshall contributes has not been further developed till the 80s and 90s, when the relevance of the conceptualization of Marshallian industrial district has been recovered; indeed, by trying to understand the strong effectiveness of Italian IDs, literature carried out several studies in which the significance of social and cultural determinants of inter-firm relationships was showed. Accordingly, the Industrial District - described as a flexible production system in which coordination of different phases are not subject to pre-established hierarchical mechanism but to market forces and to a system of social sanctions imposed by the community - was defined as "a socio-territorial entity, which is characterized by the active co-presence of both a community of people and a population of industrial firms in one naturally and historically bounded area. In the district, unlike in other environments, […] community and firms tend to merge" (Becattini, 1990). By taking into account the social perspective of above, it has also emphasized that IDs structure is grounded on a dense and strong network of relationships - among autonomous and heterogeneous agents (firms, families, local institutions) - having determinants like the sharing of norms and culture, reciprocity and trust (Iandoli *et al*, 2012).

The Local production System (LPS) can be considered a theoretical extension of the Industrial Districts conceptualization to a wider typology of local productive configuration like, for example, district multi-sectoral area and, also, territorial clusters (Pilotti *et al*, 2013). Indeed, as Belussi (1999) suggested, strictly speaking we can use the Industrial District term only for identifying an isolated aggregation of exclusively small firms belonging to the same sector. According to Lombardi M. (2003), LPS are complex entities within which the social, economic, institutional and geographic factors are closely entwined; distinctive characteristic of LPSs as systems are; i) the sense of belonging to a territorial community of actors that share values - as well as trust, loyalty, reciprocity, reputation - through which rivalry, emulation, imitation, competition and co-operation co-exist and proliferate; ii) for firms, the existence of barriers to entry that can be overcome only after long interactive dynamics with local actors; iii) high frequency dynamics of interactions among LPS internal actors and low frequency dynamics of interactions between LPS internal actors and outside agents; iv) information flows leaded by final firms as strategic agents - having market knowledge not shared with other local agents – that activate other local agents by transforming their hidden information into operational parameters, i.e. into the characteristic of components of goods that have to be produced within the LPS (*ibidem*).

By analyzing decline of Fordist mass production - in the late 1970s and 1980s - and by observing contextual big expansion of flexible manufacturing activities (i.e., forms of production characterized by the ability to change process and product configurations with great rapidity), Scott (1998) theorized New Industrial Spaces (NISs) as a theoretical framework aimed at interpreting the re-agglomeration tendencies of the industrial districts of the above years; as argued by this scholar, NISs are characterized by networks of extremely malleable external linkages, by labour market relations and by the propensity to externalize production processes under conditions of rising flexibility; as consequence, NISs give rise to many specialized agglomerated subsectors (*ibidem*); so, efficiency results from economies linked to flexibility and geographical proximity of a selected set of specialized producers (*ibidem*). As highlighted by Moulaert and Sekia (2003), NISs framework integrates agglomerate production system with social regulation system (social regulation system provides "(i) the coordination of interfirm transactions and the dynamics of entrepreneurial activity; (ii) the organization of local labor markets and social reproduction of workers; and (iii) the dynamics of community formation and social reproduction").

By trying to systematize the literature trend of 80s and 90s on territorialised productive organization, it has also developed the *Milieux Innovateurs* (MI) theoretical framework by the GREMI group (Group de Reserche Europeen sur les Milieux

Innovateurs - Camagni, 1991; Camagni and Maillat, 1995). Maillat & Lecoq (1992). They defined *Milieux Innovateurs* as "a complex territorial system of formal and informal networks, made up of economic and technological interdependencies, capable of initiating synergetic and innovative processes". The MI approach derives from association between the localised production system – viewed like a generalised form of the several territorialized productive organization and defined "as a set of interdependent activities that are technically and economically organised and territorially conglomerated" (Maillat, 1998) - and the milieu concept that has been linked to "the technological and market environment, which incorporates and masters know-how, rules, standards, values and relational capital" (*ibidem*) and that has been considered as a cognitive set on which the functioning of the localised production systems depends (*ibidem*). According to the MI idea, milieu has to be considered innovative when it is able to gather, from the outside world, the necessary specific information and resources to innovate (*ibidem*).

Another very debated theoretical framework of territorial systemic innovation is the Innovation Systems (ISs) one; it highlights the significance of the interactions among the people and institutions involved in innovation and it emphasizes that the process of innovation requires intensive cooperation among agents of innovation such as universities and research centres, technology centres, financing institutions, industry associations and government agencies and bodies. The ISs approach also asserts the systemic nature of the innovation processes and argues that an economy's capability to generate innovations doesn't only depend on how innovation actors perform, but rather on how they interact each other (Gregersen and Johnson, 1996).

De la Mothe and Paquet (1998) have pointed out the "pillars" of the IS conceptualization: i) the linkages (both formal and informal) between organizations; ii) the firms as elements of a network of public and private sector; iii) organizations aimed at initiating, importing, modifying and diffusing new technologies; iv) the flows of intellectual resources among organizations; v) learning as a key economic resource.

By looking at territorial declinations of the ISs concept, two territorial theoretical perspectives were carried out from literature: National Innovation Systems

(NISs) and Regional Innovation Systems (RISs). After an initial strong literature interest on the NISs perspective (Freeman, 1987; Lundvall, 1992, Nelson , 1993; Edquist, 1997), scholars massively pointed their attention on the Regional Innovation System one (P. Cooke, 1992; P. Cooke et al., 1997) because of the broad acknowledgment of the critical role played by regional proximity of innovation agents.

Studies on learning economy have triggered several scholars to also develop the Learning Region (LR) framework; as argued by Shearmur R. (2011) "the learning region idea emphasizes regional capacities to capture and utilize codified and tacit knowledge, and highlights the role of research institutions and qualified workers". According to the Learning Region idea, innovation actors - sharing the same local context - learn to cooperate with each other in addressing economic and social innovation. These actors include enterprises, customers, producers, consultants, research institutes and universities, etc. In other words, the local community learns together in an integrated way with all parts of the socioeconomic system. Thus, communication and cooperation among the different actors are critical points enabling people to learn from each other (Gustavsen et al., 2007). Also institutions, interpreted as normative structures, play an important role in promoting stable and efficient interaction and collaboration. According to Florida (1995), learning regions are able to offer the critical inputs for the development of knowledge-intensive economic organization, such as: "a manufacturing infrastructure of interconnected vendors and suppliers; a human infrastructure that can produce knowledge workers, facilitates the development of a team orientation, and which is organized around life-long learning; a physical and communication infrastructure which facilitates and supports constant sharing of information, electronic exchange of data and information, just-in-time delivery of goods and services, and integration into the global economy; and capital allocation and industrial governance systems attuned to the needs of knowledge-intensive organizations" (Florida, 1995).

At the end of '90s, literature also carried out the Triple Helix (TH) framework (Etzkowitz H. & Leydesdorff L., 1995, Etzkowitz H. & Leydesdorff L., 2000) which states that "the university can play an enhanced role in innovation in increasing knowledge-based societies" (Etzkowitz H. & Leydesdorff L., 2000); this conceptualization focused "on the network overlay of communication and expectations that reshape the institutional arrangements among universities, industries and governmental agencies" (*ibidem*). The TH model of university, industry and government relations is aimed at interpreting the knowledge infrastructure constituted by respective overlapping institutional spheres; each sphere takes the role of the other and hybrid organizations emerge at the interfaces (*ibidem*). The TH is a framework without a specific territorial focus; indeed, it has been applied both at national level and at regional one: "most countries and regions are presently trying to attain some form of Triple Helix" (*ibidem*) by realizing an innovative environment with "university spin-off firms, tri-lateral initiatives for knowledge based economic development, and strategic alliances among firms (large and small, operating in different areas, and with different levels of technology), government laboratories and academic research groups" (*ibidem*).

Addition of the emergence concept within literature on territorial systemic innovation has been proposed by the "ecology of innovation" (EI) framework (David and Metcalf, 2008); the "ecology" idea has been acquired from biology for answering to the need of considering the continual evolutionary nature of interrelations among individuals, innovative activities and their environment (Finegold, 1999; Pepaioannu T. *et al*, 2007). Within EI conceptualization David and Metcalf (2008) highlighted that "a system depends on connections (interactions) and cannot be described or understood simply in terms of their components" (*ibidem*); furthermore, these scholars sustained that under the development of "innovation systems" there are emergent properties of an ecology of innovation, resulting from the formation of mutually reinforcing inter-organizational relationships between individual and organizational entities specialized in functional capabilities. The ecology of innovation approach refers to a theoretical corpus which constitutes its foundation: the complex adaptive systems (CAS) theory, that looks at the system as a set of connected or interdependent different agents, with the capacity to alter or change learning from experience. These agents act through their own schema and surrounding knowledge and conditions.

More recently (2008), literature also carried out the Smart Specialisation (SS) theoretical framework; this new framework quickly made a significant impact on the policy audience, particularly in Europe. In fact the smart specialisation concept is a key element of the EU 2020 innovation plan (accordingly, the European Commission has decided to build a platform of services - S3 - to support regions in their efforts to devise and implement a smart specialisation strategy). Smart specialisation is about regional knowledge resources (R&D and innovation) and it suggests that a region should specialise in R&D and innovation related to economic sector relevant for its competitiveness. The specialisation seeks the concentration of resources upon focused knowledge development or knowledge acquisition and experience-based expertise that complements relevant regional resources. “Smart specialization thus involves both a logic of concentration and a logic of particularization of a region’s knowledge assets” (Foray *et al*, 2011). The Smart Specialization advocates different policies for core and periphery regions. Core regions, that are at the scientific and technological frontier, can invest in the invention of a General Purpose Technology (GPT), while periphery regions are better advised to invest in the «co-invention of applications » - that is – the development of the applications of a GPT in one or several important domains of the regional economy. By so doing, the periphery regions and the firms within them become part of a realistic and practicable competitive environment - defining a viable market niche that will not be quickly eroded away by the entry of external competitors. In the Smart Specialization idea a critical role is played by local actors endowed with entrepreneurial knowledge. To foster innovations, knowledge about science and techniques is not sufficient. It is necessary a blended entrepreneurial knowledge, which combines knowledge about science, technology and engineering with knowledge of market growth potential, potential competitors as well as the knowledge of production systems, and of the whole set of inputs, services and competencies required for launching a new activity. This knowledge is dispersed and fragmented. The synthesis and integration of all these typologies of knowledge is a necessary requisite to start an innovative business.

The fundamental idea of SS framework is that a public policy should identify entrepreneurial discoveries and support, and possibly channel entrepreneurial initiatives in direction of regional smart specialization through a variety of incentive mechanisms. Furthermore, the public policy should monitor and assess the progress of entrepreneurial experiments and guide the formation of a shared strategic vision enhancing the future exploitation of the region's emerging opportunities for specialisation. Finally, public measures should be able to identify and address potential coordination failures and monitor and reassess the degree to which the shared strategic vision is being realized, the effectiveness of measures addressing coordination failures, the impacts on the region's economy, and the sustainability of the development without continuing public support (Foray *et al*, 2011);

The Smart Specialization framework had the merit of eliminating many illusions related to effective regional innovation policies. It advocates that innovation policies must be embedded in the local reality. Camagni and Capello (2012) have agreed on many of the assumptions of Smart Specialization. Particularly, they underlined the key concept of "embeddedness" and "connectedness" put forward in the scientific debate by the Smart Specialization perspective. But they criticized the simplicistic dichotomy between advanced research area (the leader or "core" regions) and the co-innovation area (the follower of "periphery" regions). They state that "the geography of innovation is much more complex than a simple core-periphery model: the capacity to pass from knowledge to innovation and from innovation to regional growth is different among regions, and the identification of specific 'innovation patterns' is necessary"(Camagni and Capello, 2012). Innovation Pattern (IP) theoretical framework, recently proposed by the ESPON KIT (Knowledge, Innovation, Territory) group, argued that invention, innovation and diffusion are not necessarily intertwined; specificity of learning processes, quality of human capital and knowledge externalities, present at regional level, make a determinant role in structuring the local pattern of innovation. According to IP idea, different regions develop different cognitive and social spaces and this explains different pattern of innovation; so, beside the leader regions and follower regions there are also regions able to imitate and adapt on innovation that already exists (ESPON, 2012).

The ESPON KIT group claimed that in some cases a sub-system of knowledge generation may be present, in some other not, and knowledge could be acquired from outside. In the idea of the ESPON KIT group it is possible to consider alternative situations on which the innovation may be built on a) internal knowledge base; b) local creativity even in absence of local knowledge; c) innovative applications of a knowledge developed elsewhere; d) imitative processes; furthermore, the ESPON KIT group stated that a territorial pattern of innovation is made of a combination of territorial specificities and different modes of performing the different phases of the innovation process (Creation of knowledge, Innovation, Economic Efficiency). Among all possible combinations, the archetypes are the followings: a) an endogenous innovation pattern, where the local conditions – education, human capital, urban externalities, territorial receptivity of external knowledge, collective learning and entrepreneurship - “are all present to support the creation of knowledge, its local diffusion and transformation into innovation and its widespread local adoption” (ESPON, 2012); b) 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; c) 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.

1.2.2 Emergence and self-sustainability

This section is aimed at investigating how the concepts of emergence and self-sustainability (SS) have been dealt in theoretical frameworks of territorial systemic innovation.

Several scholars of theoretical frameworks in 1.2.1 section have showed signs to the emergence and self-sustainability concepts, in more or less explicit way.

Martin and Sunley (2011) argued that spatial agglomeration of firms, like Industrial District, are the result of self-organising macro-features in an unplanned way from the micro behaviours and iterative interactions of agents; more on this point, they sustained that the spaces produced by economic agents - in turn - feed back to influence the behaviours and properties of those agents (*ibidem*). Other scholars also emphasized the link between IDs framework and the self-sustainability concept; indeed Becattini (2002) suggested to look at Industrial District as a self-reproducing form of the societal production process; furthermore, Zeleny (1999) argued that " as long as SME network responds and "covers" the everchanging chains, the network remains self-organizing (autopoietic) and self-sustaining".

Lombardi (2003) alluded to the concept of emergence within the Local Production Systems framework by highlighting the co-evolving behavior of LPS actors: indeed, according to this author, LPSs structure is an effect of unintentional result of adaptive dynamics and co-evolving behavior of agents. Furthermore, Belussi (1999) looked at the reproductive capability as a strict requisite for the identification of a Local Productive System, so alluding to the significance of the self-sustainability concept for the LPSs theoretical framework. The emergence and self-sustainability features have been also emphasized in specific typologies of LPSs like, for example, territorial cluster, that is – according to Porter M. E. (2000) – a "geographic concentration of interconnected companies, specialized suppliers and service providers, firms in related industries, and associated institutions (e.g. universities, standard agencies, and trade associations) in particular fields that compete but also cooperate"; indeed, Martin & Sunley (2011) referred to the emergence concept within territorial cluster framework by sustaining the reciprocal influence - as result of a relational system of firm interdependencies - operating between cluster level properties and firms level properties that belongs to the cluster; furthermore, Martin & Sunley (2011) also showed signs to the self-sustainability idea by highlighting the reinforcement effect played by the emergence of localised externalities - or spillovers of various kinds - on the process of a particular industrial/technological specialism belonging to the cluster; still on the self-sustainability idea, Porter M.E. (1998) sustained the self-reinforcing cycle as mechanism of cluster growth.

Within NISs framework Scott (1998) argued that each particular space is the site of an evolving polarized complex of production activities, as well as local labour market phenomena and social life, which inner dynamics are “a congeries of interconnected producers and associated local labour markets”; so, by referring to the above feature of evolution with inner dynamics, we note that within NISs framework there is an implicit recall to the emergence concept.

MI – with an implicit allusion to the emergence idea - has been also viewed as the seat of permanent processes of adjustment, transformation and evolution due to the interaction logic and collective learning dynamics (Maillat, D., 1998). Furthermore, we also emphasize links between the self-sustainability idea and the MI framework by observing that the role of Milieux Innovateurs is to guide the localised production system attached to it “towards a new state in which the territorial logic continues to manifest itself.” (Maillat, 1998); more on the last point, Maillat stated explicitly the self-sustaining nature of MI by looking at evolution of Milieux Innovateurs as the way in which they reproduce themselves, change and innovate (Maillat, 1998) and by pointing out that the renewing of innovation capacities is a critical feature for the existence - over time - of the Milieux Innovateurs (Maillat, 1998).

Several scholars have linked ISs and the concept of emergence, more or less explicitly: Stahle (2002) argued that within an Innovation System there is a question of complex interaction among actors; so - implicitly - this scholar emphasized the emergence as an underlying feature of the IS framework; Metcalfe & Ramlogan (2008) sustained that “innovation systems are emergent phenomena”; Cooke (2012) highlighted the engagement between emergence concept and Regional Innovation System framework by looking at emergence as “a cognate concept to co-evolution and complexity”; more on this point, Cooke (2012) explicitly referred to some examples of the emergence form of RISs within his new book ("Complex Adaptive Innovation Systems: Relatedness and Transversality in the Evolving Region", 2012).

Scholars also highlighted the link between the self-sustainability concept and the IS framework: indeed, STRATA-ETAN Expert Group (2002) suggested that “public action can be used to create self-generating conditions”; furthermore, Stahle (2002) referred to the basic condition required for the creation of a social system generating innovations as a question of a system with a self-generative capacity to create and sustain an operative environment where innovation are generated.

MacKinnon *et al*. (2002) alluded to the emergence concept within Learning Regions framework by referring to adaptive behavior of certain regions to changes in the external market environment as result of key learning sources like relational assets or untraded interdependencies. Furthermore, MacKinnon *et al*. (2002) implicitly referred to the link between the self sustainability idea and the LR framework by emphasizing that continued participation of firms in the processes of open exchange of knowledge and ideas is necessary to sustain over time localized forms of collective learning.

The TH literature also alluded to the emergence idea: indeed, Leydesdorff & Etzkowitz (1998) emphasized the continuous restructuration of the opportunity matrix of the network of university-industry-government relations as result of the reconstruction, from different angles, by each of the participating instances; moreover, they highlighted that innovation needs of room for “bottom-up” initiatives (Etkowitz & Leydesdorff, 2000).

Triple Helix literature also referred to the self-sustainability concept by sustaining the need of controlling wealth generation in the economy and novelty generation in order to have the retention and reproduction of the system (Leydesdorff L., 2006).

As the Ecology of Innovation theoretical framework is grounded on CAS conceptualization, it is evident that the concept of emergence extensively lives within it.

Literature referred to the link between the self-sustainability idea and the Ecology of Innovation theoretical framework by dealing with innovation vitality of certain ecosystems like Silicon Valley; indeed, Finegold (1999) showed how clusters or industrial districts “have become self-sustaining high-skills ecosystems (HSEs), that once started, generate a positive, mutually reinforcing dynamic that fuels ongoing knowledge creation and growth and adaption to changing competitive conditions”.

Foray *et al* (2011) – by dealing with Smart Specialisation framework - suggested the need to monitor and reassess policy programs in order to evaluate the achievement of the sustainability of the development without continuing public support; accordingly, also European Commission - by looking at Smart Specialization – argued that research and innovation strategies <<can ensure that research and innovation resources reach critical mass, i.e. sufficient momentum to become self-sustaining>> (EC, 2011).

Camagni R. and capello R. (2013) sustained the self-organized way as the manner in which decisions of local actors and entrepreneurial creativity have to be supported by pro-active policies of the Innovation Pattern framework; so, they explicitly alluded to the significance of the emergence idea within IP framework. Still, Camagni R. and capello R. (2013) implicitly referred to the link between self-sustainability and Innovation Pattern framework by emphasizing that the aim of IP policies is to reinforce the virtuous aspects that characterize each pattern; finally, last scholars carried out explicit calls to the self-sustainability concept within IP framework: indeed, they highlighted the important role, in innovation processes, played by self-reinforcing feedbacks from innovation to knowledge and from economic growth to innovation and knowledge (Camagni R. & Capello R., 2012).

Emergence concept and frameworks of territorial systemic innovation

Authors	Industrial District (ID)
Martin, R., and Sunley, P., 2011	Spatial agglomeration of firms, like Industrial District or Territorial Clusters, as result of self-organising macro-features in an unplanned way from the micro behaviours and iterative interactions of agents

Authors	Local Production System (LPS)
Lombardi, M., 2003	LPS structure due to unintentional result of adaptive dynamics and co-evolving behavior of agents
Martin R. and Sunley P., 2011	Emergence of cluster level properties and firms level properties as result of a relational system of firm interdependencies".

Authors	New Industrial Spaces (NISs)
Scott, 1998	NIS as the site of an evolving polarized complex of production activities with inner dynamics

Authors	***Milieux Innovateurs***
Maillat, D., 1998	*Milieux Innovateurs* as the seat of permanent processes of adjustment, transformation and evolution due to interaction logic and collective learning dynamic

Authors	Innovation Systems
Stahle P., 2002	Innovation System as a question of complex interaction among actors
Metcalfe, S., Ramlogan,R., 2008	Innovation systems as emergent phenomena
Cooke P., 2012	Emergence idea within RIS theoretical framework as "a cognate concept to co-evolution and complexity"

Authors	Learning Region
MacKinnon D., Cumbers A. and Chapman K., 2002	Adaptive behavior of certain regions to changes in the external market environment as result of key learning sources as well as relational assets or as untraded interdependencies

Authors	Thriple Helix
Leydesdorff & Etzkowitz, 1998	Continuous restructuration of the opportunity matrix of the network of university-industry-government relations as result of the reconstruction, from different angles, by each of the participating instances
Leydesdorff & Etzkowitz, 2000	Innovation needs of room for "bottom-up" initiatives

Authors	Smart Specialisation
-	-

Authors	Innovation Pattern
Camagni, R. & Capello R., 2013	Self-organized way as the manner in which decisions of local actors and entrepreneurial creativity have to be supported by pro-active policies

Authors	Innovation Ecology
-	Note: IE is grounded on Complex Adaptive System perspective and, as consequence on the emergence concept

Self-sustainability concept and frameworks of territorial systemic innovation

Authors	Industrial District (ID)
Zeleny, 1999	Self-sustainability as result of virtuous reactions of SME network
Becattini, 2002	Self-reproducing form of the societal production process as a way to look at Industrial District

Authors	Local Production System(LPS)
Porter, 1998	Self-reinforcing cycle as mechanism of cluster growth
Belussi, 1999	Reproductive capability as a strict requisite for defining a local production system
Martin, R., Sunley, P., 2011	Reinforcing processes, like emergence of localised externalities/spillovers, as instruments for cluster development

Authors	New Industrial Spaces (NISs)
-	-

Authors	*Milieux Innovateurs*
Maillat, 1998	Evolution of Milieux Innovateurs as the way in which they reproduce themselves, change and innovate
Maillat, 1998	Guiding Localised Production System - attached to Milieux Innovateurs - towards a new state in which territorial logic continues to manifest itself as role of Milieux Innovateurs
Maillat, 1998	Renewing of innovation capacities as critical feature for the existence over time of the Milieux Innovateurs

Authors	Innovation Systems
STRATA-ETAN expert g., 2002	Self-generating status as condition created by public actions
Sthale, 2002	Self-generative capacity of a system to renew itself and to sustain an operative environment as basic condition required for the creation of a social system generating innovations "

Authors	Learning Region
MacKinnon *et al*., 2002	Sustainability over time of localized forms of collective learning as result of continuous firms participation in a process of open exchange of knowledge and ideas.

Authors	Thriple Helix
Leydesdorff , 2006	Reproduction of the system as result of local control of wealth generation in the economy and novelty generation by organized science and technology

Authors	Smart Specialisation
Foray *et al*, 2011	Sustainability of the development without continuing public support as a target for policy programs fostering smart specialization
EC, 2011	Self-sustainability as output of research and innovation strategies for Smart Specialisation

Authors	Innovation Pattern
Camagni R. & Capello R., 2012,	Self-reinforcing feedbacks from innovation to knowledge and from economic growth to innovation and knowledge as important requisites for innovation processes"
Camagni, R. & Capello R., 2013	Reinforcing of the virtuous aspects that characterize each pattern as result of smart innovation policies characterized by ad-hoc interventions for each single territorial innovation pattern,

Authors	Innovation Ecology
Fnegold D., 1999	Self-sustaining high-skills ecosystems as evolution of clusters or industrial districts characterized by a positive and mutually reinforcing dynamic, that fuels ongoing knowledge creation and growth and adaption to changing competitive conditions

1.3 Regions as *locus* of innovation

From 1.2.1 section is emerged that diffusion and absorption of knowledge depends on the presence of systemic cooperation among innovation actors.

As highlighted by OECD (2011), where there is an hub of competence at local level, namely knowledge accumulation in a location, other innovation actors move to the same place; so, it can be inferred that innovation goes toward location; obviously, the more it happens, the more the geographical proximity of innovation actors growths.

In addition to the critical role played by knowledge accumulation for territorial innovation, literature has also highlighted the significance of knowledge circulation around locations (OECD, 2010), i.e. within locations, from outside to inside locations and in the opposite way.

So, it can be inferred that innovation goes toward locations characterized by a networked hub of accumulated knowledge, with internal and external knowledge connections; in other words, it may be inferred that innovation goes towards “centers of attractiveness” of the knowledge accumulation and circulation. Obviousely, within this viewpoint the critical mass and the critical variety of competencies (relevant to explore and exploit the flow of technological opportunities) become key attributes for the innovation development.

Literature has also recognized the critical role played by local institutional conditions for their impact on the systemic development of innovation; indeed - according to Boschma R.A. (2005) idea that <<not only too little, but also too much proximity may be detrimental to interactive learning and innovation>> because <<proximity (in whatever form) have a positive impact (solving the problem of co-ordination) and also a negative impact on innovation (lock-in)>> - institutions are able to balance every form (cognitive, organizational, social, institutional, geographical) of proximity; more in general, as argued by several authors, institutions shape the behavior of actors and their relationships by means law, regulations, values, practices, routines (Trippl, 2006; Andersson and Carlssons 2006).

From the point of view of geographical dimension, <<innovation is most effectively addressed at regional level>> (European Union, 2007); indeed, <<the region is a key, necessary element in the “supply architecture’ for learning and innovation>> (Storper, 1995). Maskell and Malmberg, (1999) also suggested that forms of localized knowledge provide key competitive inputs in the globalized world. At date, it is recognized that the accumulation of technological processes occurs mainly on the regional level and that technological and knowledge spillovers tend to be geographically concentrated (Brenner and Grief, 2006. OECD, 2011). Cook and Memedovic (2003) also argued that <<regions, especially when they have developed clusters and appropriate administrative machinery for supporting innovative enterprise, represent more meaningful communities of economic interest, define genuine flows of economic activities and can take advantage of true linkages and synergies among economic actors.>>.

The smaller is a territory the bigger is the level of geographical proximity of innovation actors, and the bigger is a territory the higher is the number and variety of innovation actors; therefore, geographical proximity and critical mass/variety of innovation actors go in opposite way with respect to territorial dimension; so, according to abovementioned literature on regional dimension of innovation, it may be inferred that regional dimension represents the ideal intermediate dimension, between too small and too big territories - for balancing geographical proximity and critical mass/variety of innovation actors.

So, within this framework it can be stated that regional level works better - with respect to innovation - than national level or sub-regional level. As examples of empirical evidence, it is well known that there has been a polarization of innovation in certain regions around the world (i.e.: Silicon valley, Baden Wurttemberg).

Literature has showed two alternative ways to look at regional scale: the administrative region and the functional one: the administrative region is a territory, smaller than its sovereign state, possessing distinctive administrative power and aimed at governing actors and resources belonging to its geographical borders; as regional innovation actors are often closely linked to networks at extra-regional spatial level (Pinto H., 2009), the administrative region hasn't to be looked as a closed island.

On the other hand, according to Andersson M. and Karlsson C. (2006), the functional region may be defined <<as a territory in which the interaction between the market actors and flows of goods and services create a regional economic system whose borders are determined by the point at which the magnitude of these interactions and flows change from one direction to another>>(fig.1.1).

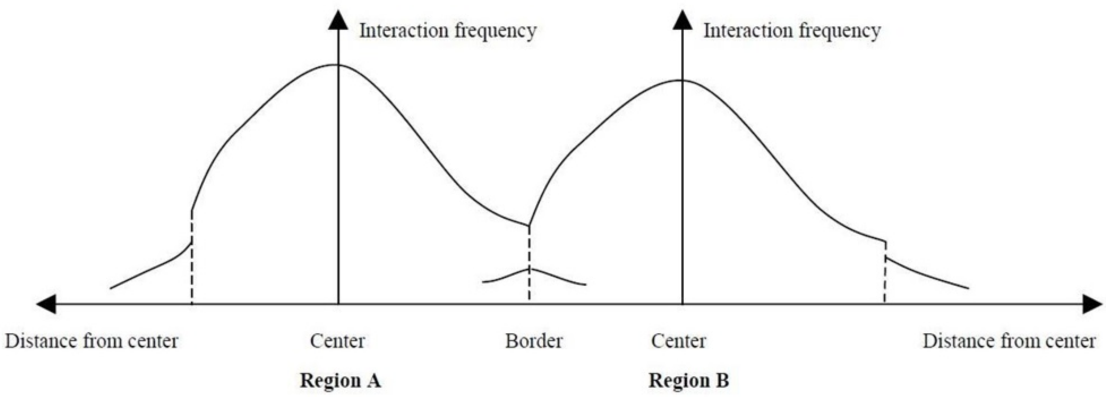


Fig.1.1: Demarcation of functional regions; source: Andersson M. and Karlsson C. (2006)

Although literature highlights that regional administrative boundaries often lack of economic meaning (Asheim B. T. *et al*, 2011), as this PhD thesis is aimed at developing a new theoretical framework useful for politically dealing with systemic character of innovation at regional scale, in the following we take into account the governmental aspect of regional innovation; so, this work adopts the concept of administrative region.

1.4 Conclusions

Systemic innovation is a key driving force for the long-term economic growth of a territory, and proximity (cognitive, organizational, social, institutional, geographical) among innovation actors is a key attribute of an innovative territory.

Literature has showed a rich array of theoretical frameworks on territorial systemic innovation; these framework are characterized by several common elements and by the evidence of a recurrent underlying reference for the emergence and self-sustainability concepts; scholars also highlighted the absence of a unified conceptual framework from which an universal model may emerge to guide research and policy (Doloreux D. and Parto S., 2004). So, literature analysis suggests the need of adopting common elements in an unified vision.

Moreover, scientific literature has achieved a large consensus on the fact that systemic innovation has to be viewed from a regional point of view and that it is strongly related to institutional condition and to the presence of intangible resources - such as culture, competence and knowledge - at regional level. So, in order to deal politically with systemic innovation, it can be inferred that regional government has a critical role for the development of regional systemic innovation.

Chapter 2

Methods to assess regional innovation

2.1 Indicators and composite indicators

Indicators are data that are used to give an interpretation of their associated factors; they are provided from surveys or from administrative databases. Indicators have to be used rationally because they don't tell the whole story; as example, in two countries there can be the same gross domestic product per capita, but there can be difference in income distribution among citizens.

When a phenomenon in observation is analyzable by a combination of several indicators, there is the need to construct a composite indicator. OECD (2008) has provided the reference criteria for the construction of a composite indicator, with the relevant passages to implement:

Theoretical Framework: is the starting point for the construction of a composite indicator; this step provides theoretical ground for identifing latent variables of the phenomenon to estimate; correct definition of theoretical framework represents a phase of fundamental importance because it influences the correlation between composite indicator and the phenomenon in observation; therefore, this step is decisive for the whole analysis and - then - it asks for the full involvement of stakeholders and experts.

Above all, this step asks for a clear definition of the multidimensional concept to measure; therefore, it requires determination of the correct conceptual categories/sub-categories.

On the definition of a composite indicator aimed at estimating regional innovation capability - for example - the Council on Competitiveness of U.S.A. (2005) have suggested "input" and "output" as conceptual categories for this phase; more in depth, the above Council suggested the following sub-categories associated to the "input" category: human capital, research and development institutions, financial capital, industrial system, infrastructural system, legal and regulatory environment, networks, quality of life, entrepreneurial culture; moreover, Council on Competitiveness suggested the following sub-categories associated to the "output" category: - idea generation, idea development, idea commercialization, regional prosperity.

Indicator selection: this is a fundamental step for the quality of the final result; indeed, quality of indicators influences accuracy (i.e. correct estimation) of the phenomenon to measure and timeliness (i.e., the temporal distance between data availability and phenomenon that should be described).
In the following, criteria of indicators quality are listed and described:

- *Relevance*: it is a qualitative concept linked to the correlation degree of statistical data.

- *Accuracy*: it is a qualitative concept on how are closed real values and extimated ones.

- *Timeliness*: it is a qualitative concept on temporal distance between data availability and phenomenon that should be described

- *Punctuality*: it is a qualitative concept on the punctuality of data publication.

- *Accessibility*: it is a qualitative concept on the easiness of acquiring data from original sources; this concept depends on conditions for consulting statistics (free, not free, reserved to research structures and so on)

- *Interpretability*: it is a qualitative concept on the easiness for studying data; it depends on precision of descriptive metadata (which are - as defined by International Organization for Standardization - data that describe and define statistical data); so, interpretability depends on accuracy in the definition of concepts, population target and variables, and also depends on accuracy in precision on information concerning eventual limits.

- *Coherence over time* and *coherence across countries*: they are qualitative concepts on the needs that statistical data should be based on concept, definitions and methodologies that should be result coherent over time and across countries.

Other critical steps: relevant is the numerical estimation of lacking data. Such estimation can be conducted by using several methodologies such as linear regression and iterative processes, for example.

Moreover, there are *further critical step* for constructing a good composite indicator: multivariate analysis (for the aggregation of indicators in few factors), data normalization and definition of the aggregation model in a composite indicator.

2.2 Innovation indicators

The definition of innovation - for measurement purposes - has been presented in the OECD Oslo manual; in first edition of this book (OECD, 1992), such definition has been only related to product and process innovation; in third edition, the definition of innovation was linked to all industrial processes, as - for example - development of new markets or new organizational internal processes: <<an innovation is the implementation of a new or significately improved product (good or services), or process, a new marketing method, or a new organizational method in business practices, workplace organization or external relations>> (OECD, 2005)

OSLO manual has been developed by OECD working party of national experts on Science and Technology Indicators (NESTI); this working party was constituted from representatives of 34 countries; since its second edition, OSLO manual became a joint product of the OECD and Eurostat (the statistical office of the European Union).

OECD has got a database with a world coverage and it is a collector of indicators provided by statistical offices of each member countries; european data are provided by Eurostat. Each national statistical office of the european member countries (ISTAT, in Italy) provides data to Eurostat. As highlighted by Gault F. (2013), the provision of innovation statistics to Eurostat - concerning the production and development of community statistics on innovation through Community Innovation Surveys (CIS) - is governed by Commission Regulation (EC) N° 1450/2004; this provision - based on concepts and definition of the most recent edition of Oslo manual - identifies the industrial coverage, frequency of reporting of variables, employment size classes of firm surveyed and various other aspects. A lot of data used for the production of innovation indicators are extracted from surveyes of which the CIS is an example. Data can be also provided from administrative databases such as business registers or tax files.

As Gault F. (2013) has sustained, innovation indicator is a difficult subject for several reasons: first of all because innovation is not an isolated event as innovation of firms is influenced by several aspects such as organization and business practices, production processes and market development; moreover, surveys questions couldn't be understood in the same way from all respondent; this issue can become further heavy when survey questions are in different languages and in different countries. So, cognitive testing (to ensure data comparability resulting from survey questions) and survey design is a fundamental step. Furthermore, statistical data provided from surveys can exibit change - over time - which may or may not be correlated with other observables, such as - for example - economic recession. Last reason - but not least - is the difficulty of the choice among innovation indicators; indeed, as argued by Kleinknecht A. *et al* (2002), each indicator could present advantages and weakness; for patent's indicator, as example, despite patent records offer the most detailed overview of technical knowledge over long time period, the using of this indicator could cause several systmatic mystakes such as the understimaton of innovation in low technological opportunity sectors, or as the understimation of the rate of small firms that innovate.

2.3 Current tools and methods to assess regional innovation

The understanding of the sources and patterns of innovative activity is the critical step for developing better policies; so, in the last years it has been highlighted the need of defining operational models aimed at measuring innovation performance of regions.

Since 2002 the European Commission carried out publications with information and statistical evaluations on the innovative capability of the EU regions; such publications, representing first attempt for monitoring regional european dynamics on innovation capability, were aimed at suggesting better innovation policy (Hollanders H. *et al*., 2009); moreover, these pubblications gived the start for the production of several regional scoreboards, from several organizations.

These scoreboards have been characterized for the adoption of specific performance indicators and for the implementation of a composite indicator aimed at measuring the multidimensional concept of regional innovation. Such approach was useful for the *benchmarking* of the innovation *status-quo* and for the trends identification. In the following of this section there is a description of main scoreboards, but also other tools, that have been implemented in literature for measuring innovation capability of a region. Appendix A presents main indicators related to regional innovation.

2.3.1 Scoreboards and other tools for measuring the innovation capability of a region

Innovation capability of a region has been evaluated through several tools: in the following, there is a brief description:

Science, Technology and Innovation in Europe (Eurostat, 2013): it is a pocketbook prepared by Eurostat. It gives a full framework - on science, technology and innovation of European Union - through the use of several Eurostat indicators.
Indicators portfolio is subdivided in seven pillars: government budget appropriations or outlays on R&D, R&D expenditures, R&D personnel, human resources in science and technology, innovation, patents, high-technology. This pocketbook does not calculate a composite indicator.

Categorisation of OECD regions using innovation-related variables (Marsan G.A., Maguire K., 2011): it analyzes 240 regions of 23 countries by identifying eight groups of regions; this categorization is grounded on the similarity of performance for the 12 variables used in the statistical cluster analysis (statistical methodology that enables the definition of groups in data); then, eight groups of regions are classified in three macro-categories, for policy reccomendations:

-"knowledge hubs", in which there are regions with best results in innovation and science and technology indicators;

-"industrial production", in which there are regions, with different production characteristic, that face specific challenges for restructuring and trasformation to keep up with innovation frontier;

-"non-S&T-driven regions", in which there are regions that need to build up knowledge absosption capacity and knowledge generation assets.

Thriple helix: according to the Triple Helix theoretical framework, some scholars have implemented a methodology aimed at measuring the knowledge base of an economy in terms of Triple-Helix relations among technology, organization, and territory; three variables have been used as proxies for the dimensions of technology, organization, and geography, at systemic level: technology has been indicated by the sector classification, organization by the company size in terms of numbers of employees, and the geographical position by the postal codes in the addresses (Leydesdorff L. et al., 2005). So, an indicator of interaction effects was developed - at the network level - through the use of the Shannon's formulas (Shannon C.E., 1948); this indicator was used to measure the knowledge base of the economy in observation .

Pattern of innovation: by using a list of indicators able to cover all aspects of the complex knowledge-innovation chain, a cluster analysis has been applied to identify whether the “territorial patterns of innovation” actually exist in Europe, or - more precisely - to identify the existence of innovative behaviours, in european regions, that could be associated to conceptualizations of the several territorial patterns of innovation (ESPON, 2012).

Results showed that there is a variety of possible innovation patterns in Europe: two clusters (named "european science-based area" and "applied science area") that can be associated to the "endogenous innovation pattern", two clusters (named "smart technological application area" and "smart and creative diversification area") that can be associated to "creative application pattern", and one cluster (named "creative imitation area") that can be associated to "imitative innovation pattern".

Regional innovation scoreboards: generally speaking, regional innovation scoreboards are tools of immediate understanding for policy makers; indeed, through the use of innovation scoreboards strenght or weakness of the system can be identify, and effects of the implemented policy can be evalued (Paasi, M. 2005).
In the last years, the Directorate General Enterprise and Industry of the European Commission has financed the Pro Inno Europe initiative in order to create a focal point for innovation policy analysis and policy cooperation in Europe. The initiative has produced several national and regional innovation scoreboards; these scoreboard were used as a reference point by innovation policy makers across the EU. Last edition of the Regional Innovation Scoreboard (RIS) of European Commission provides a comparative assessment of innovation performance across 190 regions of the European Union, Norway and Switzerland (European Commission, 2014). This scoreboard is aimed at assessing the regional innovation performances by evaluating the factors which play a role in the innovation process. Average innovation performance is measured using a composite indicator: the "Regional Innovation Index"; this index is calculated as the unweighted average of the normalised scores of 11 indicators. But, the output of this scoreboard (i.e. the innovation ranking and the classification of regions) is grounded on a composite indicator that is not related to any specific conceptual model of innovation. The lack <<of an underlying model of the innovation process>> (Hollanders, Van Cruysen, 2008) - beyond all the editions of the Regional Innovation Scoreboard - is a critical point shared by many other scoreboards.

Italian regional innovation scoreboards: in the last years, several italian regional scoreboards have been also implemented: Scoreboard Regionale dell'Innovazione per la comparazione delle performance del sistema innovativo lombardo (Finlombarda, Regione Lombardia, Fondazione Rosselli, 2005), Innovation Scoreboard Regione Lazio (Regione Lazio, Filas, 2010);Puglia, Analisi del Sistema Innovativo Regionale (CERPI, 2008), Scoreboard Regionale dell'Innovazione per la comparazione delle performance del sistema innovativo piemontese (Fondazione Rosselli, 2007), Il quadro di valutazione regionale della competitività e dell'innovazione in Umbria (Regione Umbria, Servizio Controllo strategico e valutazione politiche, 2009), Scoreboard regionale dell'innovazione e della ricerca Friuli Venezia Giulia, (Area Science Park, Agemont, Ires, Cres, DGR Consulting, 2007).

By analyzing the above italian regional innovation scoreboards,we note that - like regional innovation scoreboard of European Commission - also italian regional scoreboards lack of an underlying conceptual model of the regional innovation process; so - like regional innovation scoreboard of European Commission - the italian regional innovation scoreboards suffer from a certain degree of methodological weakness.

Summarizing, regional innovation scoreboards can be useful for evaluating the factors which play a role in the innovation process but - generally speaking - scoreboards are characterized by a certain degree of methodological weakness.

Furthermore, scoreboards - and all the other tools proposed by literature - have showed no attention in the implementation of the self-sustainability concept, i.e.in the necessity to measure the level of innovation cycles aimed at self-mantening an effective regional innovation.

2.4 Conclusions

Understanding the sources and patterns of innovative activity is the critical step for developing better policies; an answer can be provided by implementing operational models aimed at measuring innovation performance of regions.

Since 2002 the European Commission carried out publications with information and statistical evaluations on the innovative capability of the EU regions.

All these works have been characterized for the adoption of specific performance indicators and for the implementation of a composite indicator aimed at measuring the multidimensional concept of regional innovation.

To date, regional innovation scoreboards proposed by literature are characterized by a certain grade of methodological weakness because of the absence of a conceptual framework beyond; only few different tools aimed at measuring regional innovation have referred to a conceptual model; so, only few other different tools have developed an operational model not methodologically so weak as the scoreboards one. But, in all current tool there isn't the implementation of the self-sustainability concept, i.e. there isn't a measurement related to the level of innovation cycles aimed at self-mantaining an effective regional innovation.

Our idea is that the implementation of the self-sustainability should be the goal of any regional innovation policy. In chapter 6 a conceptual self-sustaining model is presented; this model can be operazionalized in order to calculate the self-sustainability level of the regional innovation.

Chapter 3

The Campania RIS: an assessment analysis

3.1 Introduction

As emerged in chapter 2, regional innovation scoreboards of current literature are characterized by a certain grade of methodological weakness because of the absence of a conceptual framework beyond; but scoreboards - as we highlight in the following of this chapter- are useful tools because they let to measure the level of local resources and competencies.

So, in this chapter we develop an assesment analysis through the development of a scoreboard - on Campania RIS as case study - with the aim to understand the usefulness of these tools.

Our scoreboard is the result of a work assuming, as theoretical reference framework, literature on main italian and international regional scoreboards (Hollanders et al., 2009 (a); Hollanders et al., 2009 (b); Manjón, J. V. G., 2010, Council on Competitiveness of U.S.A., 2005; Fondazione Rosselli & Finlombarda, 2005; Filas (Lazio region), 2010; Cotec, 2011; Cerpi, 2008; Fondazione Rosselli, 2007; Regione umbria, 2009; Ires - Friuli Venezia Giulia, 2007).

3.2 Innovation Scoreboard of Campania Region

3.2.1 Methodology

In table 3.1 there is a description of the conceptual strategy adopted for the implementation of the scoreboard .

STEP		NOTES
1	Literature analysis	analyzed topics: regional innovation system, regional innovation key drivers, regional innovation scoreboards, methodologies for the construction of a composite indicator
2	Definition of the framework hypothesis	determination of the starting hypothesis on critical dimensions of regional innovation
3	Analysis of regional innovation indicators	Analysis of databases of innovation indicators
4	Definition of the starting proposals of indicators	Main selection criteria: potential impact with respect to hypothesized dimensions, minimization/absence of overlapping, data availability in brief time
5	Revisiting step on framework proposal	Objectives: enhancement both of the framework and of the indicators portfolio
6	Deepening step on framework proposal	Final definition of the critical dimensions to measure
7	Revisiting step on indicators proposal	Revisitation of indicators on the base of the critical dimensions selected in step 6
8	Lacking data treatment, statistical validation of scoreboard structure, data normalization, calculation of composite indicators	

Table 3.1: conceptual strategy adopted for the construction of the scoreboard

At section 3.6 we present main innovation indicators proposed by literature and normalization of our scoreboard statistical data.

First of all, as suggested by the methodological approaches of literature (OECD, 2008), we have identified macrofactors and dimensions of regional innovation. Therefore, coherently with "ProInno Europe Regional Innovation Scoreboard 2009", our scoreboard structure presents 3 macrofactors which are related to: 1) "enablers factors", 2) "firm activities", 3) "results".

Each of above macrofactors has been associated to specific regional innovation critical dimension that have been suggested from literature analysis (Hollanders et al., 2009-a; Manjón, J. V. G., 2010, Council on Competitiveness of U.S.A., 2005); so, we have selected 10 critical dimensions: 3 of 10 dimensions ("human resources", "finance for innovation", "institutional support") have been associated to the macrofactor "Enablers factors", 4 of 10 ("network connections", "innovative entrepreneurship", "exploitation of the research", "firms investments") to the macrofactor "firm activities" and last 3 of 10 ("innovating firms", "economical effects", "new ideas development") to the macrofactor "Results".

Finally, each of the abovementioned 10 dimensions has been associated to specific indicators, which have been chosen on the base of the following criteria:

- accessibility of data;
- guarantee of timeliness in the updating of data;
- presence of the indicator in the knownest regional innovation scoreboard;
- representative nature with respect to the dimensions;
- minimization of the overlapping;

So, from literature analysis on main italian and international scoreboards, (Hollanders et al., 2009 (a); Council on Competitiveness of U.S.A., 2005; Fondazione Rosselli & Finlombarda, 2005; Filas (Lazio region), 2010; Cotec, 2011; Cerpi, 2008; Fondazione Rosselli, 2007; Regione umbria, 2009; Ires - Friuli Venezia Giulia, 2007) we have selected critical indicators and - as consequence - we have developed our starting scoreboard structure, as reported in table 3.2:

Macrofactor	Dimension	Indicators	Number of lacking data
Enablers factors	Human resources	Public expenditures for education	0
		Public expenditures for education with respect to population	0
		Students of secondary superior school and post secondary (not university) school	0
		University students	0
		PhD students	1
		Population aged 20-24 with superior school diploma	0
		Population with tertiary education per 100 population aged 25-64	0
		Population aged 30-34 with university title	0
		S&E (science and engineering) graduates aged 20-29	0
		Participation in life-long learning per 100 population aged 25-64	1
		R&D personnel	0
	Finance for innovation	Venture capital investments in early-stage	5
		Venture capital investments in expansion/replacement	8
		Venture capital (%GDP)	4
		Number of investments in venture capital	0
	Institutional support	Public R&D expenditures (% of GDP)	0
Firm activities	Network connections	Innovative SMEs co-operating with others - % of all SMEs	0
	Innovative entrepreneurs hip	Broadband access by firms	0
		SMEs innovating in-house - % of all SMEs	0
	Exploitation of the research	EPO patents per million population	1
	Firms investments	Business R&D expenditures - % of GDP	0
Results	Innovating firms	Technological (product or process) innovators - % of all SMEs	0

		Non-technological (marketing or organisational) innovators -(% of all SMEs -	0
		Reduced labour costs resulting from process innovations - % ofSMEs	0
		Reduced use materials and energy resulting from process innovations - % of SMEs	0
	Economical effects	Employment in medium-high & hightech manufacturing	1
		Percentage of employment in knowledge-intensive services	0
	New ideas development	Rate of enrolment in the register of the enterprises	0
		Rate of birth of firms	0

Table 3. 2: starting structure for the scoreboard

Our starting scoreboard structure has been verified through a factorial analysis aimed at validating the starting associations among macrofactors, dimensions and indicators; more in depth, 2 indicators ("Public expenditures for education" and Public expenditures for education with respect to population") were eliminated from "Enablers factors" because they resulted as variables not correlated to the other indicators of this macrofactor; in "Result" macrofactor, the indicator "Percentage of employment in knowledge-intensive services " is resulted inversely correlated to the other variable; so, last one indicator couldn't be introduced in the construction of "Results" macrofactor (we have erase "Percentage of employment in knowledge-intensive services" - and not the second one - because we have noted - by consulting related metadata - that last one indicator was in partial overlapping with some indicators of "human resources" dimension); moreover, "Rate of enrolment in the register of the enterprises" were not result to have an high correlation with the other indicator of the related group; a further analysis suggested us to cancel "venture capital (%GDP)" indicator because of the impossibility to correctly estimate lacking values for this variable (impossibility due to its very high variability). So, the final structure of our scoreboard was constituted by 24 indicators (section 3.2.2 presents the scoreboard final structure).

In order to evaluate lacking data we have implemented a linear regression methodology on historical series; accordingly, as the number of PhD students of Valle D' Aosta region didn't have an historical series, PhD students value for valle D'Aosta region was fixed at zero value.

Obviousely, indicators refer to different phenomena; therefore, they have different unities of measure. So, to compare indicators it is necessary to normalize the data.
The normalization formula for each indicator (with X as value) was the following one:

$$X^* = \frac{X - MIN\ (X_i)}{MAX\ (X_i) - MIN\ (X_i)}$$

where i=1,…,20 refers to the regions;
X* is the normalized value resulting from the above MIN-MAX procedure

In order to calculate the value of the regional innovation composite indicator, we have calculated the dimensions values as simple average of related indicators values.

Furthermore, macrofactors were calculated as pondered average of the related dimension values, where the weight of each dimension was equal to the number of related indicators:

Macrofactor 1. “Enablers factors”

- Human resources: 9/13
- Finance for innovation: 3/13
- Institutional support: 1/13

Macrofactor 2: “Firms activities”

- network connections: 1/5
- Innovative entrepreunership: 2/5
- Exploitation of research: 1/5
- Firms investments: 1/5

Macrofactor 3: “Results”

- Innovating firms: 4/6
- Economical effects: 1/6
- New ideas development: 1/6

Each macrofactor have had 1/3 as related weight for the construction of the composite index on regional innovation.

3.2.2 Scoreboard structure

In table 3.3 there is a description of the final scoreboard structure with - in parenthesis - the position of the Campania region, in decrementing sense, with respect to 20 italian regions (in terms of macrofactors, dimensions and indicators):

Macrofactor	Dimension	Indicator
Enablers factors - (17)	Human resources - (17)	Students of secondary superior school and post secondary (not university) school - (17)
		University students - (17)
		PhD students - (11)
		Population aged 20-24 with superior school diploma - (16)
		Population with tertiary education per 100 population aged 25-64 - (15)
		Population aged 30-34 with university title - (20)
		S&E (science and engineering) graduates aged 20-29 - (11)
		Participation in life-long learning per 100 population aged 25-64 - (17)
		R&D personnel - (10)
	Finance for innovation * - (18)	Venture capital investments in early-stage - (16)
		Venture capital investments in expansion/replacement - (12)
		Number of venture capital investments - (16)
	Institutional support - (3)	Public R&D expenditures (% of GDP) - (3)
Firm activities - (18)	Network connections - (19)	Innovative SMEs co-operating with others - % of all SMEs - (19)
	Innovative entrepreunership * - (18)	Broadband access by firms - (13)
		SMEs innovating in-house - % of all SMEs - (17)
	Exploitation of the research - (15)	EPO patents per million population - (15)
	Firms investments - (10)	Business R&D expenditures - % of GDP - (10)

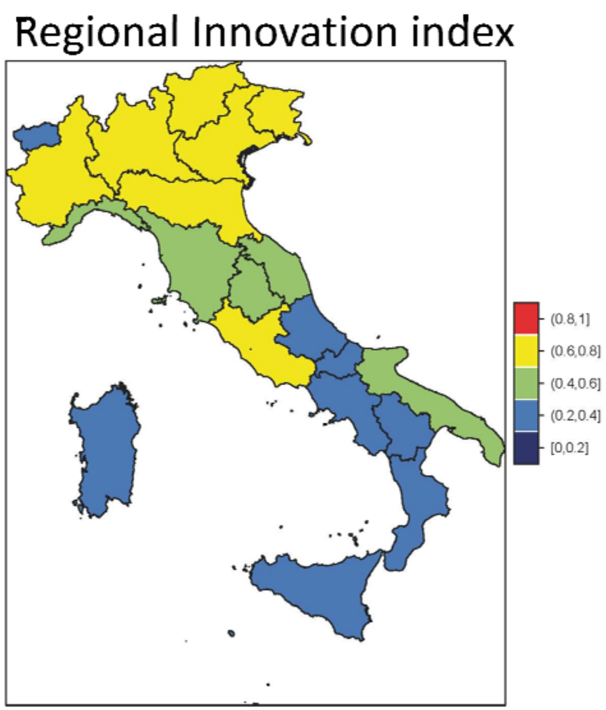
Risultats - (12)	Innovating firms - (14)	Technological (product or process) innovators - % of all SMEs - (17)
		Non-technological (marketing or organisational) innovators -(% of all SMEs - (7)
		Reduced labour costs resulting from process innovations - % of SMEs - (15)
		Reduced use materials and energy resulting from process innovations - % of SME - (17)
	Economical effects - (10)	Employment in medium-high & hightech manufacturing - (10)
	New ideas development - (2)	Rate of birth of firms - (2)

Table 3.3 – final scoreboard structure

* * There are <<ex aequo>>.

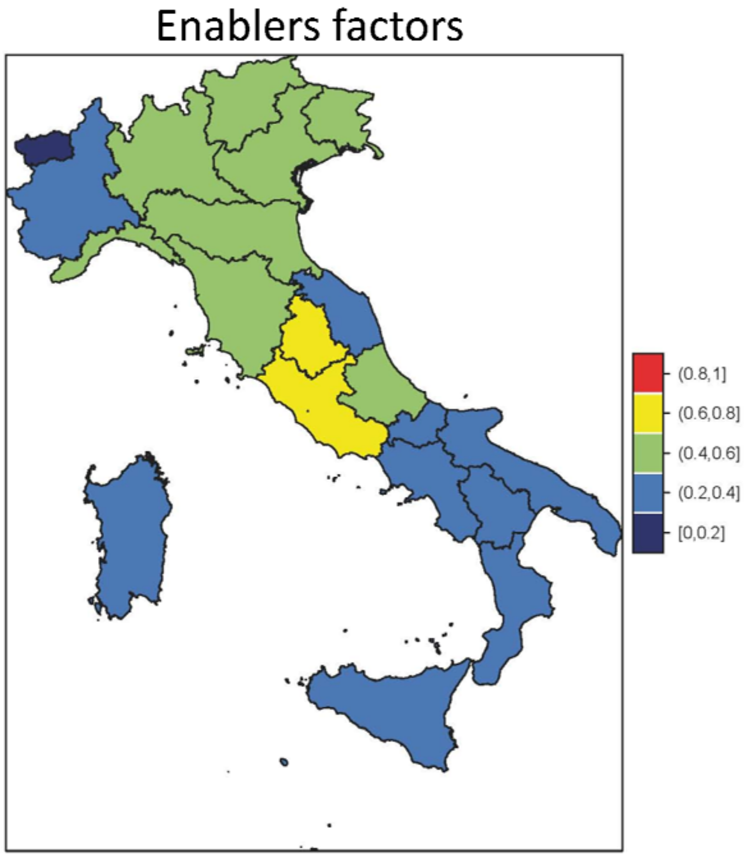
() In parenthesis the position of the Campania region, in decrementing sense, with respect to 20 italian regions.

3.3 Results

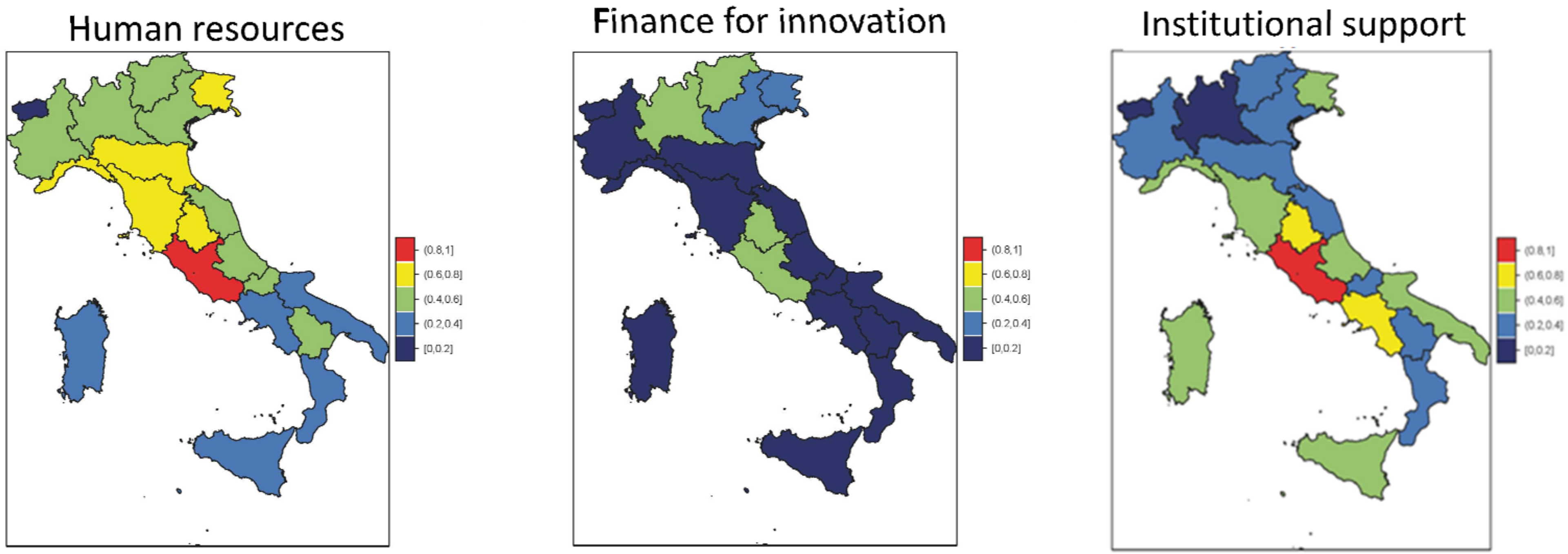


Ranking	Region	Composite index of regional innovation
1	Lazio	0,711
2	Emilia-Romagna	0,703
3	Lombardia	0,679
4	Friuli-Venezia Giulia	0,660
5	Piemonte	0,650
6	Trentino-Alto Adige	0,621
7	Veneto	0,615
8	Umbria	0,522
9	Marche	0,493
10	Toscana	0,429
11	Liguria	0,425
12	Puglia	0,423
13	Basilicata	0,394
14	Abruzzo	0,389
15	Valle d'Aosta	0,347
16	**Campania**	**0,330**
17	Sardegna	0,324
18	Sicilia	0,290
19	Molise	0,281
20	Calabria	0,214

Macrofactor 1: “Enablers factors”: this macrofactor represents innovation drivers not related to firms (human resources, finance for innovation,institutional support).

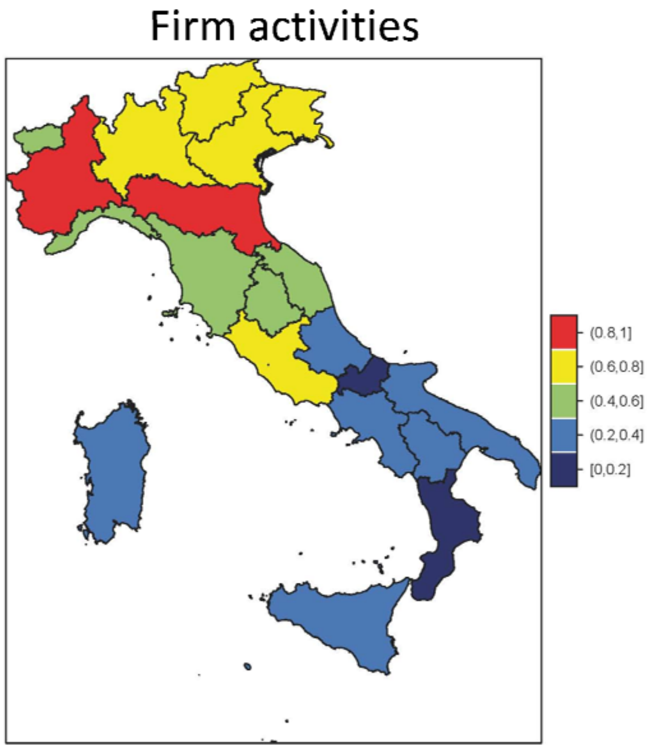


Ranking	Region	"Enablers factors" index
1	Lazio	0,791
2	Umbria	0,612
3	Friuli-Venezia Giulia	0,576
4	Emilia-Romagna	0,574
5	Liguria	0,557
6	Toscana	0,524
7	Lombardia	0,492
8	Trentino-Alto Adige	0,481
9	Veneto	0,438
10	Abruzzo	0,411
11	Marche	0,393
12	Piemonte	0,374
13	Basilicata	0,333
14	Molise	0,314
15	Calabria	0,285
16	Sardegna	0,273
17	**Campania**	**0,249**
18	Sicilia	0,222
19	Puglia	0,205
20	Valle d'Aosta	0,052


Human resources
(0.8,1]
(0.6,0.8]
(0.4,0.6]
(0.2,0.4]
[0,0.2]
Finance for innovation
(0.8,1]
(0.6,0.8]
(0.4,0.6]
(0.2,0.4]
[0,0.2]
Institutional support
(0.8,1]
(0.6,0.8]
(0.4,0.6]
(0.2,0.4]
[0,0.2]

REGION	ENABLERS FACTORS					
	Human resources		Finance for innovation		Institutional support	
	Ranking	Index	Ranking	Index	Ranking	Index
Piemonte	11	0,473	10	0,115	16	0,254
Valle d'Aosta	20	0,074	20	0	20	0
Lombardia	9	0,493	1	0,597	19	0,167
Liguria	3	0,737	15	0,039	6	0,489
Trentino-Alto Adige	12	0,467	2	0,558	12	0,37
Veneto	10	0,479	5	0,381	18	0,239
Friuli-V.G.	4	0,66	6	0,35	5	0,503
Emilia-Romagna	2	0,74	9	0,14	11	0,377
Toscana	6	0,648	8	0,142	4	0,559
Umbria	5	0,651	3	0,493	2	0,624
Marche	8	0,516	13	0,074	17	0,244
Lazio	1	0,875	4	0,47	1	1
Abruzzo	7	0,539	16	0,022	9	0,428
Molise	14	0,42	19	0,002	14	0,295
Campania	17	0,286	18	0,015	3	0,617
Puglia	18	0,231	14	0,062	10	0,403
Basilicata	13	0,435	17	0,019	13	0,355
Calabria	15	0,354	12	0,08	15	0,27
Sicilia	18	0,231	11	0,109	7	0,475
Sardegna	16	0,29	7	0,163	8	0,452

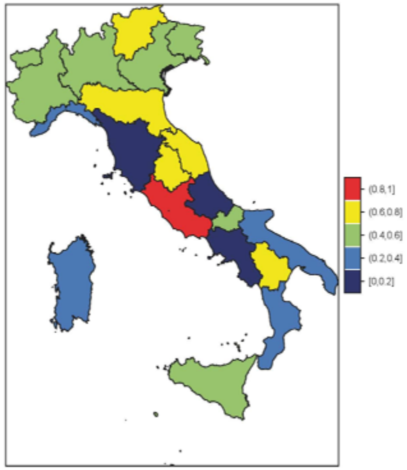
Macrofactor 2: “Firm activities - This macrofactor represents firms behaviour with respect to innovation processes (network connections, innovative entrepreunership, exploitation of research, firms investments).



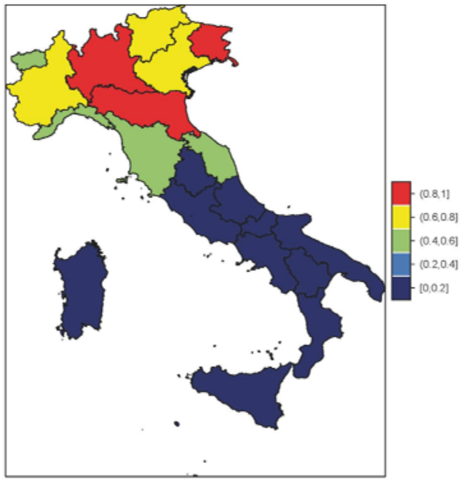
Ranking	Region	"Firm activities" index
1	Piemonte	0,828
2	Emilia-Romagna	0,812
3	Friuli-Venezia Giulia	0,798
4	Lombardia	0,783
5	Veneto	0,697
6	Trentino-Alto Adige	0,690
7	Lazio	0,601
8	Valle d'Aosta	0,593
9	Marche	0,518
10	Umbria	0,495
11	Liguria	0,439
12	Toscana	0,402
13	Puglia	0,358
14	Basilicata	0,341
15	Sicilia	0,311
16	Sardegna	0,274
17	Abruzzo	0,247
18	**Campania**	**0,239**
19	Calabria	0,147
20	Molise	0,135

REGION	Firm activities							
	Network connections		Innovative entrepreneurship		Exploitation of research		Firm investments	
	Ranking	Index	Ranking	Index	Ranking	Index	Ranking	Index
Piemonte	9	0,589	1	0,93	6	0,69	1	1
Valle d'Aosta	13	0,444	5	0,868	8	0,452	11	0,331
Lombardia	12	0,558	2	0,924	3	0,891	3	0,619
Liguria	14	0,254	14	0,5	9	0,436	6	0,506
Trentino-Alto Adige	2	0,739	9	0,718	5	0,748	5	0,524
Veneto	11	0,574	6	0,832	4	0,766	7	0,484
Friuli-V.G.	8	0,59	3	0,906	1	1	4	0,587
Emilia-Romagna	5	0,689	4	0,877	2	0,99	2	0,626
Toscana	18	0,166	12	0,535	10	0,41	9	0,362
Umbria	4	0,701	7	0,742	12	0,147	14	0,142
Marche	3	0,72	11	0,575	7	0,511	13	0,209
Lazio	1	1	8	0,733	13	0,095	8	0,445
Abruzzo	20	0	17	0,394	11	0,176	12	0,271
Molise	10	0,585	20	0,027	19	0,01	18	0,025
Campania	19	0,068	18	0,363	15	0,059	10	0,344
Puglia	15	0,24	10	0,686	14	0,06	16	0,119
Basilicata	6	0,646	15	0,472	18	0,022	17	0,091
Calabria	17	0,226	19	0,254	20	0	20	0
Sicilia	7	0,592	16	0,395	17	0,034	14	0,142
Sardegna	16	0,232	13	0,533	16	0,053	19	0,02

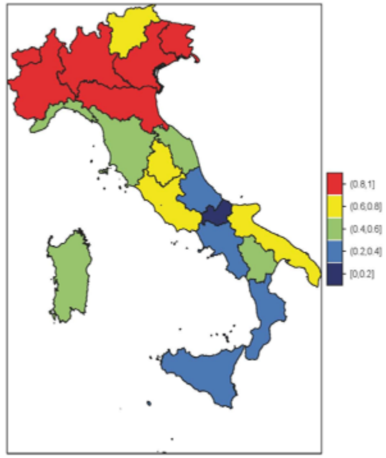
Network connections



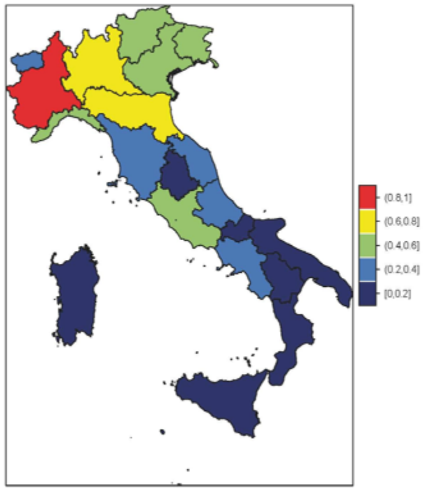
Exploitation of research



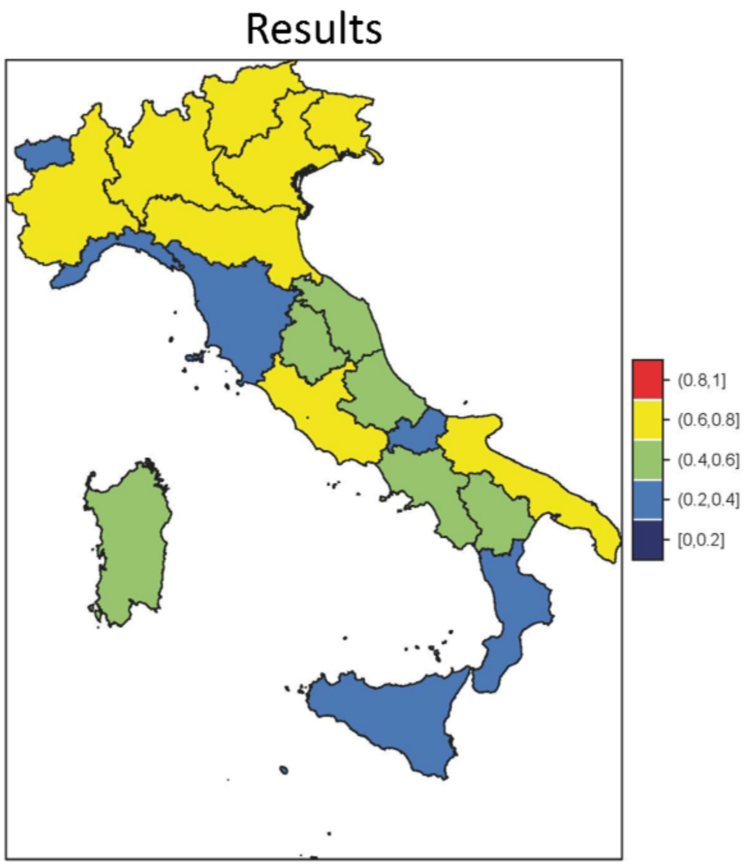
Innovative entrepreunership



Firm investments



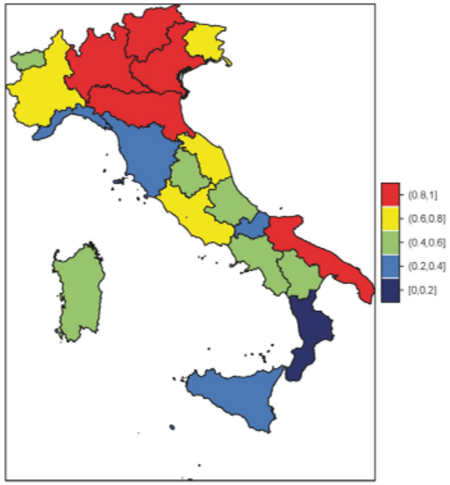
Macrofactor 3: “Results” - this macrofactor represents results of firms innovation processes.



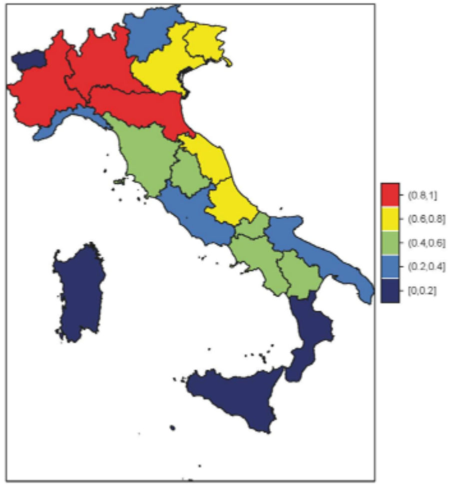
Ranking	Region	"Results" index
1	Lombardia	0,761
2	Piemonte	0,749
3	Lazio	0,740
4	Emilia-Romagna	0,723
5	Veneto	0,709
6	Puglia	0,705
7	Trentino-Alto Adige	0,692
8	Friuli-Venezia Giulia	0,606
9	Marche	0,569
10	Abruzzo	0,508
11	Basilicata	0,508
12	**Campania**	**0,501**
13	Umbria	0,458
14	Sardegna	0,425
15	Valle d'Aosta	0,398
16	Molise	0,393
17	Toscana	0,362
18	Sicilia	0,336
19	Liguria	0,280
20	Calabria	0,211

REGION	Results					
	Innovating firms		Economical effects		New ideas development	
	Ranking	Index	Ranking	Index	Ranking	Index
Piemonte	7	0,761	1	1	8	0,452
Valle d'Aosta	11	0,529	20	0	14	0,27
Lombardia	4	0,829	3	0,876	13	0,372
Liguria	19	0,204	13	0,362	7	0,503
Trentino-Alto Adige	1	0,967	15	0,286	20	0
Veneto	3	0,832	4	0,799	19	0,127
Friuli-V.G.	8	0,681	5	0,762	18	0,151
Emilia-Romagna	5	0,814	2	0,899	17	0,181
Toscana	17	0,344	12	0,413	12	0,385
Umbria	13	0,481	11	0,423	11	0,402
Marche	9	0,621	6	0,735	16	0,194
Lazio	6	0,782	14	0,312	1	1
Abruzzo	15	0,444	7	0,634	4	0,641
Molise	16	0,356	9	0,487	9	0,446
Campania	14	0,458	10	0,432	2	0,741
Puglia	2	0,853	16	0,24	6	0,575
Basilicata	10	0,56	8	0,539	14	0,27
Calabria	20	0,142	18	0,086	5	0,612
Sicilia	18	0,287	17	0,14	3	0,728
Sardegna	12	0,508	19	0,08	10	0,438

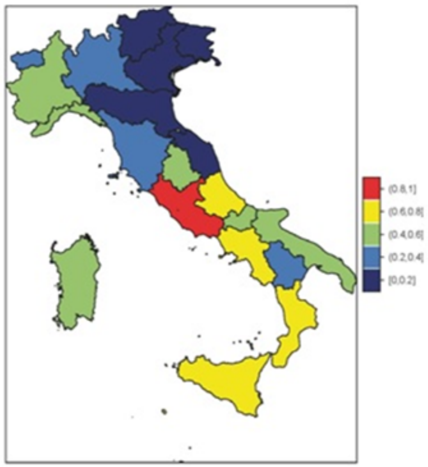
Innovating firms



Economical effects



New ideas development



Groups of regions: methodological note

Through the use of the "k-means" [1] methodology we have obtained 4 groups of regions; for each of these ones we assigned a label: first group (low innovators) includes Molise, Calabria and Sicily; second group (medium low innovators*)* includes Abruzzo, Campania, Puglia, Basilicata and Sardinia. Regions belonging to last one group showed a regional innovation index next to Valle D' Aosta one, but depending by different factors. For example, "firms activity" is the greatest macrofactor for Valle D' Aosta; on the contrary, "firm activities" macrofactor is the lowest one for the abovementioned "medium low innovators" regions; so, Valle D'Aosta and "medium low innovators" regions may not be associated in the same group. Third group is the middle one, defined as *"*medium innovators*"*. This group is constituted by Liguria, Toscana, Umbria and Marche. Finally, fourth group (high innovators) is constituted by Piemonte, Lombardia, Trentino-Alto Adige, Veneto, Friuli-Venezia Giulia, Emilia-Romagna and Lazio.

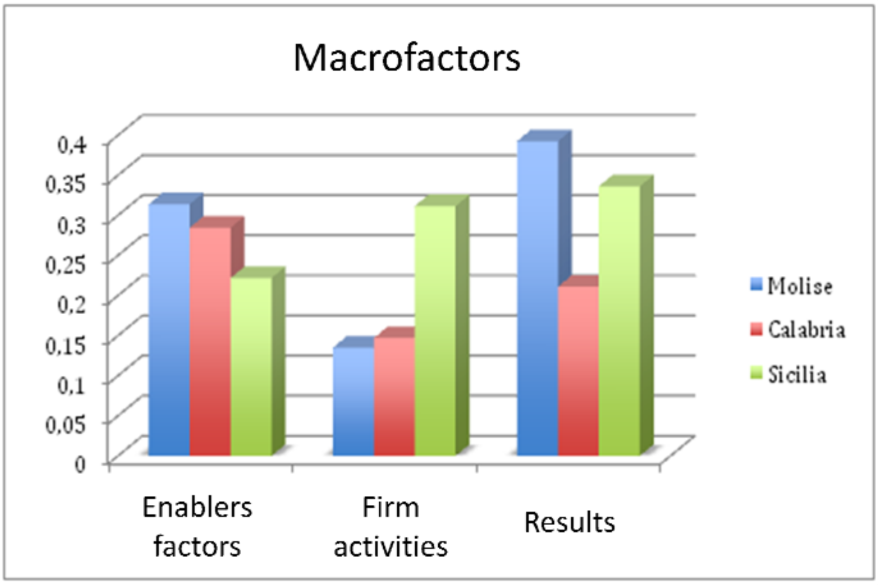
Valle D' Aosta has got different features with respect to each of the other groups; therefore, Valle D'Aosta can't be grouped with none of the abovementioned groups. Since the aim of "k-means" classification is to obtain homogenous groups, regional innovation index of Valle D' Aosta, that belongs to the range of medium low innovators, suggest us to define a new group : "Medium-low innovators: Valle D'Aosta".

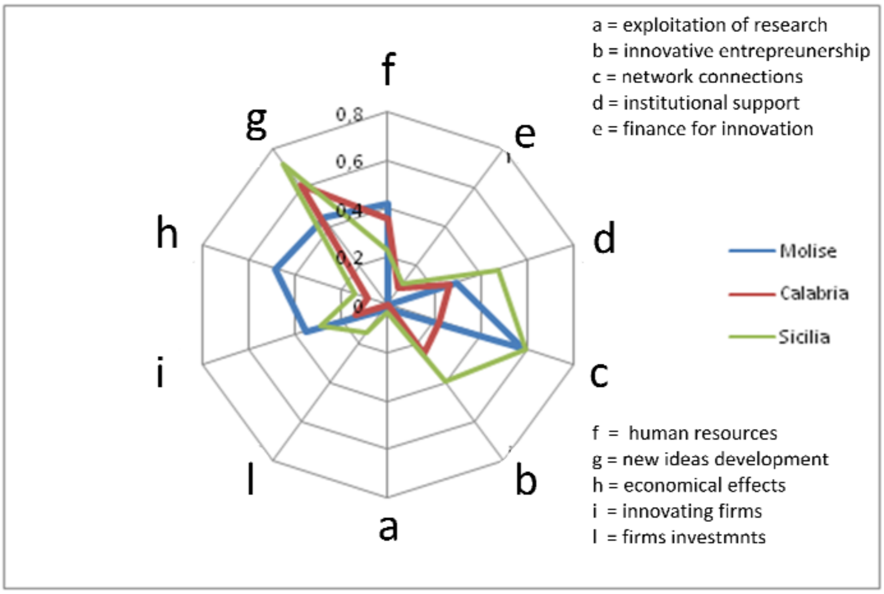
[1]An automatic classification of the regions was carried out - in order to compare italian regions - by using a not-hierarchical classification: *k-means*. This methodology let us to obtain homogenous groups of regions; so - with this objective - we have assigned to each group a label depending from the distance of the group average with respect to the global average. Range corresponding to the distance between the greatest and smallest value of regional innovation index was divided in 5 micro-ranges with the following labels: low innovators, medium low innovators, medium innovators, medium high innovators and high innovators.

Low Innovators

- Molise
- Calabria
- Sicilia

	Enablers factors	Firm activities	Results	Inter-group variance
Average value	0,273	0,198	0,313	0,021

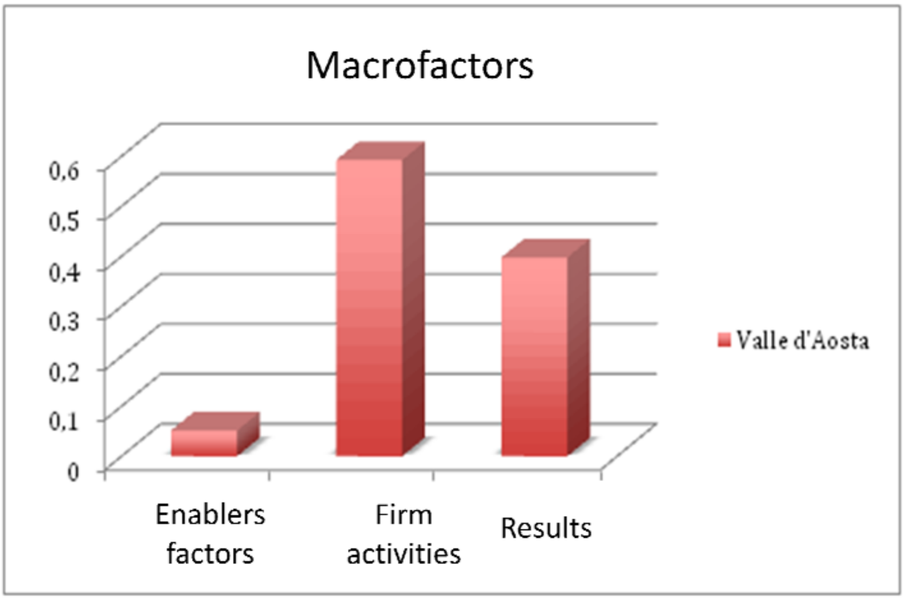


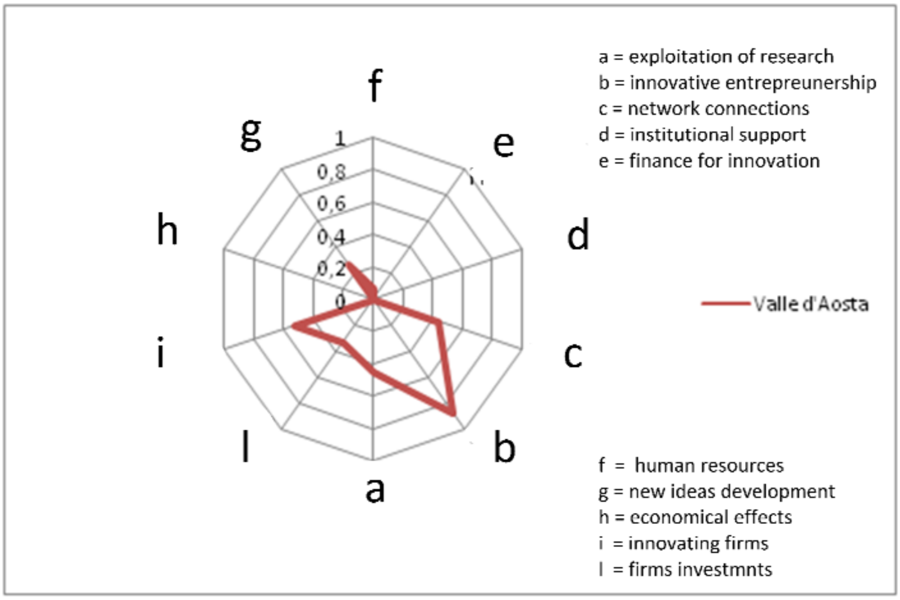


Medium low innovators: Valle D'Aosta

- Valle D'Aosta

	Enablers factors	Firm activities	Results	Inter-group variance
Average value	0,052	0,593	0,398	0,000

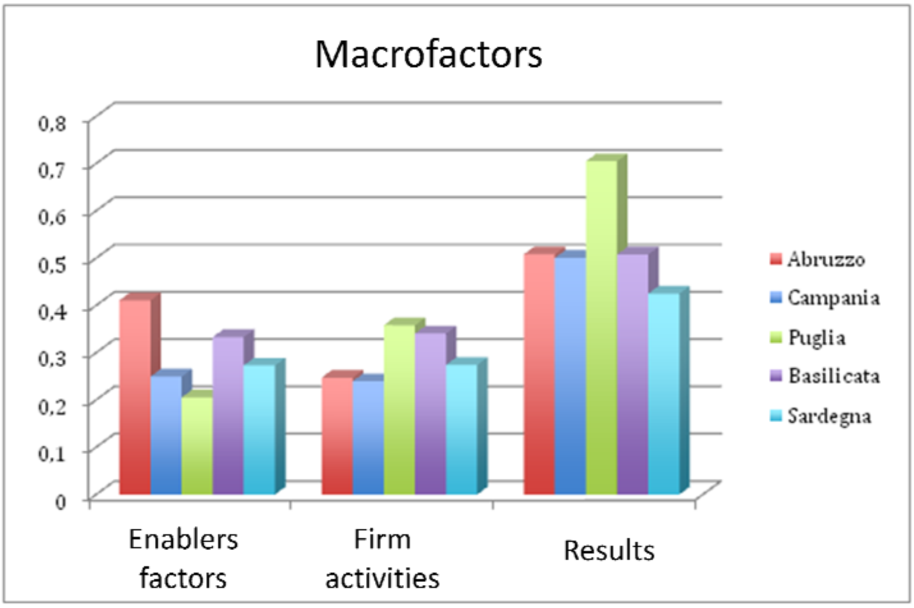


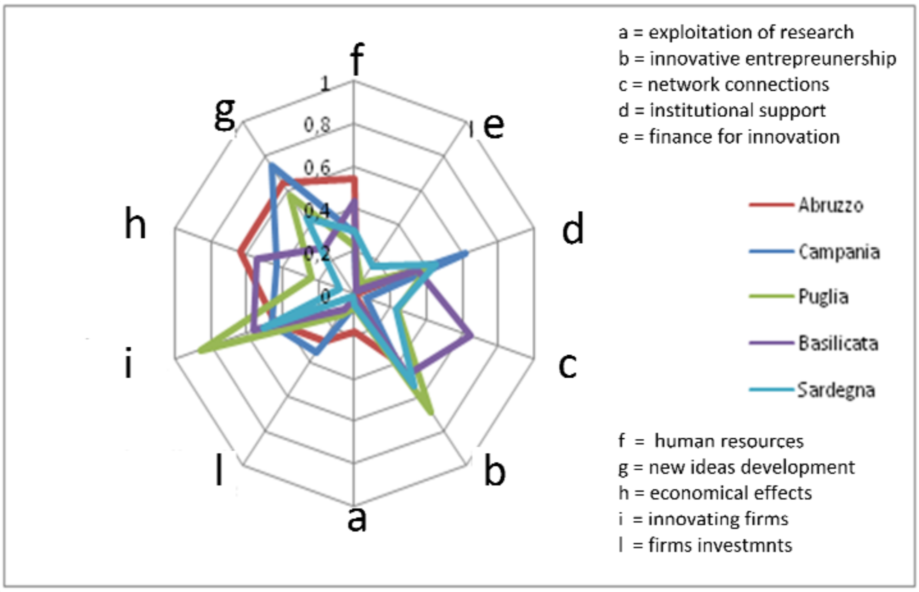


Medium low Innovators

- Abruzzo
- Campania
- Puglia
- Basilicata
- Sardegna

	Enablers factors	Firm activities	Results	Inter-group variance
Average value	0,294	0,292	0,529	0,017

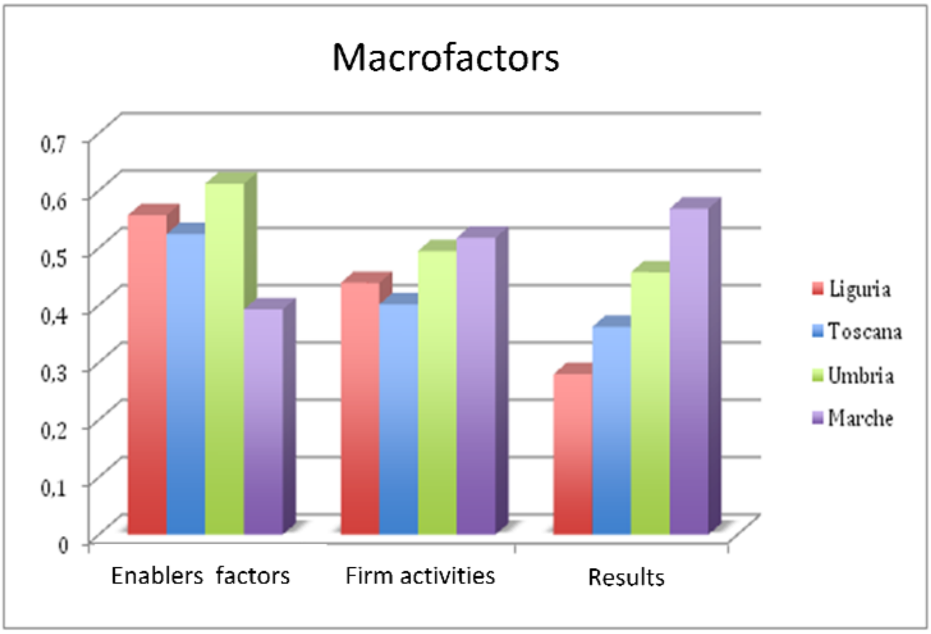


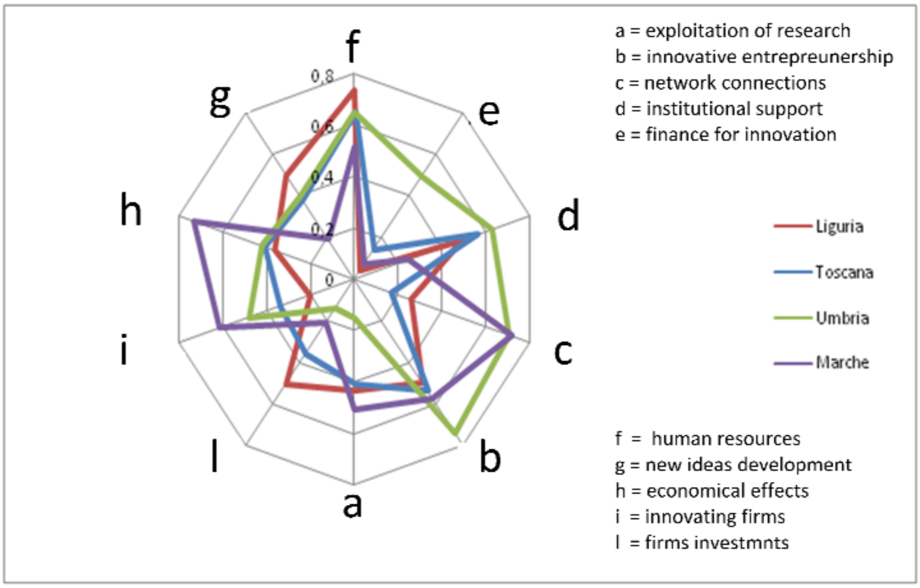


Medium Innovators

- Liguria
- Toscana
- Umbria
- Marche

	Enablers factors	Firm activities	Results	Inter-group variance
Average value	0,294	0,292	0,529	0,017

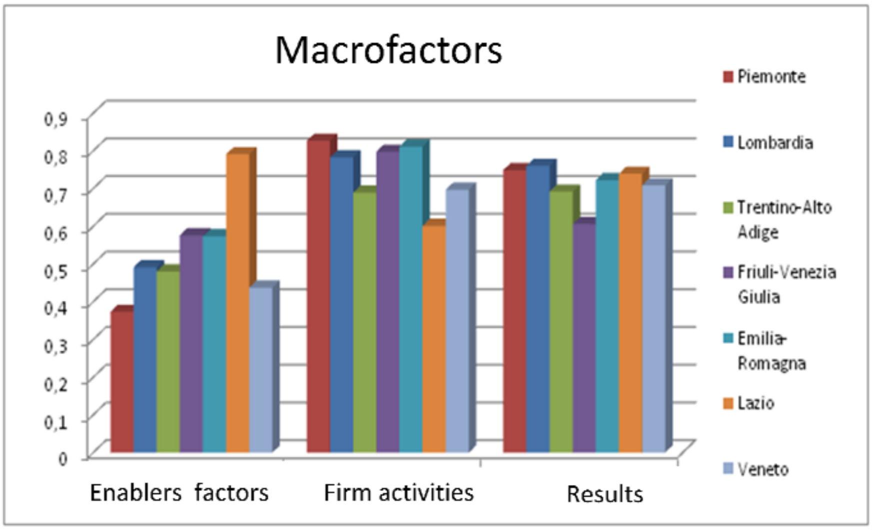


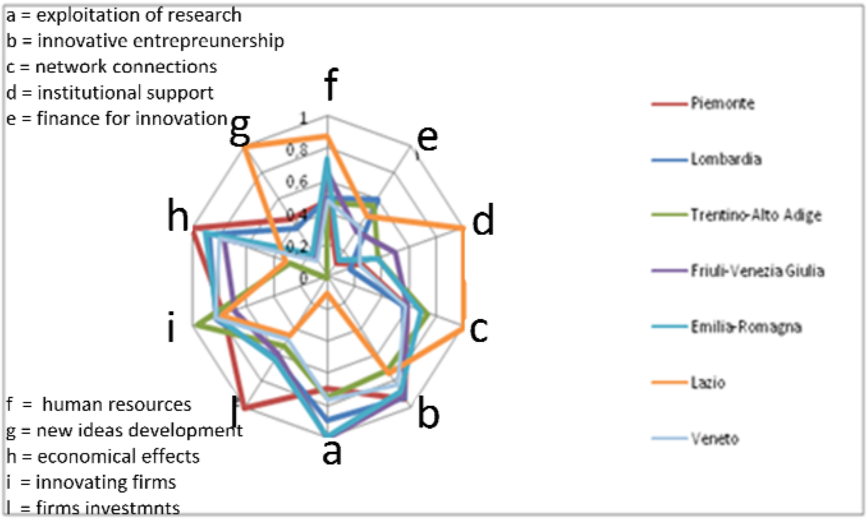


High Innovators

- Piemonte
- Lombardia
- Trentino-Alto Adige
- Veneto
- Friuli-Venezia Giulia
- Emilia-Romagna
- Lazio

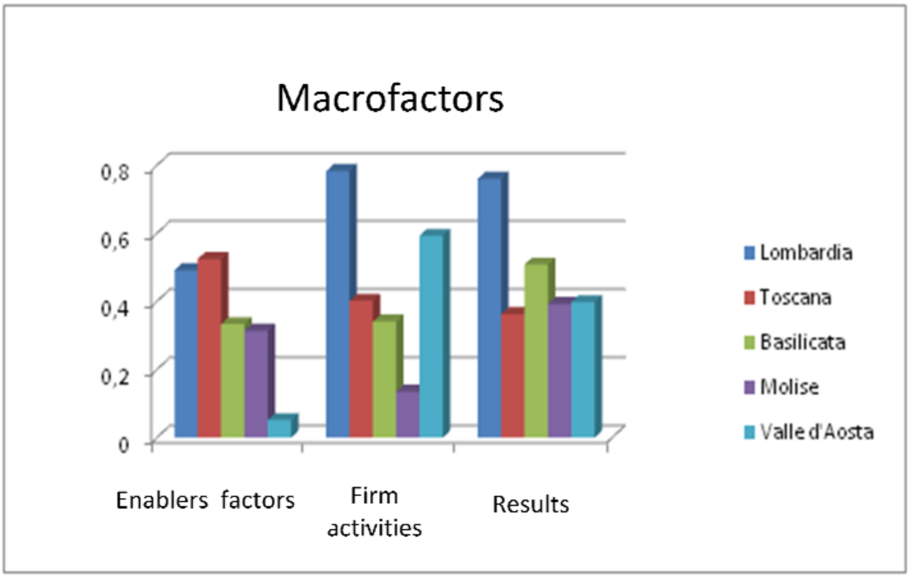
	Enablers factors	Firm activities	Results	Inter-group variance
Average value	0,532	0,744	0,711	1,988

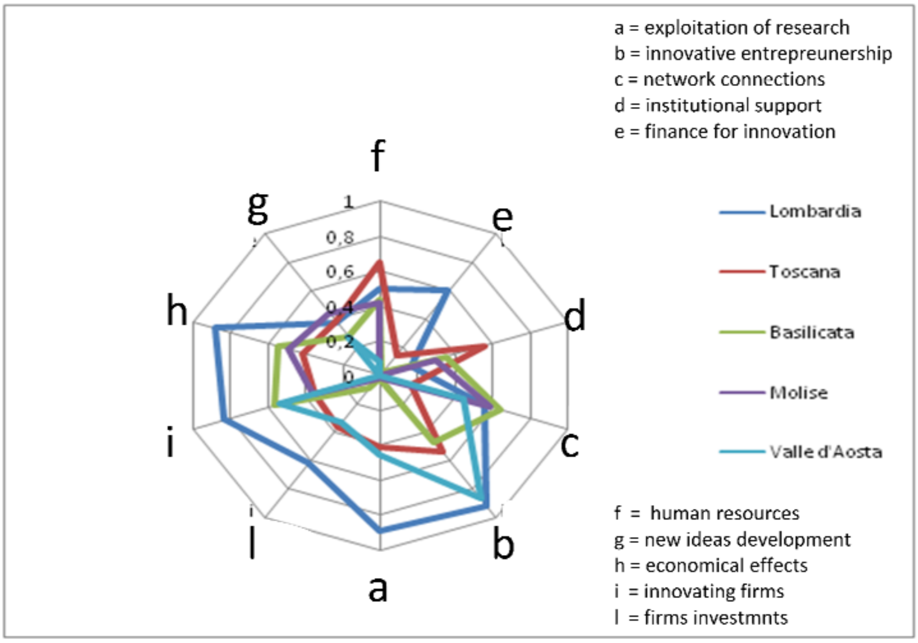




Comparison among central regions of each group

Group	central region	Enablers factors	Firm activities	Results
Low innovators	Molise	0,314	0,135	0,393
Medium low innovators: Valle d'Aosta	Valle d'Aosta	0,052	0,593	0,398
Medium low innovators	Basilicata	0,333	0,341	0,508
Medium innovators	Toscana	0,524	0,402	0,362
High innovators	Lombardia	0,492	0,783	0,761

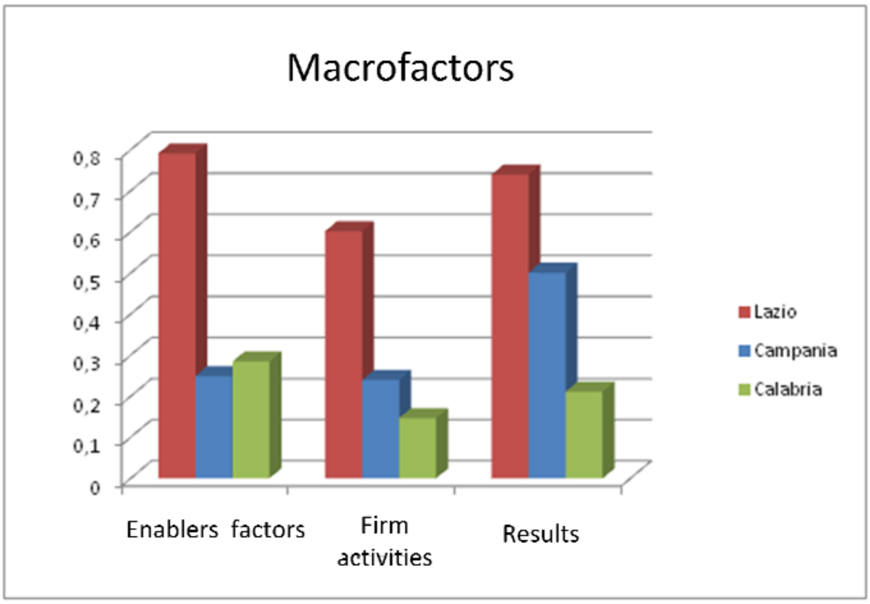


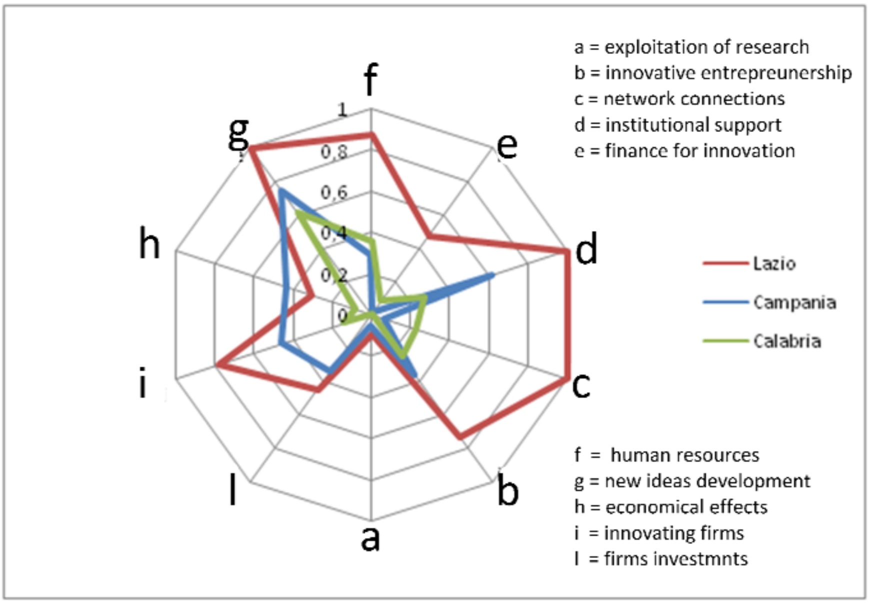


3.4 Focus on Campania Region

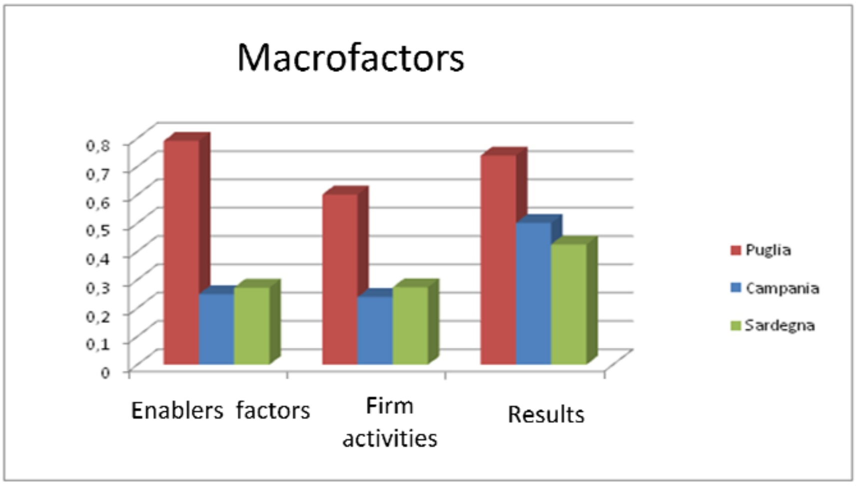
Comparison of the Campania region performance with respect to some italian regions let us to understand critical levers to move in order to get better the Campania innovative capability.

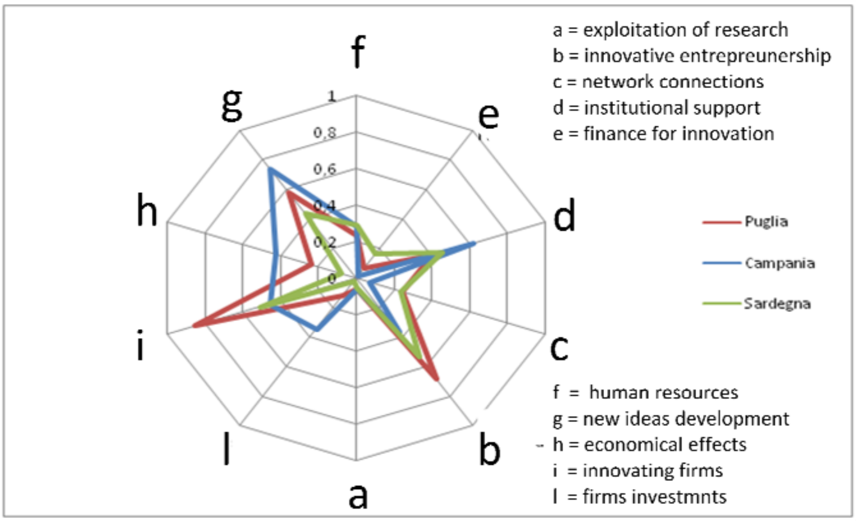
Comparison among Campania region and regions with the highest regional innovation index (Lazio) and with the lowest one (Calabria):



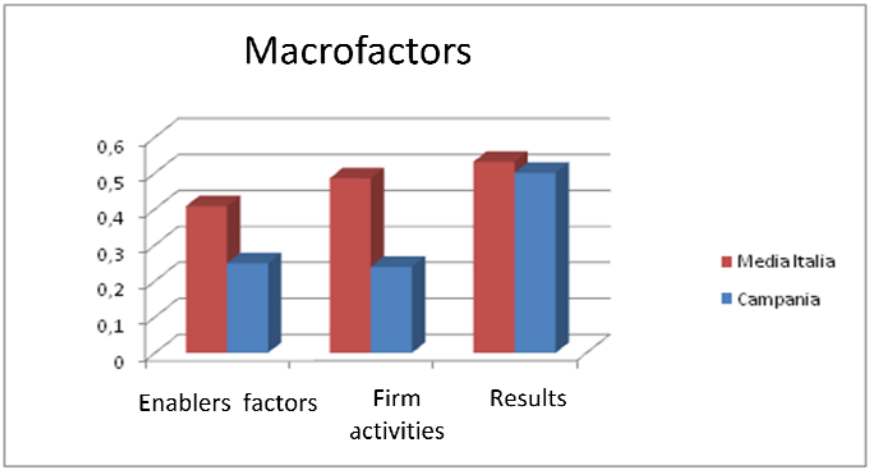


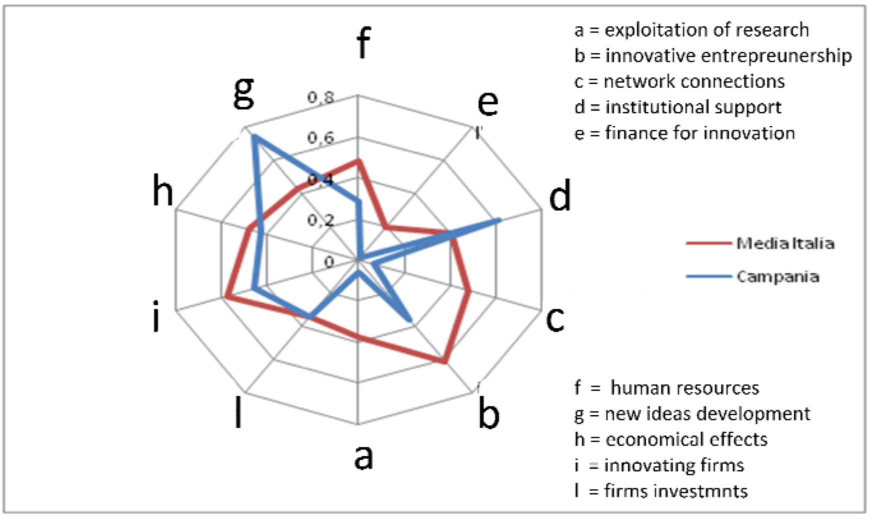
Comparison among Campania region and regions with the highest regional innovation index (Puglia) and the lowest one (Sardegna) belonging to the same group of Campania:



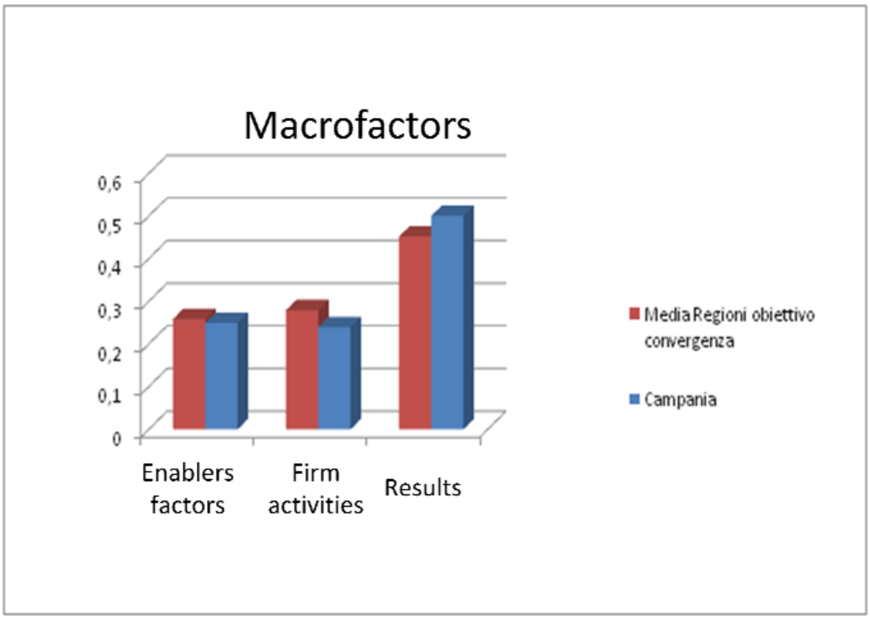


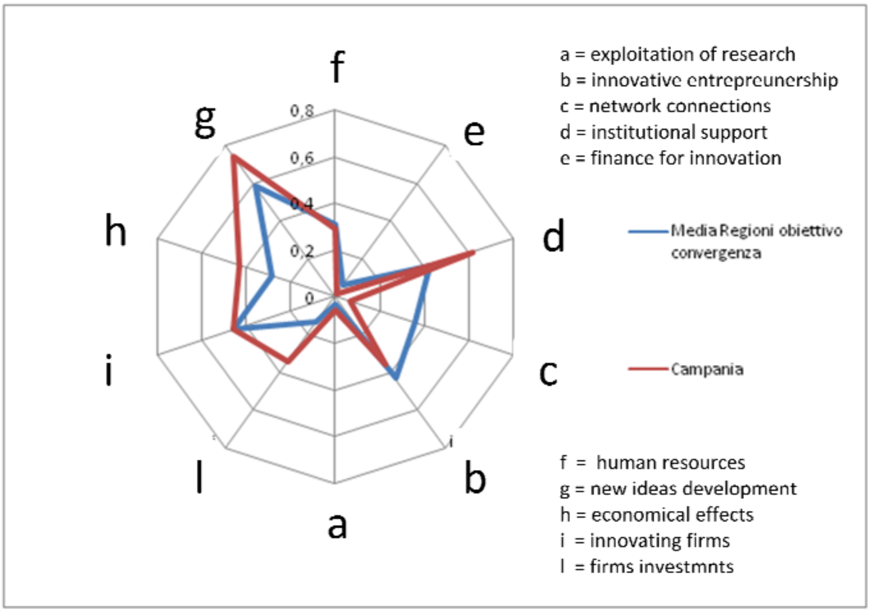
Comparison between Campania region and the Italian average (italian value has been calculated as simple average value of macrofactors and as simple average value of dimensions, among all the italian region):





Comparison between Campania region and the average value of the "convergence objective italian regions" (Campania, Calabria, Sicilia, Puglia and Basilicata) - the average value of the "convergence objective regions" has been calculated as simple average value of macrofactors and as simple average value of dimensions:

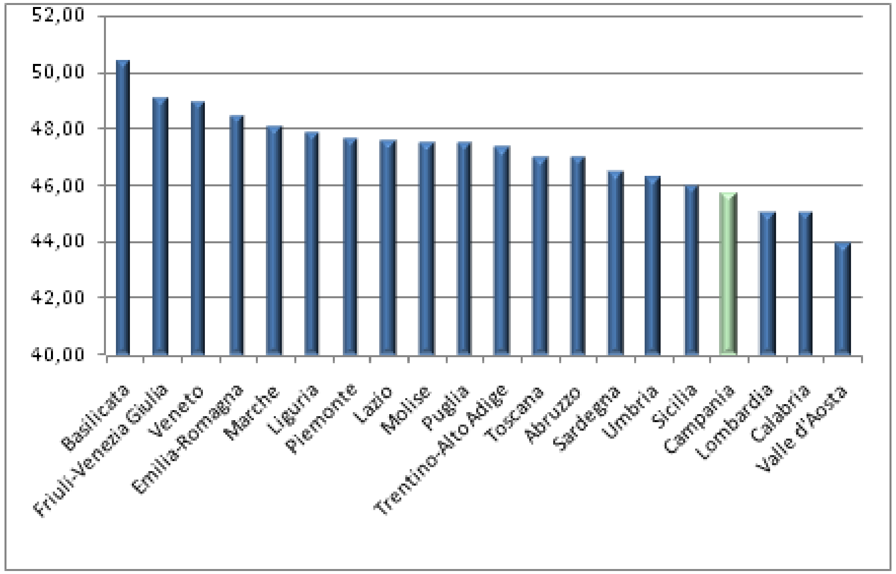




In the following thare are metadata and specific results related to innovation indicators adopted by our scoreboard.

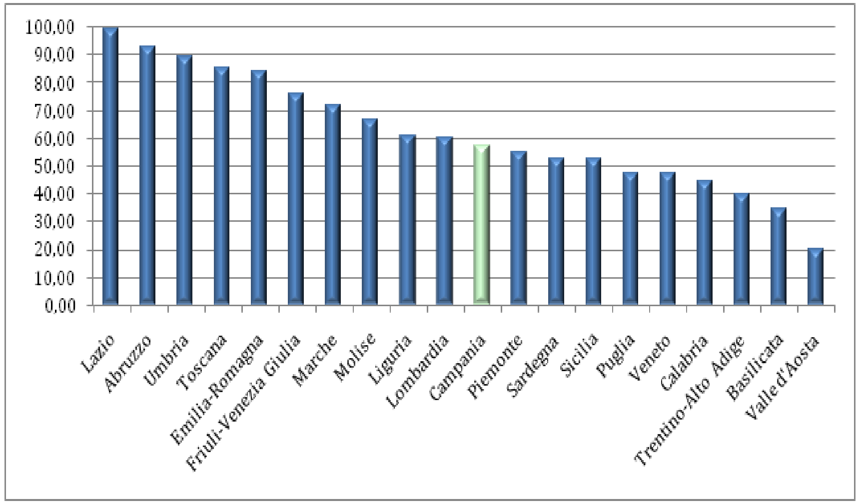
Students of sec. sup. school and post sec. (not univer)	
Variable definition	• Numerator: students in upper secondary school and in post secondary (not university) - 3,4 levels of ISCED UNESCO 1997 • Denominator: population aged 15-24
Year	2009
Source:	EUROSTAT – Statistics database

Voice	Value
Number of observations	20
Number of lacking values	0
Average	47,168
Variance	2,240
Coefficient of variation	0,032



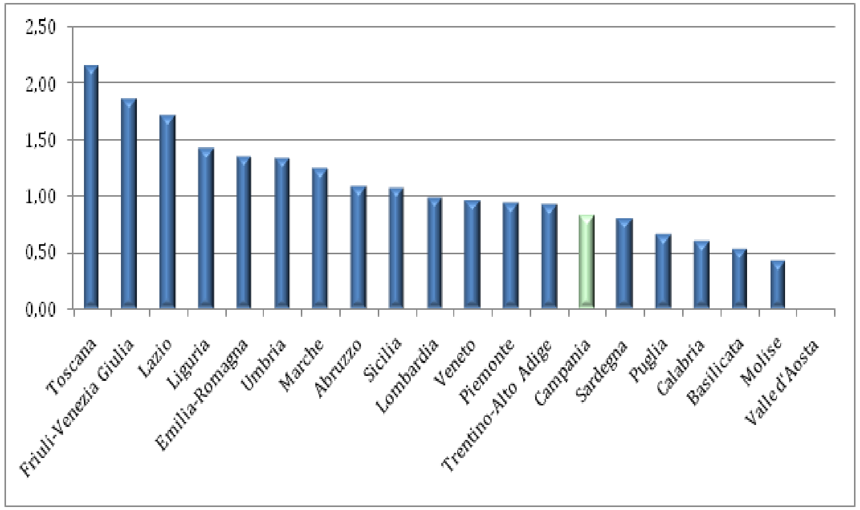
University students	
Variable definition	• Numerator: sum of students number in tertiary education (5a and 5b levels - ISCED UNESCO 1997). • Denominator: population aged 20-24
Year	2009
Source:	EUROSTAT – Statistics database

Voice	Value
Number of observations	20
Number of lacking values	0
Average	61,77
Variance	444,58
Coefficient of variation	0,3431



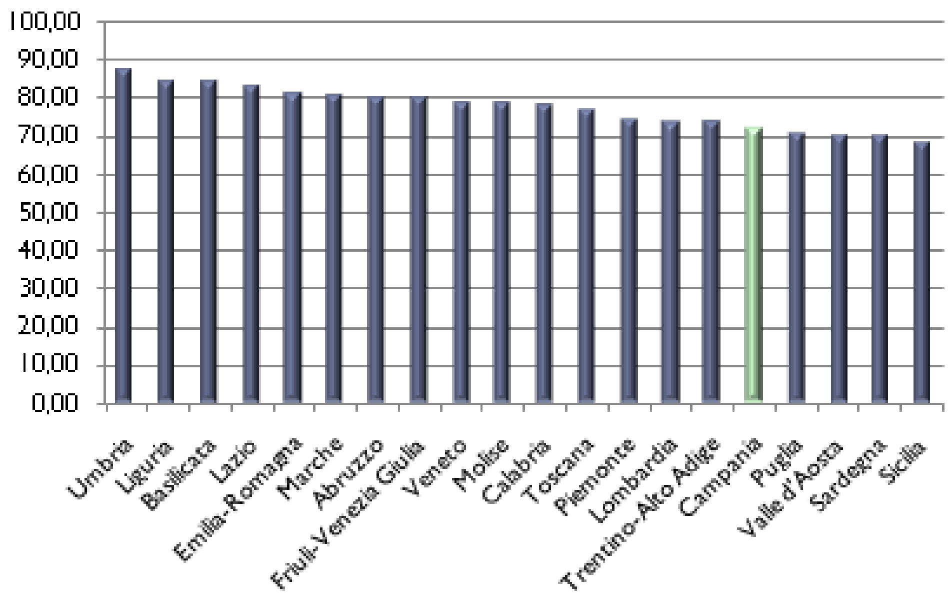
PhD students	
Variable definition	• Numerator: number of students in tertiary education (6 level - ISCED UNESCO 1997) • Denominator: population aged 25-34
Year	2009
Source:	EUROSTAT – Statistics database

Voice	Value
Number of observations	20
Number of lacking values	1
Average	1,04
Variance	0,26
Coefficient of variation	0,487



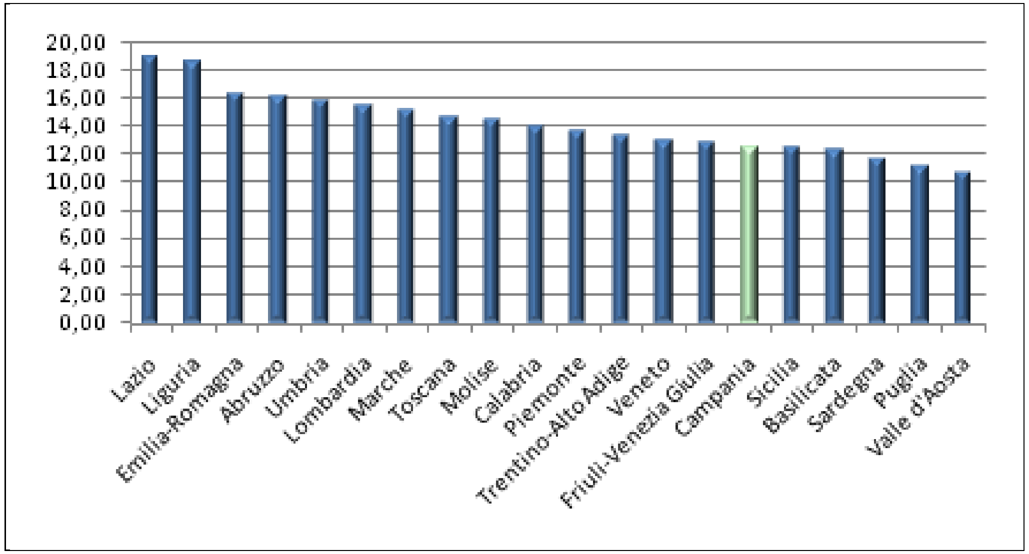
Population aged 20-24 with superior school diploma	
Variable definition	• Numerator: population aged 20-24 with uppper secondary school diploma • Denominator: population aged 20-24 • Data expressed in percentage values
Year	2009
Source:	ISTAT - Banca dati di Indicatori territoriali per le politiche di sviluppo

Voice	Value
Number of observations	20
Number of lacking values	0
Average	77,515
Variance	28,449
Coefficient of variation	0,069



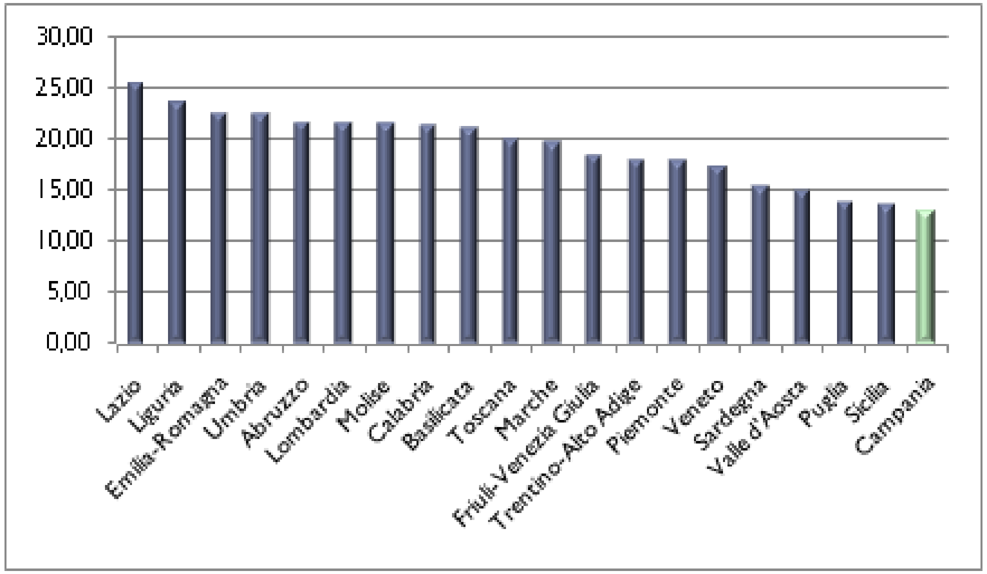
Population with tertiary education per 100 population aged 25-64	
Variable definition	• Numerator: number of people aged 25-64 with tertiary education (5 or 6 level of ISCED UNESCO 1997) • Denominator: population aged 25-64 • Data expressed in percentage values
Year	2009
Source:	EUROSTAT – Statistics database

Voice	Value
Number of observations	20
Number of lacking values	0
Average	14,223
Variance	5,16
Coefficient of variation	0,156



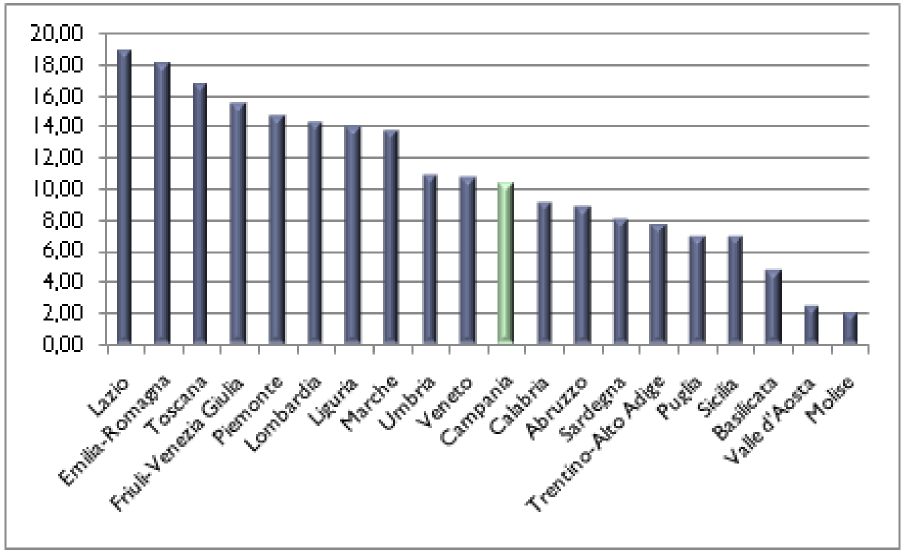
Population aged 30-34 with university title	
Variable definition	• Numerator: population aged 30-34 with tertiary education degree • Denominator: population aged 30-34 • Data expressed in percentage values
Year	2009
Source:	ISTAT – *Noi*Italia 2012

Voice	Value
Number of observations	20
Number of lacking values	0
Average	19,203
Variance	12,377
Coefficient of variation	0,183



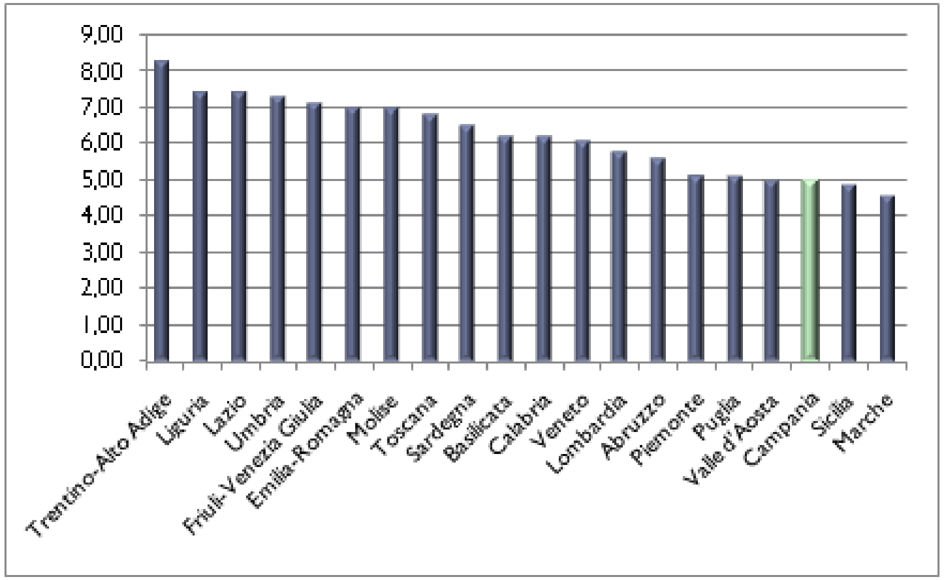
S&E (science and engineering) graduates aged 20-29	
Variable definition	• Numerator: number of graduates aged 20-29 in science and engineering • Denominator: population aged 20-29 • Data related to 1.000 inhabitants aged 20-29
Year	2009
Source:	ISTAT – *Noi*Italia 2012

Voice	Value
Number of observations	20
Number of lacking values	0
Average	10,776
Variance	22,898
Coefficient of variation	0,444



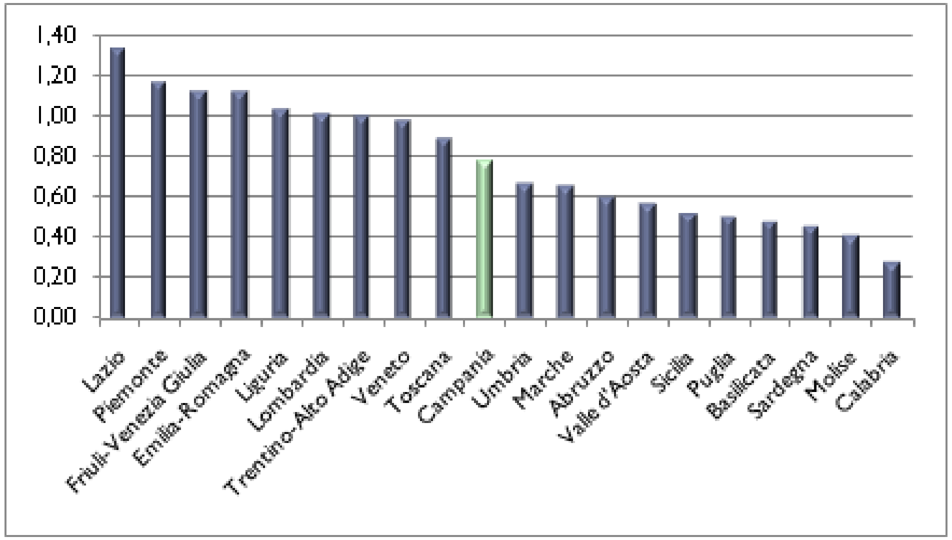
Participation in life-long learning per 100 population aged 25-64	
Variable definition	• Numerator: population aged 25-64 in a learning life phase • Denominator: population aged 25-64 • Data expressed in percentage values
Year	2009
Source:	EUROSTAT – Statistics database

Voice	Value
Number of observations	20
Number of lacking values	1
Average	6,284
Variance	1,029
Coefficient of variation	0,161



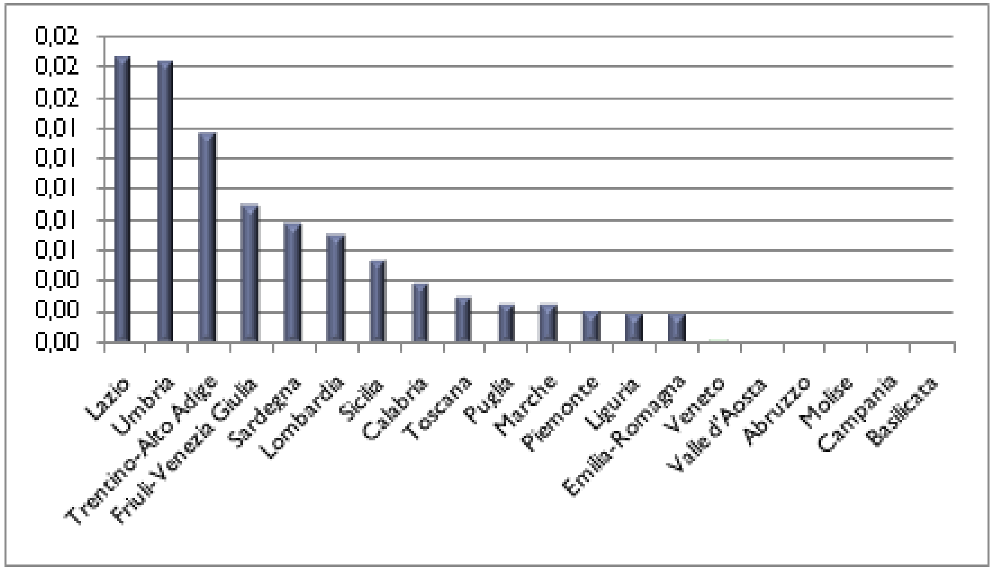
R&D personnel	
Variable definition	• Numerator: number of R&D personnel • Denominator: active population • Data expressed in percentage values
Year	2009
Source:	EUROSTAT – Statistics database

Voice	Value
Number of observations	20
Number of lacking values	0
Average	0,777
Variance	0,087
Coefficient of variation	0,380



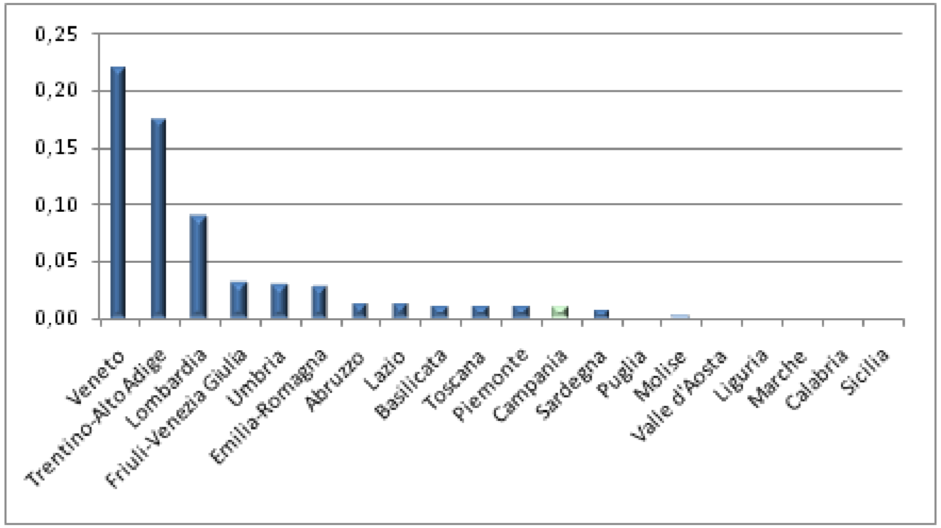
Inv. VC inv. in early-stage	
Variable definition	• Numerator: Venture Capital investments in early stage financing phase (data expressed in thousand euro) • Denominator: gross domestic product at regional level (data expressed in thousand euro) • Data expressed in percentage values
Year	2009
Source:	ISTAT - Banca dati di Indicatori territoriali per le politiche di sviluppo

Voice	Value
Number of observations	20
Number of lacking values	5
Average	0,007
Variance	0,000
Coefficient of variation	0,891



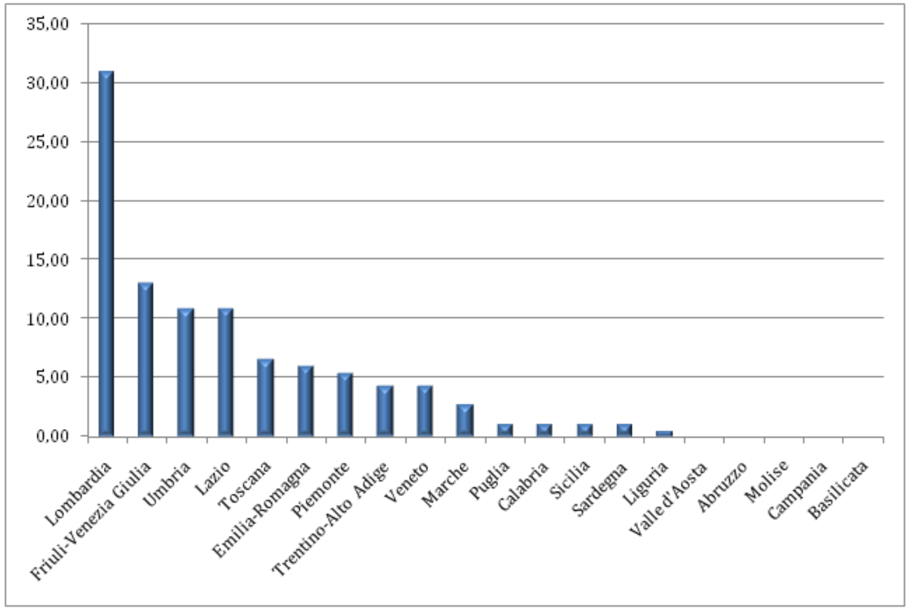
Venture Capitalinvestments in expansion/replacement	
Variable definition	• Numerator: Venture Capital investments in expansion capital and replacement capital phase (data expressed in thousand euro). • Denominator: gross domestic product at regional level (data expressed in thousand euro) • Data expressed in percentage values
Year	2009
Source:	ISTAT - Banca dati di Indicatori territoriali per le politiche di sviluppo

Voice	Value
Number of observations	20
Number of lacking values	8
Average	0,053
Variance	0,005
Coefficient of variation	1,304



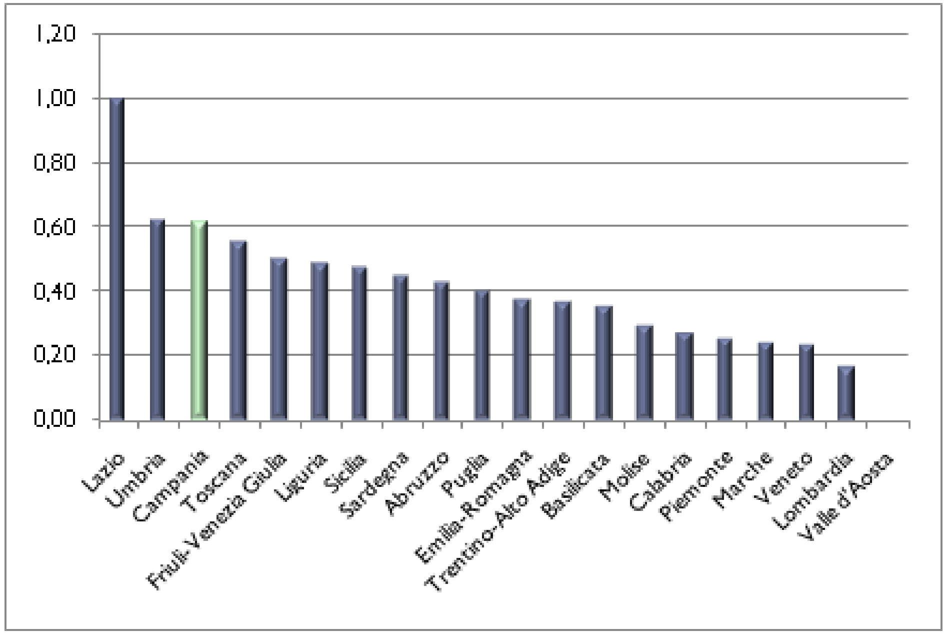
Number of venture capital investments	
Variable definition	• Numeratore: number of venture capital regional investments • Denominator: total number of Venture Capital investments in Italy • Data expressed in percentage values
Year	2009
Source:	AIFI – PWC

Voice	Value
Number of observations	20
Number of lacking values	0
Average	5,0
Variance	53,9
Coefficient of variation	1,468



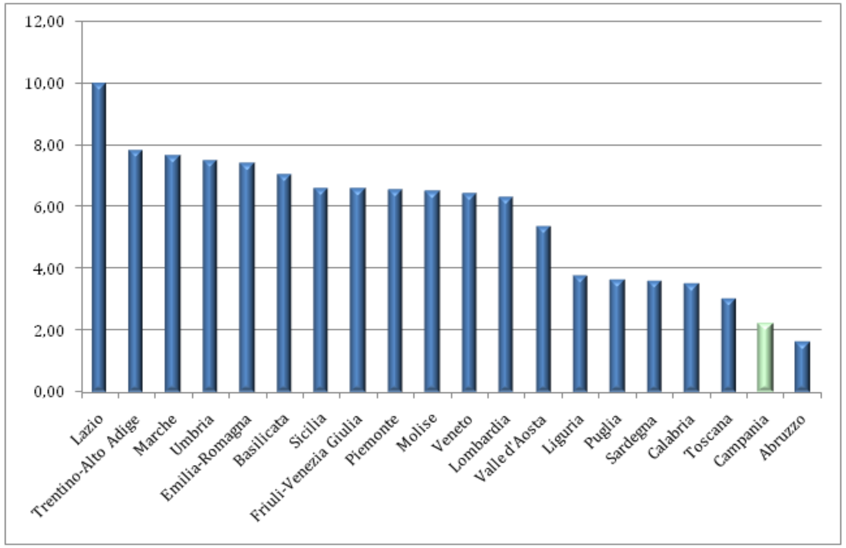
Public R&D expenditures (% of GDP)	
Variable definition	• Numerator: R&D public expenditures (data expressed in thousand euro) • Denominator: gross domestic product (data expressed in thousand euro) • • Data expressed in percentage values
Year	2009
Source:	ISTAT - Banca dati di Indicatori territoriali per le politiche di sviluppo

Voice	Value
Number of observations	20
Number of lacking values	0
Average	0,406
Variance	0,041
Coefficient of variation	0,501



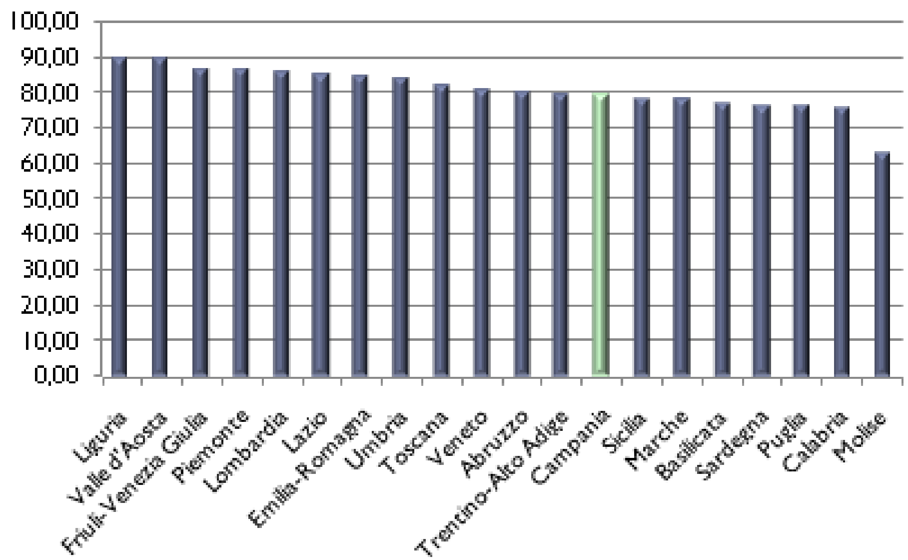
Innovative SMEs co-operating with others - % of all SMEs	
Variable definition	• Numerator: Small and Medium Enterprises (SMEs) number co-operating with others **in** 2006 – 2008 years • Denominator: total number of active SMEs in 2008 • Data expressed in percentage values
Year	2006 – 2008
Source:	ISTAT, Rilevazione sull'innovazione nelle imprese. Anni 2006-2008

Voice	Value
Number of observations	20
Number of lacking values	0
Average	5,66
Variance	4,82
Coefficient of variation	0,378



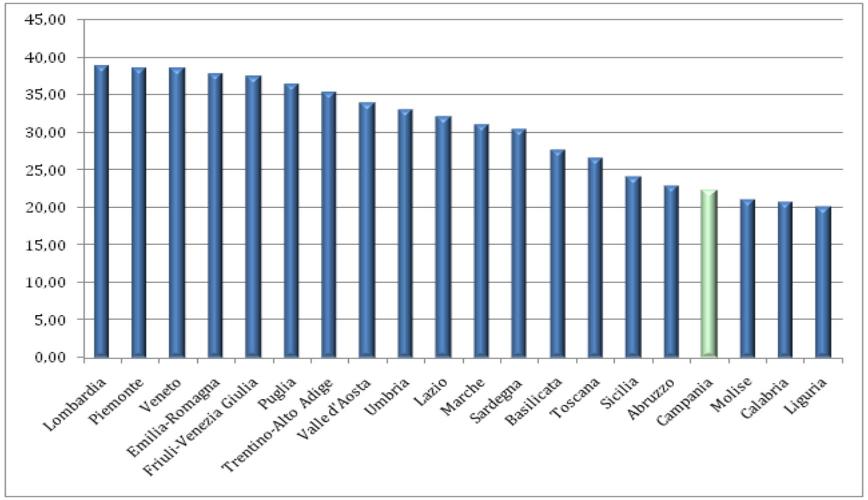
Broadband access by firms	
Variable definition	• Numerator: number of enterprises accessing web by broadband • Denominator: total number of enterprises • Data expressed in percentage values
Year	2009
Source:	ISTAT – *Noi*Italia 2012

Voice	Value
Number of observations	20
Number of lacking values	0
Average	81,047
Variance	35,386
Coefficient of variation	0,073



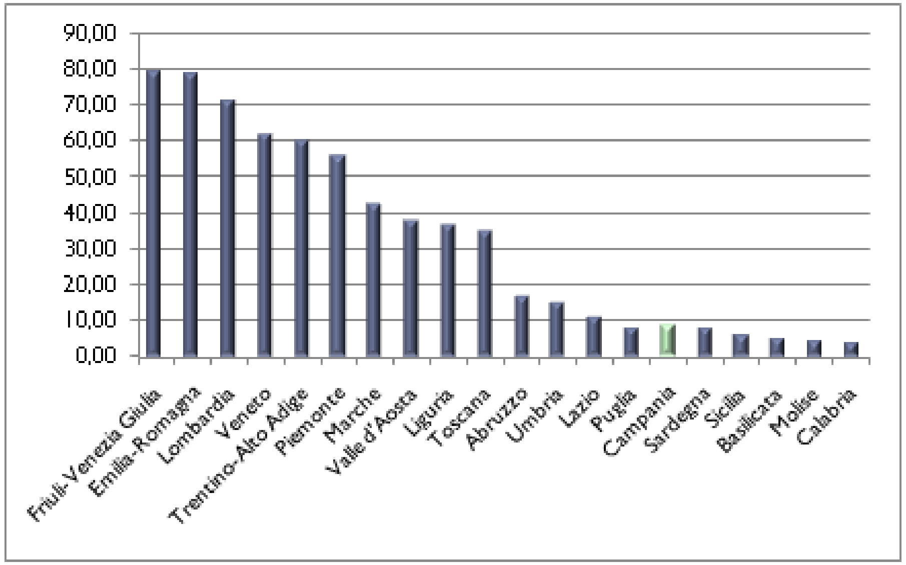
SMEs innovating in-house - % of all SMEs	
Variable definition	• Numeratore: number of Small and Medimun Enterprises (SMEs) innovating "in-house" in 2006 – 2008 years • Denominator: total number of active SMEs in 2008 • Data expressed in percentage values
Year	2006 – 2008
Source:	ISTAT, Rilevazione sull'innovazione nelle imprese. Anni 2006-2008

Voice	Value
Number of observations	20
Number of lacking values	0
Average	30,5
Variance	45,3
Coefficient of variation	0,215



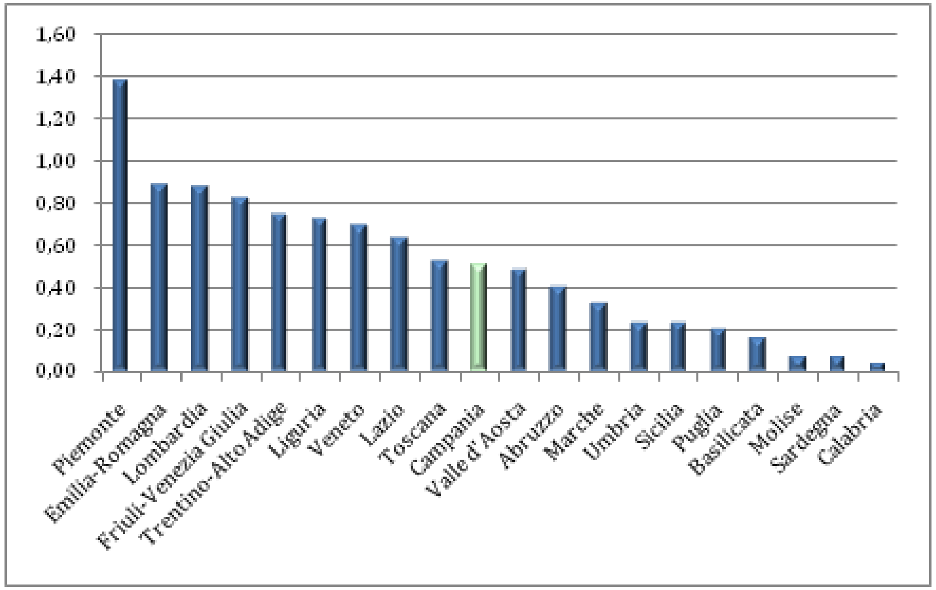
EPO patents per million population	
Variable definition	• Numeratore: number of deposited patents at European Patent Office (EPO) • Denominator: population number • Data expressed per milion inhabitants
Year	2009
Source:	EUROSTAT – Statistics database

Voice	Value
Number of observations	Number of observations
Number of lacking values	Number of lacking values
Average	Average
Variance	Variance
Coefficient of variation	Coefficient of variation



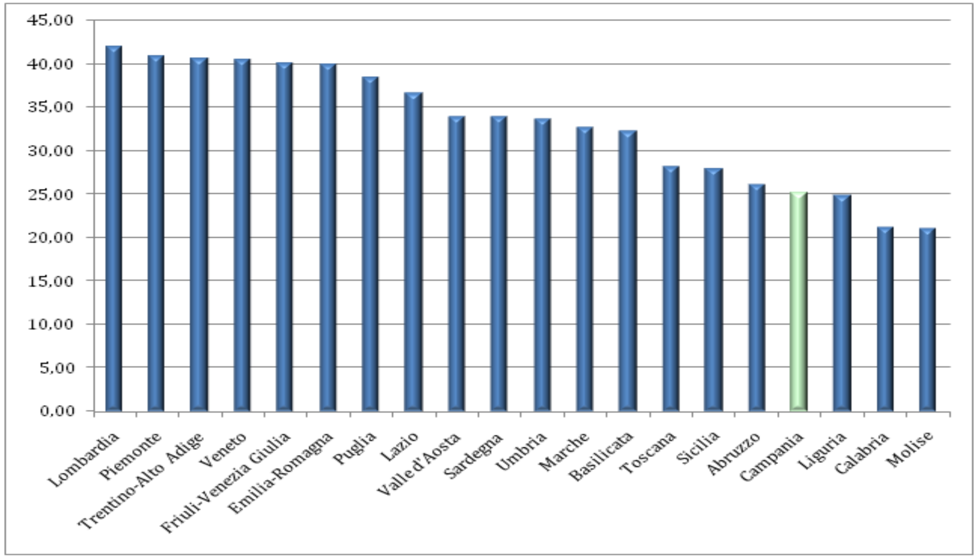
Business R&D expenditures - % of GDP	
Variable definition	• Numerator: sum of R&D expenditures of business sector • Denominator: gros domestic product at regional level • Data expressed in percentage values
Year	2009
Source:	ISTAT – *Noi* Italia 2012

Voice	Value
Number of observations	20
Number of lacking values	0
Average	0,503
Variance	0,12
Coefficient of variation	0,691



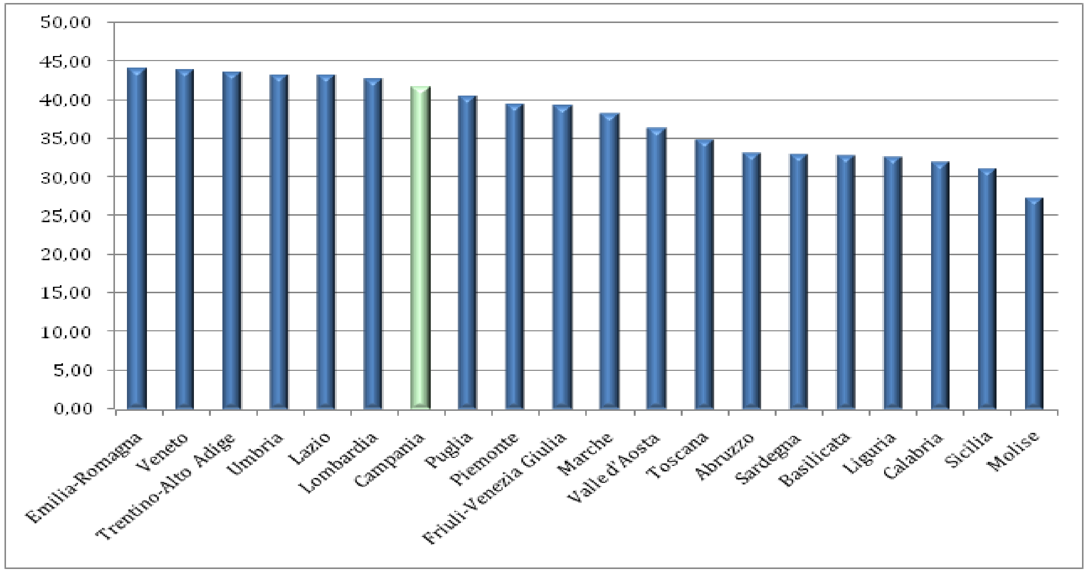
Technological (product or process) innovators - % of all SMEs	
Variable definition	• Numeratore: number of Small and Medium Enterprises with product or process innovation in 2006 – 2008 years • Denominator: total number of active SMEs in 2008 • Data expressed in percentage values
Year	2006 – 2008
Source:	ISTAT, Rilevazione sull'innovazione nelle imprese. Anni 2006-2008

Voice	Value
Number of observations	20
Number of lacking values	0
Average	33,0
Variance	47,52
Coefficient of variation	0,203



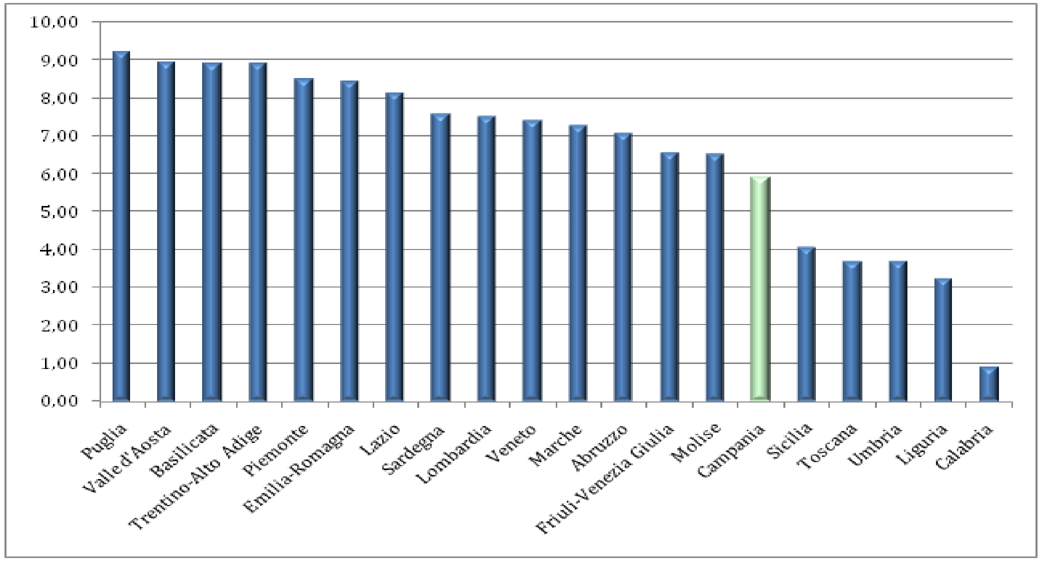
Non-technological (marketing or organisational) innovators -(% of all SMEs)	
Variable definition	• Numerator: number of Small and Medium Enterprises with organizational or marketing innovation in 2006 – 2008 years • Denominator: total number of active SMEs in 2008 • Data expressed in percentage values
Year	2006 - 2008
Source:	ISTAT, Rilevazione sull'innovazione nelle imprese. Anni 2006-2008

Voice	Value
Number of observations	20
Number of lacking values	0
Average	37,6
Variance	27,0
Coefficient of variation	0,138



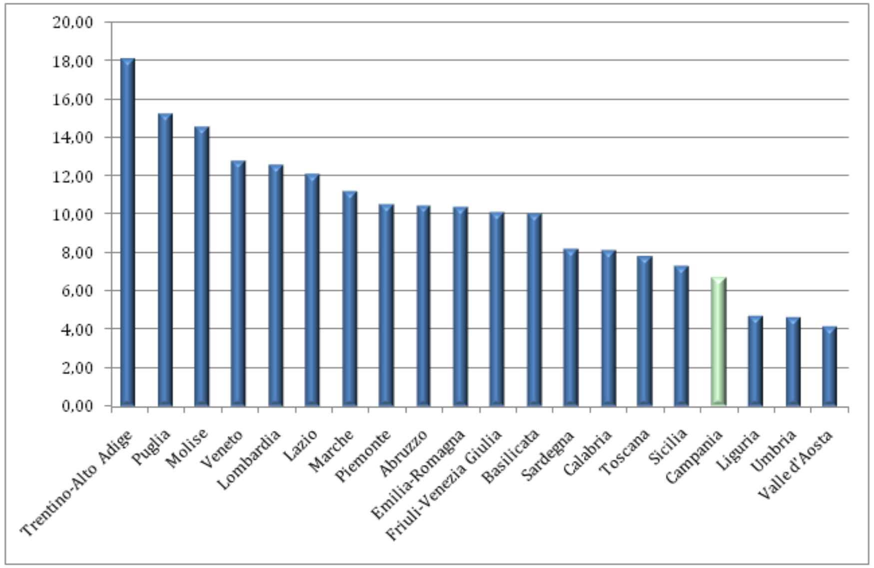
Reduced labour costs resulting from process innovations - % of SMEs	
Variable definition	• Numerator: number of Small and Medium Enterprises with labour costs reduction linked to product or process innovation in 2006 – 2008 years • Denominator: total number of active SMEs in 2008 • Data expressed in percentage values
Year	2006 - 2008
Source:	ISTAT, Rilevazione sull'innovazione nelle imprese. Anni 2006-2008

Voice	Value
Number of observations	20
Number of lacking values	0
Average	6,6
Variance	5,4
Coefficient of variation	0,351



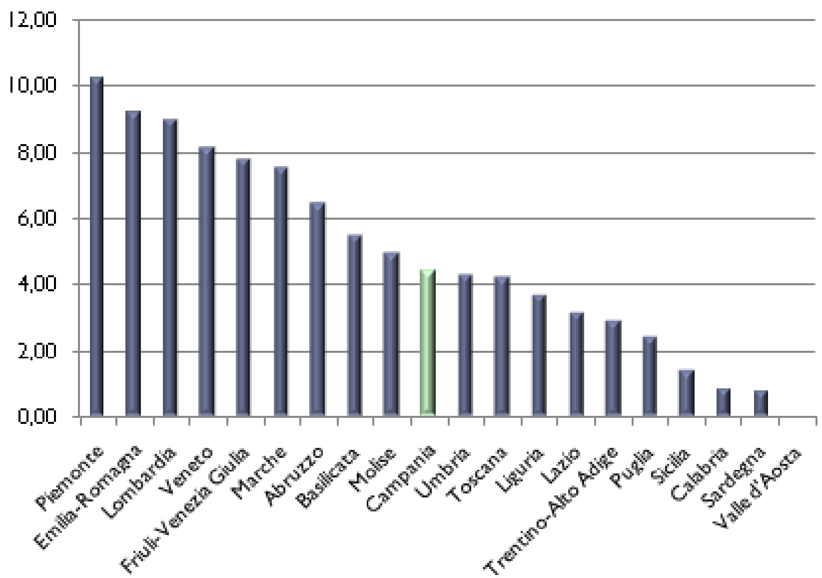
Reduced use materials and energy resulting from process innovations - % of SME	
Variable definition	• Numeratore: number of Small and Medium Enterprises with reduced use materials and energy resulting from process innovations in 2006 – 2008 years • Denominator: total number of active SMEs in 2008 • Data expressed in percentage values
Year	2006 - 2008
Source:	ISTAT, Rilevazione sull'innovazione nelle imprese. Anni 2006-2008

Voice	Value
Number of observations	20
Number of lacking values	0
Average	10,0
Variance	13,45
Coefficient of variation	0,367



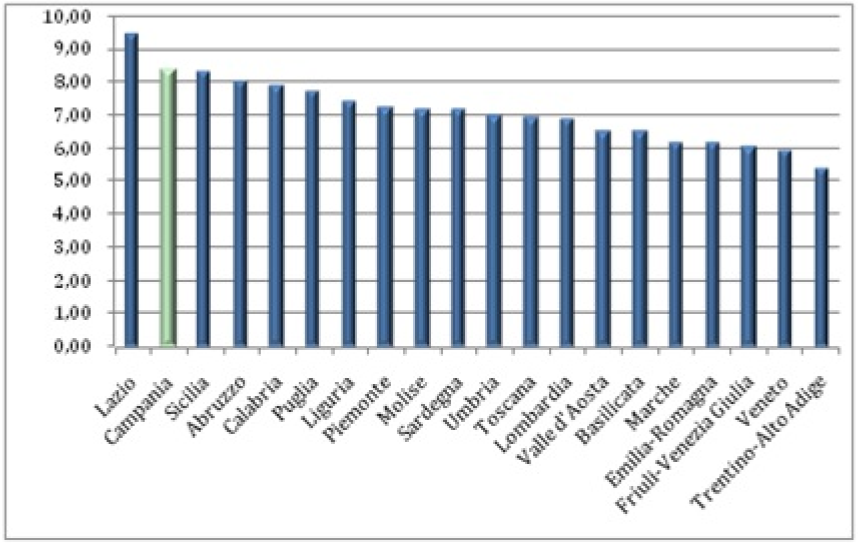
Employment in medium-high & hightech manufacturing	
Variable definition	• Numerator: number of employment in medium - high & high - tech manufacturing • Denominator: total work force • Data expressed in percentage values
Year	2009
Source:	EUROSTAT – Statistics database

Voice	Value
Number of observations	20
Number of lacking values	1
Average	5,123
Variance	9,3
Coefficient of variation	0,626



Rate of birth of firms	
Variable definition	• Numeratore: number of 2009 created enterprises . • Denominator: number of 2009 active enterprises • Data expressed in percentage values
Year	2009
Source:	ISTAT - Banca dati di Indicatori territoriali per le politiche di sviluppo

Voice	Value
Number of observations	20
Number of lacking values	0
Average	7,077
Variance	0,923
Coefficient of variation	0,136



Our regional inovation scoreboard let us to have a look on the Campania conditions with respect to other italian regions, in terms of macrofactors, dimensions and single indicators related to innovative capability. Scoreboard results let us to identify the strenght and weakness points of the Campania Regional innovation System. Therefore, such results can represent an useful tool for the definition of policies aimed at getting better the innovative capability of Campania region.

Main weakness points of Campania RIS, emerged from our scoreboard, are the following ones:

- low level of venture capital investments in the phase of early stage financing;
- low capability of inter-firms collaboration about product or process innovation
- low percentage of firms that innovate *in house* or in collaboration with other organizations
- limited patent capability
- low firms capability to realize product or process innovations and to translate innovations in efficiency of productive processes

The abovementioned problems of Campania region are also confirmed by other sources (Banca d'Italia, 2012).

3.5 Conclusions

As highlighted in this chapter, scoreboards are useful tools because they let to measure the level of local resources and competencies; but, as emphasized in chapter 2, methodologies adopted by regional innovation scoreboards of current literature are characterized by a certain grade of weakness because of the absence of a conceptual framework beyond; so, it should be necessary to develop methodologically stronger scoreboard, with a conceptual model beyond; furthermore, in current regional innovation scoreboards there isn't a measurement related to the self-sustainability concept, i.e. there isn't a measurement related to the level of innovation cycles aimed at self-mantaining an effective regional innovation; but we argue that the self-sustainability should be the goal of any regional innovation policy; so, with this aim, in the following chapters we analyze features of regional systemic innovation with the objective to develop a self-sustaining conceptual model from which it can be possible to implement methodologically stronger scoreboards (and other measuring tools) and - also - to evaluate the level of regional innovation self-sustainability.

3.6 Annex

In the following we present tables on main organizations involved both in the supply of regional innovation indicators and in the development of regional innovation scoreboards related to italian regions; furthermore, we give a deepening on regional innovation indicators published by Pro inno Europe regional innoation scoreboard 2009 and by the OECD database (published data at october 2011); at last, we present

Organizations and regional innovation indicators

Organizzations	Profile	Sources	Pubblication frequency
Istat	The National Institute of Statistics (Istat) is the main supplier of official statistical information in Italy	National surveys and government departments	annual
Eurostat	Eurostat is the statistical office of the European Union situated in Luxembourg. Its task is to provide the European Union with statistics at European level that enable comparisons between countries and regions.	Community innovation surveys and national statistic institutes	annual (biennal for community innovation surveys)
OECD	The OECD is a unique forum where the governments of 30 democracies work together to address the economic, social and environmental challenges of globalisation. The OECD is also at the forefront of efforts to understand and to help governments respond to new developments and concerns, such as corporate governance, the information economy and the challenges of an ageing population. The Organization provides a setting where governments can compare policy experiences, seek answers to common problems, identify good practice and work to co-ordinate domestic and international policies.	Eurostat, EPO Worldwide Statistical Patent Database (PATSTAT), USPTO Trademark, International Monetary Fund, National data sources, World Intellectual Property Organization (WIPO), UNESCO	annual

Regional innovation scoreboards related to italian regions

Organizations	Profile	Compared regions	Indicators number	Indicators source
Pro Inno Europe	Pro Inno Europe has been an initiative of European Commission (Directorate General Enterprise and Industry)	italian regions	16	Eurostat
Regione Umbria	Italian region	italian regions	28	Eurostat ed Istat
Finanziaria laziale di sviluppo	In-house society of Lazio region	italian regions	15	Eurostat ed Istat
Fondazione Rosselli	No profit rsearch institute.	european regions	36	Eurostat, EPO,Ufficio italiano cambi, Ministero per l'Innovazione e le Tecnologie su dati Assinform, MIUR – CINECA, ISTAT, Cordis, AIFI, Unioncamere Piemonte, Istituto Nazionale per il Commercio Estero (ICE), ISI Web of Knowledge, Database KEIN
Finlombarda SpA e Fondazione Rosselli	In-house society of Lombardia regiona	european regions	17	Eurostat, European venture capital association, Kompass Federation of European Securities Exchanges, ISI Web of Knowledge, Cordis-UE, AIFI (Associazione Italiana del Private Equity e Venture Capital), CHI Research Inc, EPO
Istituto di ricerca economiche e sociali – IRES FVG	No profit association	european regions	11	Eurostat, ISI Web of Knowledge, Cordis-UE, CHI Research Inc
Fondazione COTEC	Private foundation	italian regions	14	OECD, ISTAT, EUROSTAT, "incentivi online, MEDIOCREDITO CENTRALE 2010", "Settimo rapporto sulla valorizzazione della ricerca nelle università - NETVAL -2010", "L'università in cifre – MIUR – 2009"

Pro Inno Europe

Pro Inno Europe – Regional Innovation Scoreboard 2009 –					
INDICATOR CODE-NAME	INDICATOR DEFINITION	INDICATOR RATIONALE	NUMERATOR-DENOMINATOR	SOURCE	EUROSTAT: LATEST AVIALABLE DATA /// DATA FREQUENCY FROM 2000
1-TERTIARY EDUCATION	Population with tertiary education per 100 population aged 25-64	This is an indicator of the supply of advanced skills. It is not limited to science and technical field because of the adoption of innovation in many areas, in particular in the service sectors, depends on a wide range of skills . Furthermore, it includes the entire working-age population , because future economic growth could require drawing on the non-active fraction of the population. International comparisons of educational levels however are difficult due to large discrepancies in educational systems, access, and the level of attainment that is required to receive a tertiary degree. Differences among	NUMERATOR: Number of persons in age class with some form of post-secondary education (ISCED 5 and 6) DENOMINATOR: the reference population is all age classes between 25 and 64 year inclusive	Eurostat – Data Navigation Tree: Database by themes / General and regional statistics / Regional statistics / Regional science and technology statistics (reg_sct) / Human Resources in Science and Technology (HRST) (reg_hrst) / Annual data on HRST and sub-groups (NUTS level 0, 1 and 2) (hrst_st_rcat)	2009 /// 2009, 2008, 2007, 2006, 2005, 2004, 2003, 2002, 2001, 2000

		countries should be nterpreted with caution.			
2- LIFE-LONG LEARNING	Participation in life-long learning per 100 population aged 25-64	A central characteristic of a knowledge economy is continual technical development and innovation. Individuals need to continually learn new ideas and skills or to participate in life-long learning. All types of learning are valuable, since it prepares people for “learning to learn”. The ability to learn can then be applied to new tasks with social and economic benefits.	NUMERATOR: Number of persons involved in life-long learning. Life-long learning is defined as participation in any type of education or training course during the four weeks prior to the survey. The information collected relates to all education or training whether or not relevant to the respondent's current or possible future job. It includes initial education, further education, continuing or further training, training within the company, apprenticeship, on-the-job training, seminars, distance learning, evening classes, self-learning etc. It includes also courses followed for general interest and may cover all forms of education and training as language, data processing, management, art/culture, and health/medicine courses. DENOMINATOR: The reference population is all age classes between 25 and 64 years inclusive.	Eurostat – Data Navigation Tree: Database by themes / General and regional statistics / Regional statistics / Regional labour market statistics (reg_lmk) / Regional socio-demographic labour force statistics – LFS series (reg_lfsd) / Life-long learning – participation of adults aged 25-64 in education and training, at NUTS levels 1 and 2 (1000) (ref_lfsd2plll) N.B.: Il suddetto percorso (qui riportato dalla pubblicazione "ris 2009 methodology report" della PRO INNO) non è corretto perchè, alla data del 31/8/11, non esiste l'indicatore in oggetto! N.B.2: da una ricerca fatta nel sito eurostat si individua la corrispondenza dell' indicatore "participation of adults aged 25-64 in education and training" con l'indicatore "life-long learning" (v. metadata) . PERCORSO CORRETTO PER "LIFE-LONG LEARNING": Eurostat – Data Navigation Tree: Database by themes / General and regional statistics / Regional statistics / Regional education statistics (reg_educ) / Participation of adults aged 25-64 in education and training, at NUTS levels 1 and 2 (from 2008) - % (trng_lfse_04)	2010 /// 2010, 2009, 2008
3- PUBLIC R&D	Public R&D	R&D expenditure represents one of the	NUMERATOR: All R&D expenditures	Eurostat – Data Navigation Tree: Database by	2007 /// 2007,

EXPENDITURE S	expenditures (% of GDP)	major drivers of economic growth in a knowledge-based economy. As such, trends in the R&D expenditure indicator provide key indications of the future competitiveness and wealth of the EU. Research and development spending is essential for making the transition to a knowledgebased economy as well as for improving production technologies and stimulating growth.	in the government sector (GOVERD) and the higher education sector (HERD). Both GOVERD and HERD according to the Frascati-manual definitions, in national currency and current prices. DENOMINATOR: Gross domestic product as defined in the European System of Accounts (ESA 1995), in national currency and current prices.	themes / General and regional statistics / Regional statistics / Regional science and technology statistics (reg_sct) / R&D expenditure and personnel (reg_rd) / Total intramural R&D expenditure (GERD) by sectors of performance and region (RD_E_gerdreg)	2005, 2004, 2003, 2000
4- BROADBAND ACCESS BY FIRMS	Broadband access	Realising Europe's full e-potential depends on creating the conditions for electronic commerce and the Internet to flourish. This indicator captures the relative use of this e-potential by the number of households that have access to broadband.	NUMERATOR: Number of households with broadband access. DENOMINATOR: Total number of households.	Eurostat – Data Navigation Tree: Database by themes / General and regional statistics / Regional statistics / Regional information society statistics (reg_isoc) / households with broadband access (isoc_r_broad_h)	2010 /// 2010, 2009, 2008, 2007, 2006
5- BUSINESS R&D EXPENDITURE S	Business R&D expenditures (% of GDP)	The indicator captures the formal creation of new knowledge within firms. It is particularly important in the science-based sector (pharmaceuticals, chemicals and some areas of electronics) where most new knowledge is created in or near R&D laboratories.	NUMERATOR: All R&D expenditures in the business sector (BERD), according to the Frascati-manual definitions, in national currency and current prices. DENOMINATOR: Gross domestic product as defined in the European System of Accounts (ESA 1995), in national currency and current prices.	Eurostat – Data Navigation Tree: Database by themes / General and regional statistics / Regional statistics / Regional science and technology statistics (reg_sct) / R&D expenditure and personnel (reg_rd) / Total intramural R&D expenditure (GERD) by sectors of performance and region (RD_E_gerdreg)	2007 /// 2007, 2005, 2004, 2003, 2000
6- NON R&D INNOVATION EXPENDITURE S	Non-R&D innovation expenditures (% of total turnover)	This indicator measures non-R&D innovation expenditure as percentage of total turnover. Several of the components of innovation expenditure, such as investment in equipment and machinery and	NUMERATOR: Sum of total innovation expenditure for SMEs only, in national currency and current prices excluding intramural and extramural R&D expenditures. (Community Innovation	NUMERATOR: Eurostat – Data Navigation Tree: Database by themes / Science and technology / Community innovation survey (inn) / Results of the fourth community innovation survey (CIS4) (inn_cis4) /	NUMERATO RE: 2008 /// 2008, 2006, 2004 DENOMINA

		the acquisition of patents and licenses, measure the diffusion of new production technology and ideas. Compared to the EIS 2007 the indicator no longer captures intramural and extramural R&D expenditures and thus no longer overlaps with the indicator on business R&D expenditures.	Survey: CIS-4 question 5.2, sum of variables RMACX and ROEKX) DENOMINATOR: Total turnover for SMEs only (both innovators and non-innovators), in national currency and current prices. (Community Innovation Survey: CIS-4 question 11.1, variable TURN04)	Innovation activity and expenditure in 2004 (inn_cis4_exp) DENOMINATOR: Eurostat – Data Navigation Tree: Database by themes / Science and technology / Community innovation survey (inn) /Results of the fourth community innovation survey (CIS4) (inn_cis4) / Basic economic information on the enterprises (inn_cis4_bas) –	TORE: 2008 /// 2008, 2006, 2004
7- SME'S INNOVATING IN-HOUSE	SMEs innovating in-house (% of all SMEs)	This indicator measures the degree to which SMEs, that have introduced any new or significantly improved products or production processes during the period 2002-2004, have innovated in-house. The indicator is limited to SMEs because almost all large firms innovate and because countries with an industrial structure weighted to larger firms would tend to do better.	NUMERATOR: Sum of SMEs with in-house innovation activities. Innovative firms are defined as those firms which have introduced new products or process either 1) inhouse or 2) in combination with other firms. This indicator does not include new products or processes developed by other firms. Data are taken from CIS4 question 2.2 and 3.2, i.e. whose SMEs which are either: • A product innovator who, to the question “Who developed these product innovations”, answered Yes to at least one of the following categories of CIS4 question 2.2: “Mainly your enterprise or enterprise group” or “Your enterprise together with other enterprises or institutions”. • A process innovator who, to the question “Who developed these process innovations”, answered Yes to	NUMERATOR: Eurostat – Data Navigation Tree: Database by themes / Science and technology / Community innovation survey (inn) / Results of the fourth community innovation survey (CIS4) (inn_cis4) DENOMINATOR: Eurostat – Data Navigation Tree: Database by themes / Science and technology / Community innovation survey (inn) / Results of the fourth community innovation survey (CIS4) (inn_cis4)	NUMERATORE: 2008 /// 2008, 2006, 2004 DENOMINATORE: 2008 /// 2008, 2006, 2004

			at least one of the following categories of CIS4 question 3.2: “Mainly your enterprise or enterprise group” or “Your enterprise together with other enterprises or institutions”. DENOMINATOR: Total number of SMEs (both innovators and non-innovators).		
8- INNOVATIVE SME'S COLLABORATING WITH OTHERS	Innovative SMEs co-operating with others (% of all SMEs)	This indicator measures the degree to which SMEs are involved in innovation co-operation. Complex innovations, in particular in ICT, often depend on the ability to draw on diverse sources of information and knowledge, or to collaborate on the development of an innovation. This indicator measures the flow of knowledge between public research institutions and firms and between firms and other firms. The indicator is limited to SMEs because almost all large firms are involved in innovation co-operation.	NUMERATOR: Sum of SMEs with innovation co-operation activities. Firms with cooperation activities are those that had any co-operation agreements on innovation activities with other enterprises or institutions in the three years of the survey period (i.e. those SMEs who replied Yes to CIS-4 question 6.2). DENOMINATOR:Total number of SMEs (both innovators and non-innovators).	NUMERATOR: Eurostat – Data Navigation Tree: Database by themes / Science and technology / Community innovation survey (inn) / Results of the fourth community innovation survey (CIS4) (inn_cis4) DENOMINATOR: Eurostat – Data Navigation Tree: Database by themes / Science and technology / Community innovation survey (inn) / Results of the fourth community innovation survey (CIS4) (inn_cis4)	NUMERATORE: 2008 /// 2008, 2006, 2004 DENOMINATORE: 2008 /// 2008, 2006, 2004
9- EPO PATENTS	EPO patents per million population	The capacity of firms to develop new products will determine their competitive advantage. One indicator of the rate of new product innovation is the number of patents. This indicator measures the number of patent applications at the European Patent Office.	NUMERATOR: Number of patents applied for at the European Patent Office (EPO), by year of filing. The national distribution of the patent applications is assigned according to the address of the inventor. DENOMINATOR: Total population as defined in the European System of	Eurostat – Data Navigation Tree: Database by themes / General and regional statistics / Regional statistics / Regional science and technology statistics (reg_sct) / European patent applications to EPO (reg_pat) / Patent applications to the EPO by priority year at the regional level (pat_ep_rtot)	2007 /// 2007, 2006, 2005, 2004, 2003, 2002, 2001, 2000

			Accounts (ESA 1995).		
10- PRODUCT AND/OR PROCESS INNOVATOR	Technological (product or process) innovators (% of all SMEs)	Technological innovation as measured by the introduction of new products (goods or services) and processes is key to innovation in manufacturing activities. Higher shares of technological innovators should reflect a higher level of innovation activities.	NUMERATOR: The number of SMEs who introduced a new product or a new process to one of their markets. Data are taken from CIS-4 questions 2.1 and 3.1, i.e. those SMEs which have either introduced: • A product innovation, i.e. have introduced either "New or significantly improved goods" or "New or significantly improved services". A process innovation, i.e. have introduced either "New or significantly improved methods of manufacturing or producing goods or services", "New or significantly improved logistics, delivery or distribution methods for your inputs, goods or services" or "New or significantly improved supporting activities for your processes, such as maintenance systems or operations for purchasing, accounting, or computing". DENOMINATOR: Total number of SMEs.	NUMERATOR: Eurostat – Data Navigation Tree: Database by themes / Science and technology / Community innovation survey (inn) / Results of the fourth community innovation survey (CIS4) (inn_cis4) DENOMINATOR: Eurostat – Data Navigation Tree: Database by themes / Science and technology / Community innovation survey (inn) / Results of the fourth community innovation survey (CIS4) (inn_cis4)	NUMERATORE: 2008 /// 2008, 2006, 2004 DENOMINATORE: 2008 /// 2008, 2006, 2004
11- MARKETING AND/OR ORGANIZATIONAL INNOVATOR	Non-technological (marketing or organizational) innovators (% of all SMEs)	The Community Innovation Survey mainly asks firms about their technical innovation. Many firms, in particular in the services sectors, innovate through other non-technological forms of innovation. Examples of these are organizational innovations. This	NUMERATOR: The number of SMEs who introduced a new marketing innovation and/or organizational innovation to one of their markets. Data are taken from CIS-4 question 10.1, i.e. those SMEs which have either	NUMERATOR: Eurostat – Data Navigation Tree: Database by themes / Science and technology / Community innovation survey (inn) / Results of the fourth community innovation survey (CIS4) (inn_cis4) DENOMINATOR: Eurostat – Data	NUMERATORE: 2008 /// 2008, 2006, 2004 DENOMINATORE: 2008

		indicator tries to capture the extent that SMEs innovate through non-technological innovation.	introduced: • A marketing innovation, i.e. have introduced either "'Significant changes to the design or packaging of a good or service" or "New or significantly changed sales or distribution methods, such as internet sales, franchising, direct sales or distribution licenses". • An organizational innovation, i.e. have introduced either "New or significantly improved knowledge management systems to better use or exchange information, knowledge and skills within your enterprise", "A major change to the organization of work within your enterprise, such as changes in the management structure or integrating different departments or activities" or "New or significant changes in your relations with other firms or public institutions, such as through alliances, partnerships, outsourcing or sub-contracting. DENOMINATOR: Total number of SMEs.	Navigation Tree: Database by themes / Science and technology / Community innovation survey (inn) / Results of the fourth community innovation survey (CIS4) (inn_cis4)	/// 2008, 2006, 2004
12- RESOURCE EFFICIENCY INNOVATORS (LABOUR; ENERGY)	Resource efficiency innovators: This indicator is captured by the following two sub-indicators each	Rationale of "Reduced labour costs resulting from process innovations (% of SMEs)": this indicator captures the cost savings from process innovation. Comment: this indicator will be included jointly with indicator 3.1.3b	NUMERATOR OF "REDUCED LABOUR COSTS RESULTING FROM PROCESS INNOVATIONS (%OF SME'S)": Sum of innovating SMEs who replied that their product or process	NUMERATORE: Eurostat – Data Navigation Tree: Database by themes / Science and technology / Community innovation survey (inn) / Results of the fourth community innovation survey (CIS4) (inn_cis4)	NUMERATORE: 2008 /// 2008, 2006, 2004 DENOMINA

	contributing for 50% of the overall score for resource efficiency innovators: • "Reduced labour costs resulting from process innovations (% of SMEs)" • "Reduced use materials and energy resulting from process innovations (% of SMEs)"	using a relative weight of 50%. Rationale of "Reduced use materials and energy resulting from process innovations (% of SMEs)": This indicator captures the energy savings from process innovation. Comment: this indicator will be included jointly with indicator 3.1.3b using a relative weight of 50%.	innovation had a highly important effect on reducing labour costs per unit of output (CIS-4 question 7.1, variable ELBR). NUMERATOR OF "REDUCED USE MATERIALS AND ENERGY RESULTING FROM PROCESS INNOVATIONS (%OF SME'S)":Numerator: Sum of innovating SMEs who replied that their product or process innovation had a highly important effect on reducing materials and energy per unit of output (CIS-4 question 7.1, variable EMAT). DENOMINATOR OF "REDUCED LABOUR COSTS RESULTING FROM PROCESS INNOVATIONS (%OF SME'S)": Total number of SMEs.	DENOMINATORE: Eurostat – Data Navigation Tree: Database by themes / Science and technology / Community innovation survey (inn) / Results of the fourth community innovation survey (CIS4) (inn_cis4)	TORE: 2008 /// 2008, 2006, 2004
13- EMPLOYMENT IN KNOWLEDGE-INTENSIVE SERVICES	Employment in knowledge-intensive services (% of total workforce)	Knowledge-intensive services provide services directly to consumers, such as telecommunications, and provide inputs to the innovative activities of other firms in all sectors of the economy. The latter can increase productivity throughout the economy and support the diffusion of a range of innovations, in particular those based on ICT.	NUMERATOR: Number of employed persons in the knowledge-intensive services sectors. These include water transport (NACE 61), air transport (NACE 62), post and telecommunications (NACE64), financial intermediation (NACE 65), insurance and pension funding (NACE 66), activities auxiliary to financial intermediation (NACE 67), real estate activities (NACE 70), renting of machinery and equipment (NACE 71), computer and related activities	Data Navigation Tree > Database by themes > Science and technology > High-tech industry and knowledge-intensive services (htec) > High-tech industries and knowledge-intensive services: employment statistics at national and regional level (htec_emp) > Annual data on employment in technology and knowledge-intensive sectors at the regional level, by gender (1994-2008, NACE Rev.1.1) (htec_emp_reg) [FROM 1994 TO 2008] or Annual data on employment in technology and knowledge-intensive sectors at the regional level, by gender (from 2008,	2007 /// 2007, 2006, 2005, 2004, 2003, 2002, 2001, 2000

			(NACE72), research and development (NACE73) and other business activities (NACE 74). DENOMINATOR: The total workforce includes all manufacturing and service sectors.	NACE Rev.2) (htec_emp_reg2) [FROM 2008 TO 2009]	
14- EMPLOYMENT IN MEDIUM-HIGH AND HIGH TECH MANUFACTURING	Employment in medium-high and high-tech manufacturing (% of total workforce)	The share of employment in high technology manufacturing sectors is an indicator of the manufacturing economy that is based on continual innovation through creative, inventive activity. The use of total employment gives a better indicator than using the share of manufacturing employment alone, since the latter will be affected by the hollowing out of manufacturing in some countries.	NUMERATOR: Number of employed persons in the medium-high and high-tech manufacturing sectors. These include chemicals (NACE24), machinery (NACE29), office equipment (NACE30), electrical equipment (NACE31), telecommunications and related equipment (NACE32), precision instrum DENOMINATOR: The total workforce includes all manufacturing and service sectors.	Eurostat - Data Navigation Tree > Database by themes > Science and technology > High-tech industry and knowledge-intensive services (htec) > High-tech industries and knowledge-intensive services: employment statistics at national and regional level (htec_emp) > Annual data on employment in technology and knowledge-intensive sectors at the regional level, by gender (1994-2008, NACE Rev.1.1) (htec_emp_reg) [FROM 1994 TO 2008] or Annual data on employment in technology and knowledge-intensive sectors at the regional level, by gender (from 2008, NACE Rev.2) (htec_emp_reg2) [FROM 2008 TO 2009]	2007 /// 2007, 2006, 2005, 2004, 2003, 2002, 2001, 2000
15- NEW-TO-MARKET SALES	Sales of new-to-market products (% of total turnover)	This indicator measures the turnover of new or significantly improved products, which are also new to the market, as a percentage of total turnover. The product must be new to the firm, which in many cases will also include innovations that are world-firsts. The main disadvantage is that there is some ambiguity in what	NUMERATOR: Sum of total turnover of new or significantly improved products for SMEs only. (Community Innovation Survey, CIS-4 question 2.3, variable TURNMAR) DENOMINATOR: Total turnover for SMEs only (both innovators and non-innovators), in national currency and	NUMERATORE: Eurostat – Data Navigation Tree: Database by themes / Science and technology / Community innovation survey (inn) / Results of the fourth community innovation survey (CIS4) (inn_cis4) DENOMINATORE: Eurostat – Data Navigation Tree: Database by themes / Science and technology / Community	NUMERATORE: 2008 /// 2008, 2006, 2004 DENOMINATORE: 2008 /// 2008, 2006, 2004

		constitutes a 'new to market' innovation. Smaller firms or firms from less developed countries could be more likely to include innovations that have already been introduced onto the market elsewhere.	current prices. (Community Innovation Survey: CIS-4 question 11.1, variable TURN04)	innovation survey (inn) / Results of the fourth community innovation survey (CIS4) (inn_cis4)	
16- NEW-TO-FIRM SALES	Sales of new-to-firm products (% of total turnover)	the firm as a percentage of total turnover. These products are not new to the market. Sales of new to the firm but not new to the market products are a proxy of the use or implementation of elsewhere already introduced products (or technologies). This indicator is a proxy for the degree of diffusion of state-of-the-art technologies.	NUMERATOR: Sum of total turnover of new or significantly improved products to the firm but not to the market for SMEs only. (Community Innovation Survey, CIS-4 question 2.3, variable TURNIN) DENOMINATOR: Total turnover for SMEs only (both innovators and non-innovators), in national currency and current prices. (Community Innovation Survey: CIS-4 question 11.1, variable TURN04)	NUMERATORE: Eurostat – Data Navigation Tree: Database by themes / Science and technology / Community innovation survey (inn) / Results of the fourth community innovation survey (CIS4) (inn_cis4) DENOMINATORE: Eurostat – Data Navigation Tree: Database by themes / Science and technology / Community innovation survey (inn) / Results of the fourth community innovation survey (CIS4) (inn_cis4)	NUMERATORE: 2008 /// 2008, 2006, 2004 DENOMINATORE: 2008 /// 2008, 2006, 2004

OECD

OECD regional innovation indicators (total indicator number is 55) are segmented in 7 groups: R&D Expenditures by performing sector (15), R&D Personnel by sector (10), Educational attainments of the labour force (3), Enrollment by level of education (8), Employment in high-technology sectors (6), Patent applications (12), Percentage of households with access to broadband (1):

RD_EXP: R&D Expenditures by performing sector	RD_EXP_BUS: R&D expenditures performed by the business sector
	RD_EXP_GOV: R&D expenditures performed by the government sector
	RD_EXP_HE: R&D expenditures performed by the higher education sector
	RD_EXP_PNP: R&D expenditures performed by the private and non-profit sector
	RD_EXP_TOT: R&D expenditure total
	RD_EXP_BUS_PPP: R&D expenditures performed by the business sector (PPP)
	RD_EXP_GOV_PPP: R&D expenditures performed by the government sector (PPP)
	RD_EXP_HE_PPP: R&D expenditures performed by the higher education sector (PPP)
	RD_EXP_PNP_PPP: R&D expenditures performed by the private and non-profit sector (PPP
	RD_EXP_TOT_PPP: R&D expenditure total (PPP)
	RD_EXP_BUS_PERC: R&D expenditures performed by the business sector (as % of GDP)
	RD_EXP_GOV_PERC: R&D expenditures performed by the government sector (as % of GDP)
	RD_EXP_HE_PERC: R&D expenditures performed by the higher education sector (as % of GDP)
	RD_EXP_PNP_PERC: R&D expenditures performed by the private and non-profit sector (as % of GDP)

	RD_EXP_TOT_PERC: R&D expenditure total (as % of GDP)
RD_PER: R&D Personnel by sector	RD_PER_BUS: R&D personnel employed by the business sector
	RD_PER_GOV: R&D personnel employed by the government sector
	RD_PER_HE: R&D personnel employed by the higher education sector
	RD_PER_PNP: R&D personnel employed by the private and non-profit sector
	RD_PER_TOT: R&D personnel total
	RD_PER_BUS_PERC: R&D personnel employed by the business sector (as % of employment)
	RD_PER_GOV_PERC: R&D personnel employed by the government sector (as % of employment)
	RD_PER_HE_PERC: R&D personnel employed by the higher education sector (as % of employment
	RD_PER_PNP_PERC: R&D personnel employed by the private and non-profit sector (as % of employment)
	RD_PER_TOT_PERC: R&D personnel total (as % of employment)
EDU_LF: Educational attainments of the labour force	EDU_LF_ISCED_02_PERC: Elementary education (as % of labour force)
	EDU_LF_ISCED_34_PERC: Secondary education (as % of labour force)
	EDU_LF_ISCED_56_PERC: Tertiary education (as % of labour force)
STU_ENR: Enrollment by level of education	STU_ENR_ISCED02: Enrollment at elementary level (ISCED 0-2)
	STU_ENR_ISCED34: Enrollment at secondary level (ISCED 3-4)
	STU_ENR_ISCED56: Enrollment at tertiary level (ISCED 5-6)
	STU_ENR_TOTAL: Total Enrollment (TOTAL)
	STU_ENR_ISCED02_PERC: Enrollment at elementary level (as % of population)
	STU_ENR_ISCED34_PERC: Enrollment at secondary level (as % of population)
	STU_ENR_ISCED56_PERC: Enrollment at tertiary level (as % of population)

	STU_ENR_TOTAL_PERC: Total Enrollment (as % of population)
EMP_HTS: Employment in high-technology sectors	HTM: High and medium high-technology manufacturing
	KIS: Knowledge intensive services
	HTM_PERC_MAN: High and medium high-technology manufacturing (as % of total manufacturing)
	KIS_PERC_SER: Knowledge intensive services (as % of total services)
	HTM_PERC_EMP: High and medium high-technology manufacturing (as % of total employment)
	KIS_PERC_EMP: Knowledge intensive services (as % of total employment)
PAT: Patent applications	PCT: PCT patent applications (fractional count; by inventor and priority year) - level
	PCT_COPAT: PCT co-patent applications (fractional count; by inventor and priority year) - level
	PCT_MILLION: PCT patent applications per million inhabitants (fractional count; by inventor and priority year) - level
	PCT_GREEN: PCT patent applications (fractional count; by inventor and priority year) in green technologies - level
	PCT_ICT: PCT patent applications (fractional count; by inventor and priority year) in ICT - level
	PCT_BIOTECH: PCT patent applications (fractional count; by inventor and priority year) in biotech - level
	PCT_NANOTECH: PCT patent applications (fractional count; by inventor and priority year) in nanotech - level
	PCT_WREGION_PER: Percent of PCT co-patent applications (fractional count; by inventor and priority year) that are done within the region
	PCT_WCOUNTRY_PER: Percent of PCT co-patent applications (fractional count; by inventor and priority year) that are done within the country

	PCT_FREGION_PER: Percent of PCT co-patent applications (fractional count; by inventor and priority year) that are done with foreign regions
	PCT_DOM_OWN: Domestic ownership of foreign patents = percent of PCT patents that have 1 or more foreign inventors and 1 or more domestic applicants in the total number of patents owned domestically (i.e. with 1 or more domestic applicants)
	PCT_FOR_OWN: Foreign ownership of domestic patents = percent of PCT patents that have 1 or more domestic inventors and 1 or more foreign applicants in the total number of patents invented domestically (i.e. with 1 or more domestic inventors
BB_ACC: Percentage of households with access to broadband	

In the following there is a brief description of OECD regional innovation indicators; note that some indcators ("RD_EXP_BUS_PERC: R&D expenditures performed by the business sector as % of GDP", "KIS_PERC_EMP: Knowledge intensive services as % of total employment" , "HTM_PERC_EMP: High and medium high-technology manufacturing as % of total employment") aren't reported here because they are included in the "Pro Inno europe indicators" section yet:

OECD					
INDICATOR CODE-NAME	INDICATOR DEFINITION	OECD METADATA	Num Deno	SOURCE	OECD: AVIALABLE DATA AND DATA FREQUENCY AT OCTOBER 2011 /// PRIMITIVE SOURCE: LATEST AVAILABLE DATA AND DATA FREQUENCY STARTING FROM 2000)
17 - RD_EXP_BUS	R&D expenditures performed by the business sector	Unit of measure used: Million of national currency, current prices Key statistical concept: All firms, organizations and institutions whose primary activity is the market production of goods or services (other than higher education) for sale to the general public at an economically significant price. It also includes the the private non-profit institutions mainly serving the above mentioned firms, organizations and institutions (See Frascati Manual section 3.4).	NO DATA FROM OECD	[a]EUROSTAT> DATA NAVIGATION TREE > DATABASE BY THEMES > GENERAL AND REGIONAL STATISTICS > REGIONAL STATISTICS>REGIONAL SCIENCE AND TECHNOLOGY STATISTICS>R&D EXPENDITURES AND PERSONNEL> TOTAL INTRAMURAL R&D EXPENDITURE (GERD) BY SECTOR OF PERFORMANCE AND REGION (rd_e_gerdreg);	OECD: 2005 (2005, 2004, 2003, 2000) /// EUROSTAT: 2007 (2007, 2005, 2004, 2003, 2000)
18 - RD_EXP_GOV	R&D expenditures performed by the	Unit of measure used: Million of national currency, current prices Key statistical concept	NO DATA FROM OECD	[a]EUROSTAT> DATA NAVIGATION TREE > DATABASE	OECD: 2005 (2005, 2004, 2003, 2000) /// EUROSTAT: 2007 (2007,

	government sector	All departments, offices and other bodies which furnish, but normally do not sell to the community, those common services, other than higher education, which cannot otherwise be conveniently and economically provided, as well as those that administer the state and the economic and social policy of the community. (Public enterprises are included in the business enterprise sector). It also includes non-profit institutions controlled and mainly financed by government, but not administered by the higher education sector (see Frascati Manual section 3.5).		BY THEMES > GENERAL AND REGIONAL STATISTICS > REGIONAL STATISTICS>REGIONAL SCIENCE AND TECHNOLOGY STATISTICS>R&D EXPENDITURES AND PERSONNEL> TOTAL INTRAMURAL R&D EXPENDITURE (GERD) BY SECTOR OF PERFORMANCE AND REGION (rd_e_gerdreg)	2005, 2004, 2003, 2000)
19 - RD_EXP_HE	R&D expenditures performed by the higher education sector	Unit of measure used: Million of national currency, current prices Key statistical concept: All universities, colleges of technology and other institutions of post-secondary education, whatever their source of finance or legal status. It also includes all research institutes, experimental stations and clinics operating under the direct control of or administered by or associated with higher education institutions (see Frascati Manual section 3.7).	NO DATA FROM OECD	[a]EUROSTAT> DATA NAVIGATION TREE > DATABASE BY THEMES > GENERAL AND REGIONAL STATISTICS > REGIONAL STATISTICS>REGIONAL SCIENCE AND TECHNOLOGY STATISTICS>R&D EXPENDITURES AND PERSONNEL> TOTAL INTRAMURAL R&D EXPENDITURE (GERD) BY SECTOR OF PERFORMANCE AND REGION (rd_e_gerdreg)	OECD: 2005 (2005, 2004, 2003, 2000) /// EUROSTAT: 2007 (2007, 2005, 2004, 2003, 2000)
20 - RD_EXP_PNP	R&D expenditures performed by the private and non-profit sector	Unit of measure used: Million of national currency, current prices Key statistical concept: Non-market, private non-profit institutions serving households (i.e. the general public) and private individuals or households (see Frascati Manual section 3.6).	NO DATA FROM OECD	[a]EUROSTAT> DATA NAVIGATION TREE > DATABASE BY THEMES > GENERAL AND REGIONAL STATISTICS > REGIONAL STATISTICS>REGIONAL SCIENCE AND TECHNOLOGY STATISTICS>R&D EXPENDITURES AND PERSONNEL> TOTAL INTRAMURAL R&D EXPENDITURE (GERD) BY SECTOR OF PERFORMANCE AND REGION (rd_e_gerdreg)	OECD: 2005 (2005, 2004, 2003, 2000) /// EUROSTAT: 2007 (2007, 2005, 2004, 2003, 2000)
21 - RD_EXP_	R&D expenditure total	Unit of measure used: Million of national currency, current prices	NO DATA FROM OECD	[a]EUROSTAT> DATA NAVIGATION TREE > DATABASE	OECD: 2005 (2005, 2004, 2003, 2000) ///

TOT		Key statistical concept: Total R and D expenditures is the sum of expenditures in the four performing sectors (business, government, higher education and private non-profit)		BY THEMES > GENERAL AND REGIONAL STATISTICS > REGIONAL STATISTICS>REGIONAL SCIENCE AND TECHNOLOGY STATISTICS>R&D EXPENDITURES AND PERSONNEL> TOTAL INTRAMURAL R&D EXPENDITURE (GERD) BY SECTOR OF PERFORMANCE AND REGION (rd_e_gerdreg)	EUROSTAT: 2007 (2007, 2005, 2004, 2003, 2000)
22 - RD_EXP_ BUS_PPP	R&D expenditures performed by the business sector (PPP - Purchasing Power Parities)	Unit of measure used: Million of current USD PPP Key statistical concept: All firms, organizations and institutions whose primary activity is the market production of goods or services (other than higher education) for sale to the general public at an economically significant price. It also includes the the private non-profit institutions mainly serving the above mentioned firms, organizations and institutions (See Frascati Manual section 3.4).	NO DATA FROM OECD	[a]EUROSTAT> DATA NAVIGATION TREE > DATABASE BY THEMES > GENERAL AND REGIONAL STATISTICS > REGIONAL STATISTICS>REGIONAL SCIENCE AND TECHNOLOGY STATISTICS>R&D EXPENDITURES AND PERSONNEL> TOTAL INTRAMURAL R&D EXPENDITURE (GERD) BY SECTOR OF PERFORMANCE AND REGION (rd_e_gerdreg)	OECD: 2005 (2005, 2004, 2003, 2000) /// EUROSTAT: 2007 (2007, 2005, 2004, 2003, 2000)
23 - RD_EXP_ GOV_PPP	R&D expenditures performed by the government sector (PPP - Purchasing Power Parities)	Unit of measure used: Million of current USD PPP Key statistical concept: All departments, offices and other bodies which furnish, but normally do not sell to the community, those common services, other than higher education, which cannot otherwise be conveniently and economically provided, as well as those that administer the state and the economic and social policy of the community. (Public enterprises are included in the business enterprise sector). It also includes non-profit institutions controlled and mainly financed by government, but not administered by the higher education sector (see Frascati Manual section 3.5).	NO DATA FROM OECD	[a]EUROSTAT> DATA NAVIGATION TREE > DATABASE BY THEMES > GENERAL AND REGIONAL STATISTICS > REGIONAL STATISTICS>REGIONAL SCIENCE AND TECHNOLOGY STATISTICS>R&D EXPENDITURES AND PERSONNEL> TOTAL INTRAMURAL R&D EXPENDITURE (GERD) BY SECTOR OF PERFORMANCE AND REGION (rd_e_gerdreg)	OECD: 2005 (2005, 2004, 2003, 2000) /// EUROSTAT: 2007 (2007, 2005, 2004, 2003, 2000)
24 - RD_EXP_ HE_PPP	R&D expenditures performed by the higher education	Unit of measure used: Million of current USD PPP Key statistical concept: All universities, colleges of technology and other	NO DATA FROM OECD	[a]EUROSTAT> DATA NAVIGATION TREE > DATABASE BY THEMES > GENERAL AND	OECD: 2005 (2005, 2004, 2003, 2000) /// EUROSTAT: 2007 (2007, 2005, 2004, 2003, 2000)

	sector (PPP - Purchasing Power Parities)	institutions of post-secondary education, whatever their source of finance or legal status. It also includes all research institutes, experimental stations and clinics operating under the direct control of or administered by or associated with higher education institutions (see Frascati Manual section 3.7).		REGIONAL STATISTICS > REGIONAL STATISTICS>REGIONAL SCIENCE AND TECHNOLOGY STATISTICS>R&D EXPENDITURES AND PERSONNEL> TOTAL INTRAMURAL R&D EXPENDITURE (GERD) BY SECTOR OF PERFORMANCE AND REGION (rd_e_gerdreg)	
25 - RD_EXP_PNP_PPP	R&D expenditures performed by the private and non-profit sector (PPP - Purchasing Power Parities)	Unit of measure used: Million of current USD PPP Key statistical concept: Non-market, private non-profit institutions serving households (i.e. the general public) and private individuals or households (see Frascati Manual section 3.6).	NO DATA FROM OECD	[a]EUROSTAT> DATA NAVIGATION TREE > DATABASE BY THEMES > GENERAL AND REGIONAL STATISTICS > REGIONAL STATISTICS>REGIONAL SCIENCE AND TECHNOLOGY STATISTICS>R&D EXPENDITURES AND PERSONNEL> TOTAL INTRAMURAL R&D EXPENDITURE (GERD) BY SECTOR OF PERFORMANCE AND REGION (rd_e_gerdreg)	OECD: 2005 (2005, 2004, 2003, 2000) /// EUROSTAT: 2007 (2007, 2005, 2004, 2003, 2000)
26 - RD_EXP_TOT_PPP	R&D expenditure total (PPP - Purchasing Power Parities)	Unit of measure used: Million of current USD PPP Key statistical concept: Total R and D expenditures is the sum of expenditures in the four performing sectors (business, government, higher education and private non-profit)	NO DATA FROM OECD	[a]EUROSTAT> DATA NAVIGATION TREE > DATABASE BY THEMES > GENERAL AND REGIONAL STATISTICS > REGIONAL STATISTICS>REGIONAL SCIENCE AND TECHNOLOGY STATISTICS>R&D EXPENDITURES AND PERSONNEL> TOTAL INTRAMURAL R&D EXPENDITURE (GERD) BY SECTOR OF PERFORMANCE AND REGION (rd_e_gerdreg)	OECD: 2005 (2005, 2004, 2003, 2000) /// EUROSTAT: 2007 (2007, 2005, 2004, 2003, 2000)
27 - RD_EXP_GOV_PERC	R&D expenditures performed by the government sector (as % of	Unit of measure used: Percentage of GDP Key statistical concept: All departments, offices and other bodies which furnish, but normally do not sell to the community,	NO DATA FROM OECD	[a]EUROSTAT> DATA NAVIGATION TREE > DATABASE BY THEMES > GENERAL AND REGIONAL STATISTICS > REGIONAL	OECD: 2005 (2005, 2004, 2003, 2000) /// EUROSTAT: 2007 (2007, 2005, 2004, 2003, 2000)

	GDP)	those common services, other than higher education, which cannot otherwise be conveniently and economically provided, as well as those that administer the state and the economic and social policy of the community. (Public enterprises are included in the business enterprise sector). It also includes non-profit institutions controlled and mainly financed by government, but not administered by the higher education sector (see Frascati Manual section 3.5).		STATISTICS>REGIONAL SCIENCE AND TECHNOLOGY STATISTICS>R&D EXPENDITURES AND PERSONNEL> TOTAL INTRAMURAL R&D EXPENDITURE (GERD) BY SECTOR OF PERFORMANCE AND REGION (rd_e_gerdreg)	
28 - RD_EXP_ HE_PERC	R&D expenditures performed by the higher education sector (as % of GDP)	Unit of measure used: Percentage of GDP Key statistical concept: All universities, colleges of technology and other institutions of post-secondary education, whatever their source of finance or legal status. It also includes all research institutes, experimental stations and clinics operating under the direct control of or administered by or associated with higher education institutions (see Frascati Manual section 3.7).	NO DATA FROM OECD	[a]EUROSTAT> DATA NAVIGATION TREE > DATABASE BY THEMES > GENERAL AND REGIONAL STATISTICS > REGIONAL STATISTICS>REGIONAL SCIENCE AND TECHNOLOGY STATISTICS>R&D EXPENDITURES AND PERSONNEL> TOTAL INTRAMURAL R&D EXPENDITURE (GERD) BY SECTOR OF PERFORMANCE AND REGION (rd_e_gerdreg) [SECTPERF: Business enterprise sector UNIT: Millions of national currency (including 'euro fixed' series for euro area countries)]	OECD: 2005 (2005, 2004, 2003, 2000) /// EUROSTAT: 2007 (2007, 2005, 2004, 2003, 2000)
29 - RD_EXP_P NP_PERC	R&D expenditures performed by the private and non-profit sector (as % of GDP)	Unit of measure used: Percentage of GDP Key statistical concept: Non-market, private non-profit institutions serving households (i.e. the general public) and private individuals or households (see Frascati Manual section 3.6).	NO DATA FROM OECD	[a]EUROSTAT> DATA NAVIGATION TREE > DATABASE BY THEMES > GENERAL AND REGIONAL STATISTICS > REGIONAL STATISTICS>REGIONAL SCIENCE AND TECHNOLOGY STATISTICS>R&D EXPENDITURES AND PERSONNEL> TOTAL INTRAMURAL R&D EXPENDITURE (GERD) BY SECTOR OF PERFORMANCE AND REGION (rd_e_gerdreg)	OECD: 2005 (2005, 2004, 2003, 2000) /// EUROSTAT: 2007 (2007, 2005, 2004, 2003, 2000)

30 - RD_EXP_TOT_PERC	R&D expenditure total (as % of GDP)	Unit of measure used: Percentage of GDP Key statistical concept: Total R and D expenditures is the sum of expenditures in the four performing sectors (business, government, higher education and private non-profit).	NO DATA FROM OECD	[a]EUROSTAT> DATA NAVIGATION TREE > DATABASE BY THEMES > GENERAL AND REGIONAL STATISTICS > REGIONAL STATISTICS>REGIONAL SCIENCE AND TECHNOLOGY STATISTICS>R&D EXPENDITURES AND PERSONNEL> TOTAL INTRAMURAL R&D EXPENDITURE (GERD) BY SECTOR OF PERFORMANCE AND REGION (rd_e_gerdreg)	OECD: 2005 (2005, 2004, 2003, 2000) /// EUROSTAT: 2007 (2007, 2005, 2004, 2003, 2000)
31 - RD_PER_BUS	R&D personnel employed by the business sector	Unit of measure used: Headcounts Key statistical concept: Persons emplyed in all firms, organizations and institutions whose primary activity is the market production of goods or services (other than higher education) for sale to the general public at an economically significant price. It also includes the the private non-profit institutions mainly serving the above mentioned firms, organizations and institutions (See Frascati Manual section 3.4).	NO DATA FROM OECD	[a]EUROSTAT> DATA NAVIGATION TREE > DATABASE BY THEMES > GENERAL AND REGIONAL STATISTICS > REGIONAL STATISTICS>REGIONAL SCIENCE AND TECHNOLOGY STATISTICS>R&D EXPENDITURES AND PERSONNEL> TOTAL R&D PERSONNEL AND RESEARCHERS BY SECTORS OF PERFORMANCE, REGION AND SEX (rd_p_persreg)	OECD: 2005 (2005, 2004, 2003, 2000) /// EUROSTAT: 2007 (2007, 2005, 2004, 2003, 2000)
32 - RD_PER_GOV	R&D personnel employed by the government sector	Unit of measure used: Headcounts Key statistical concept: Persons employed in all departments, offices and other bodies which furnish, but normally do not sell to the community, those common services, other than higher education, which cannot otherwise be conveniently and economically provided, as well as those that administer the state and the economic and social policy of the community. (Public enterprises are included in the business enterprise sector). It also includes non-profit institutions controlled and mainly financed by government, but not administered by the higher education sector (see Frascati Manual section 3.5).	NO DATA FROM OECD	[a]EUROSTAT> DATA NAVIGATION TREE > DATABASE BY THEMES > GENERAL AND REGIONAL STATISTICS > REGIONAL STATISTICS>REGIONAL SCIENCE AND TECHNOLOGY STATISTICS>R&D EXPENDITURES AND PERSONNEL> TOTAL R&D PERSONNEL AND RESEARCHERS BY SECTORS OF PERFORMANCE, REGION AND SEX (rd_p_persreg)	OECD: 2005 (2005, 2004, 2003, 2000) /// EUROSTAT: 2007 (2007, 2005, 2004, 2003, 2000)

33 - RD_PER_HE	R&D personnel employed by the higher education sector	Unit of measure used: Headcounts Key statistical concept: Persons employed in all universities, colleges of technology and other institutions of post-secondary education, whatever their source of finance or legal status. It also includes all research institutes, experimental stations and clinics operating under the direct control of or administered by or associated with higher education institutions (see Frascati Manual section 3.7).	NO DATA FROM OECD	[a]EUROSTAT> DATA NAVIGATION TREE > DATABASE BY THEMES > GENERAL AND REGIONAL STATISTICS > REGIONAL STATISTICS>REGIONAL SCIENCE AND TECHNOLOGY STATISTICS>R&D EXPENDITURES AND PERSONNEL> TOTAL R&D PERSONNEL AND RESEARCHERS BY SECTORS OF PERFORMANCE, REGION AND SEX (rd_p_persreg)	OECD: 2005 (2005, 2004, 2003, 2000) /// EUROSTAT: 2007 (2007, 2005, 2004, 2003, 2000)
34 - RD_PER_PNP	R&D personnel employed by the private and non-profit sector	Unit of measure used: Headcounts Key statistical concept: Persons employed in non-market, private non-profit institutions serving households (i.e. the general public) and private individuals or households (see Frascati Manual section 3.6).	NO DATA FROM OECD	[a]EUROSTAT> DATA NAVIGATION TREE > DATABASE BY THEMES > GENERAL AND REGIONAL STATISTICS > REGIONAL STATISTICS>REGIONAL SCIENCE AND TECHNOLOGY STATISTICS>R&D EXPENDITURES AND PERSONNEL> TOTAL R&D PERSONNEL AND RESEARCHERS BY SECTORS OF PERFORMANCE, REGION AND SEX (rd_p_persreg)	OECD: 2005 (2005, 2004, 2003, 2000) /// EUROSTAT: 2007 (2007, 2005, 2004, 2003, 2000)
35 - RD_PER_TOT	R&D personnel total	Unit of measure used: Headcounts Key statistical concept: All persons employed directly on R and D should be counted, as well as those providing direct services such as R and D managers, administrators, and clerical staff (Headcounts) (see Frascati Manual section 5.2.1).	NO DATA FROM OECD	[a]EUROSTAT> DATA NAVIGATION TREE > DATABASE BY THEMES > GENERAL AND REGIONAL STATISTICS > REGIONAL STATISTICS>REGIONAL SCIENCE AND TECHNOLOGY STATISTICS>R&D EXPENDITURES AND PERSONNEL> TOTAL R&D PERSONNEL AND RESEARCHERS BY SECTORS OF PERFORMANCE, REGION AND SEX (rd_p_persreg)	OECD: 2005 (2005, 2004, 2003, 2000) /// EUROSTAT: 2007 (2007, 2005, 2004, 2003, 2000)
36 - RD_PER_	R&D personnel employed by the	Unit of measure used: percentage of total employment	NO DATA FROM OECD	[a]EUROSTAT> DATA	OECD: 2005 (2005, 2004, 2003, 2000) ///

BUS_PER C	business sector (as % of employment)	Key statistical concept: Persons emplyed in all firms, organizations and institutions whose primary activity is the market production of goods or services (other than higher education) for sale to the general public at an economically significant price. It also includes the the private non-profit institutions mainly serving the above mentioned firms, organizations and institutions (See Frascati Manual section 3.4).		NAVIGATION TREE > DATABASE BY THEMES > GENERAL AND REGIONAL STATISTICS > REGIONAL STATISTICS>REGIONAL SCIENCE AND TECHNOLOGY STATISTICS>R&D EXPENDITURES AND PERSONNEL> TOTAL R&D PERSONNEL AND RESEARCHERS BY SECTORS OF PERFORMANCE, REGION AND SEX (rd_p_persreg)	EUROSTAT: 2007 (2007, 2005, 2004, 2003, 2000)
37 - RD_PER_ GOV_PER C	R&D personnel employed by the government sector (as % of employment)	Unit of measure used: percentage of total employment Key statistical concept: Persons employed in all departments, offices and other bodies which furnish, but normally do not sell to the community, those common services, other than higher education, which cannot otherwise be conveniently and economically provided, as well as those that administer the state and the economic and social policy of the community. (Public enterprises are included in the business enterprise sector). It also includes non-profit institutions controlled and mainly financed by government, but not administered by the higher education sector (see Frascati Manual section 3.5).	NO DATA FROM OECD	[a]EUROSTAT> DATA NAVIGATION TREE > DATABASE BY THEMES > GENERAL AND REGIONAL STATISTICS > REGIONAL STATISTICS>REGIONAL SCIENCE AND TECHNOLOGY STATISTICS>R&D EXPENDITURES AND PERSONNEL> TOTAL R&D PERSONNEL AND RESEARCHERS BY SECTORS OF PERFORMANCE, REGION AND SEX (rd_p_persreg)	OECD: 2005 (2005, 2004, 2003, 2000) /// EUROSTAT: 2007 (2007, 2005, 2004, 2003, 2000)
38 - RD_PER_ HE_PERC	R&D personnel employed by the higher education sector (as % of employment)	Unit of measure used: percentage of total employment Key statistical concept: Persons employed in all universities, colleges of technology and other institutions of post-secondary education, whatever their source of finance or legal status. It also includes all research institutes, experimental stations and clinics operating under the direct control of or administered by or associated with higher education institutions (see Frascati Manual section 3.7).	NO DATA FROM OECD	[a]EUROSTAT> DATA NAVIGATION TREE > DATABASE BY THEMES > GENERAL AND REGIONAL STATISTICS > REGIONAL STATISTICS>REGIONAL SCIENCE AND TECHNOLOGY STATISTICS>R&D EXPENDITURES AND PERSONNEL> TOTAL R&D PERSONNEL AND RESEARCHERS BY SECTORS OF PERFORMANCE, REGION AND SEX (rd_p_persreg)	OECD: 2005 (2005, 2004, 2003, 2000) /// EUROSTAT: 2007 (2007, 2005, 2004, 2003, 2000)
39 - RD_PER_P NP_PERC	R&D personnel employed by the private and non-	Unit of measure used: percentage of total employment Key statistical concept:	NO DATA FROM OECD	[a]EUROSTAT> DATA NAVIGATION TREE > DATABASE	OECD: 2005 (2005, 2004, 2003, 2000) /// EUROSTAT: 2007 (2007,

	profit sector (as % of employment)	Persons employed in non-market, private non-profit institutions serving households (i.e. the general public) and private individuals or households (see Frascati Manual section 3.6).		BY THEMES > GENERAL AND REGIONAL STATISTICS > REGIONAL STATISTICS>REGIONAL SCIENCE AND TECHNOLOGY STATISTICS>R&D EXPENDITURES AND PERSONNEL> TOTAL R&D PERSONNEL AND RESEARCHERS BY SECTORS OF PERFORMANCE, REGION AND SEX (rd_p_persreg)	2005, 2004, 2003, 2000)
40 - RD_PER_TOT_PERC	R&D personnel total (as % of employment)	Unit of measure used: percentage of total employment Key statistical concept: All persons employed directly on R and D should be counted, as well as those providing direct services such as R and D managers, administrators, and clerical staff (Headcounts) (see Frascati Manual section 5.2.1).	NO DATA FROM OECD	[a]EUROSTAT> DATA NAVIGATION TREE > DATABASE BY THEMES > GENERAL AND REGIONAL STATISTICS > REGIONAL STATISTICS>REGIONAL SCIENCE AND TECHNOLOGY STATISTICS>R&D EXPENDITURES AND PERSONNEL> TOTAL R&D PERSONNEL AND RESEARCHERS BY SECTORS OF PERFORMANCE, REGION AND SEX (rd_p_persreg)	OECD: 2005 (2005, 2004, 2003, 2000) /// EUROSTAT: 2007 (2007, 2005, 2004, 2003, 2000)
41 - EDU_LF_ISCED_02_PERC	Elementary education (as % of labour force)	Unit of measure used: Percentage of total labour force. For some regions, the percentage of labour force by educational attainment doesn't add up to 100 because of the share of non respondent in each region. Key statistical concept: ISCED 0 Pre-primary education, ISCED 1 Primary education, ISCED 2 Lower secondary education.Explanation of the ISCED classification and concordance tables for each country: http://www.oecd.org/dataoecd/41/42/1841854.pdf	NO DATA FROM OECD	V. nota b	OECD: 2008 (2008, 2007, 2006, 2005, 2004, 2003, 2002, 2001)
42 - EDU_LF_ISCED_34_PERC	Secondary education (as % of labour force)	Unit of measure used: Percentage of total labour force. For some regions, the percentage of labour force by educational attainment doesn't add up to 100 because of the share of non respondent in each region. Key statistical concept: ISCED 3 Upper secondary education, ISCED 4 Post-secondary non-tertiary education. Explanation of the	NO DATA FROM OECD	V. nota b	OECD: 2008 (2008, 2007, 2006, 2005, 2004, 2003, 2002, 2001)

		ISCED classification and concordance tables for each country: http://www.oecd.org/dataoecd/41/42/1841854.pdf			
43 - EDU_LF_ISCED_56_PERC	Tertiary education (as % of labour force)	Unit of measure used: Percentage of total labour force. For some regions, the percentage of labour force by educational attainment doesn't add up to 100 because of the share of non respondent in each region. Key statistical concept: ISCED 5 Tertiary-type of programmes, ISCED 6 Advanced Research Qualifications. Explanation of the ISCED classification and concordance tables for each country: http://www.oecd.org/dataoecd/41/42/1841854.pdf	NO DATA FROM OECD	V. nota b	OECD: 2008 (2008, 2007, 2006, 2005, 2004, 2003, 2002, 2001)
44 - STU_ENR_ISCED02	Enrollment at elementary level (ISCED 0-2)	Unit of measure used: Headcounts Key statistical concept: ISCED 0 Pre-primary education, ISCED 1 Primary education, ISCED 2 Lower secondary education.Explanation of the ISCED classification and concordance tables for each country: http://www.oecd.org/dataoecd/41/42/1841854.pdf	NO DATA FROM OECD	[a]EUROSTAT>REGIONAL STATISTICS>REGIONAL EDUCATION STATISTICS>NUMBER OF STUDENTS BY LEVEL OF EDUCATION, ORIENTATION, SEX AND REGION. P.S.: IN ORDER TO OBTAIN THE INDICATOR'S DATA YOU HAVE TO CALCULATE THE FOLLOWING SUM: "PRE-PRIMARY EDUCATION - LEVEL 0 (ISCED 1997)" + "PRIMARY EDUCATION OR FIRST STAGE OF BASIC EDUCATION - LEVEL 1 (ISCED 1997)" + "LOWER SECONDARY OR SECONDARY STAGE OF EDUCATION - LEVEL 2 (ISCED 1997)"	OECD: 2008 (2008, 2007, 2006, 2005, 2004, 2003, 2002, 2001, 2000) /// EUROSTAT: 2009 (2009, 2008, 2007, 2006, 2005, 2004, 2003, 2002, 2001, 2000)
45 - STU_ENR_ISCED34	Enrollment at secondary level (ISCED 3-4)	Unit of measure used: Headcounts Key statistical concept: ISCED 3 Upper secondary education, ISCED 4 Post-secondary non-tertiary education. Explanation of the ISCED classification and concordance tables for each country: http://www.oecd.org/dataoecd/41/42/1841854.pdf	NO DATA FROM OECD	[a]EUROSTAT>REGIONAL STATISTICS>REGIONAL EDUCATION STATISTICS>NUMBER OF STUDENTS BY LEVEL OF EDUCATION, ORIENTATION, SEX AND REGION. P.S.: IN ORDER TO OBTAIN THE INDICATOR'S DATA YOU HAVE TO CALCULATE THE FOLLOWING SUM: "UPPER	OECD: 2008 (2008, 2007, 2006, 2005, 2004, 2003, 2002, 2001, 2000) /// EUROSTAT: 2009 (2009, 2008, 2007, 2006, 2005, 2004, 2003, 2002, 2001, 2000)

				SECONDARY EDUCATION - LEVEL 3 (ISCED 1997)" + "POST-SECONDARY NON-TERTIARY EDUCATION - LEVEL 4 (ISCED 1997)"	
46 - STU_ENR _ISCED56	Enrollment at tertiary level (ISCED 5-6)	Unit of measure used: Headcounts Key statistical concept: ISCED 5 Tertiary-type of programmes, ISCED 6 Advanced Research Qualifications. Explanation of the ISCED classification and concordance tables for each country: http://www.oecd.org/dataoecd/41/42/1841854.pdf	NO DATA FROM OECD	[a]EUROSTAT>REGIONAL STATISTICS>REGIONAL EDUCATION STATISTICS>NUMBER OF STUDENTS BY LEVEL OF EDUCATION, ORIENTATION, SEX AND REGION. P.S.: IN ORDER TO OBTAIN THE INDICATOR'S DATA YOU HAVE TO TAKE THE FOLLOWING ITEM ONLY: "TERTIARY EDUCATION - LEVEL 5-6 (ISCED 1997)"	OECD: 2008 (2008, 2007, 2006, 2005, 2004, 2003, 2002, 2001, 2000) /// EUROSTAT: 2009 (2009, 2008, 2007, 2006, 2005, 2004, 2003, 2002, 2001, 2000)
47 - STU_ENR _TOTAL	Total Enrollment (TOTAL)	Unit of measure used: Headcounts Key statistical concept: Total enrolled in any educational level (ISCED Total)	NO DATA FROM OECD	[a]EUROSTAT>REGIONAL STATISTICS>REGIONAL EDUCATION STATISTICS>NUMBER OF STUDENTS BY LEVEL OF EDUCATION, ORIENTATION, SEX AND REGION. P.S.: IN ORDER TO OBTAIN THE INDICATOR'S DATA YOU HAVE TO TAKE THE FOLLOWING ITEM ONLY: "TOTAL (ISCED 1997)"	OECD: 2008 (2008, 2007, 2006, 2005, 2004, 2003, 2002, 2001, 2000) /// EUROSTAT: 2009 (2009, 2008, 2007, 2006, 2005, 2004, 2003, 2002, 2001, 2000)
48 - STU_ENR _ISCED02 _PERC	Enrollment at elementary level (as % of population)	Unit of measure used: Percentage of population Key statistical concept: ISCED 0 Pre-primary education, ISCED 1 Primary education, ISCED 2 Lower secondary education.Explanation of the ISCED classification and concordance tables for each country: http://www.oecd.org/dataoecd/41/42/1841854.pdf	NO DATA FROM OECD	V. nota b	OECD: 2008 (2008, 2007, 2006, 2005, 2004, 2003, 2002, 2001, 2000)
49 - STU_ENR _ISCED34 _PERC	Enrollment at secondary level (as % of population)	Unit of measure used: Percentage of population Key statistical concept: ISCED 3 Upper secondary education, ISCED 4 Post-secondary non-tertiary education. Explanation of the ISCED classification and concordance tables for each	NO DATA FROM OECD	V. nota b	OECD: 2008 (2008, 2007, 2006, 2005, 2004, 2003, 2002, 2001, 2000)

		country: http://www.oecd.org/dataoecd/41/42/1841854.pdf			
50 - STU_ENR _ISCED56 _PERC	Enrollment at tertiary level (as % of population)	Unit of measure used: Percentage of population Key statistical concept: ISCED 5 Tertiary-type of programmes, ISCED 6 Advanced Research Qualifications. Explanation of the ISCED classification and concordance tables for each country: http://www.oecd.org/dataoecd/41/42/1841854.pdf	NO DATA FROM OECD	V. nota b	OECD: 2008 (2008, 2007, 2006, 2005, 2004, 2003, 2002, 2001, 2000)
51 - STU_ENR _TOTAL_P ERC	Total Enrollment (as % of population)	NO DATA FROM OECD	NO DATA FROM OECD	V. nota b	OECD: 2008 (2008, 2007, 2006, 2005, 2004, 2003, 2002, 2001, 2000)
52 - HTM	High and medium high-technology manufacturing	Unit of measure used: Headcounts Key statistical concept: Employment in high and medium-high-technology manufacturing: Employment in high-tecnology sectors corresponds to the following ISIC Divisions/Groups/Classes: 2423 Manufacture of pharmaceuticals, medicinal chemicals and botanical products; 30 Manufacture of office machinery and computers; 32 Manufacture of radio, television and communication equipment and apparatus; 33 Manufacture of medical, precision and optical instruments, watches and clocks; 353 Manufacture of aircraft and spacecraft. Employment in medium-high-tecnology sectors corresponds to the following ISIC Divisions/Groups/Classes: 24 Manufacture of chemicals and chemical product, excluding class 2423 Manufacture of pharmaceuticals, medicinal chemicals and botanical products; 29 Manufacture of machinery and equipment n.e.c.; 31 Manufacture of electrical machinery and apparatus n.e.c.; 34 Manufacture of motor vehicles, trailers and semi-trailers; 35 Manufacture of other transport equipment, excluding group 351 Building and repairing of ships and boats and excluding group 353 Manufacture of aircraft and spacecraft	NO DATA FROM OECD	V. nota b	OECD: 2008 (2008, 2007, 2006, 2005, 2004, 2003, 2002, 2001, 2000)
53 - KIS	Knowledge intensive services	Unit of measure used: Headcounts Key statistical concept: Employment in the following ISIC divisions: 61 Water transport, 62 Air transport, 64 Post and	NO DATA FROM OECD	V. nota b	OECD: 2008 (2008, 2007, 2006, 2005, 2004, 2003, 2002, 2001, 2000)

		Telecommunications, 65 Financial intermediation, except insurance and pension funding, 66 Insurance and pension funding, except compulsory social security, 67 Activities auxiliary to financial intermediation, 70 Real estate activities, 71 Renting of machinary and equipment without operator and of personal and household goods, 72 Computer and related activities, 73 Research and development, 74 Other business activities, 80 Education, 85 Health and social work and 92 Recreational, cultural and sporting activities.			
54 - HTM_PERC_MAN	High and medium high-technology manufacturing (as % of total manufacturing)	Unit of measure used: Percentage of employment in manufacturing Key statistical concept: Employment in high and medium-high-technology manufacturing: Employment in high-tecnology sectors corresponds to the following ISIC Divisions/Groups/Classes: 2423 Manufacture of pharmaceuticals, medicinal chemicals and botanical products; 30 Manufacture of office machinery and computers; 32 Manufacture of radio, television and communication equipment and apparatus; 33 Manufacture of medical, precision and optical instruments, watches and clocks; 353 Manufacture of aircraft and spacecraft. Employment in medium-high-tecnology sectors corresponds to the following ISIC Divisions/Groups/Classes: 24 Manufacture of chemicals and chemical product, excluding class 2423 Manufacture of pharmaceuticals, medicinal chemicals and botanical products; 29 Manufacture of machinery and equipment n.e.c.; 31 Manufacture of electrical machinery and apparatus n.e.c.; 34 Manufacture of motor vehicles, trailers and semi-trailers; 35 Manufacture of other transport equipment, excluding group 351 Building and repairing of ships and boats and excluding group 353 Manufacture of aircraft and spacecraft	NO DATA FROM OECD	V. nota b	OECD: 2008 (2008, 2007, 2006, 2005, 2004, 2003, 2002, 2001, 2000)
55 - KIS_PERC_SER	Knowledge intensive services (as % of total services)	Unit of measure used: Percentage of employment in services Key statistical concept: Employment in the following ISIC divisions: 61 Water transport, 62 Air transport, 64 Post and Telecommunications, 65 Financial intermediation, except insurance and pension funding, 66 Insurance and pension funding, except compulsory social	NO DATA FROM OECD	V. nota b	OECD: 2008 (2008, 2007, 2006, 2005, 2004, 2003, 2002, 2001, 2000)

		security, 67 Activities auxiliary to financial intermediation, 70 Real estate activities, 71 Renting of machinary and equipment without operator and of personal and household goods, 72 Computer and related activities, 73 Research and development, 74 Other business activities, 80 Education, 85 Health and social work and 92 Recreational, cultural and sporting activities.			
56 - PCT	PCT patent applications (fractional count; by inventor and priority year) - level	Unit of measure used: Count Key statistical concept: Patents are a key measure of innovation output, as patent indicators reflect the inventive performance of countries, regions, technologies, firms, etc. They are also used to track the level of diffusion of knowledge across technology areas, countries, sectors, firms, etc., and the level of internationalisation of innovative activities. Patent indicators can serve to measure the output of R and D, its productivity, structure and the development of a specific technology or industry. Among the few available indicators of technology output, patent indicators are probably the most frequently used. The relationship between patents as an intermediate output resulting from R and D inputs has been investigated extensively. Patents are often interpreted as an output indicator; however, they could also be viewed as an input indicator, as patents are used as a source of information by subsequent inventors. Like any other indicator, patent indicators have many advantages and disadvantages. The advantages of patent indicators are : patents have a close link to invention; patents cover a broad range of technologies on which there are sometimes few other sources of data; the contents of patent documents are a rich source of information (on the applicant, inventor, technology category, claims, etc.); and patent data are readily available from patent offices. However, patents are subject to certain drawbacks: the value distribution of patents is skewed as many patents have no industrial application (and hence are of little value to society) whereas a few are of substantial value; many inventions are not patented because they are not patentable or inventors may protect the inventions using other methods, such as secrecy, lead time, etc.; the propensity to patent differs across countries and industries; differences in patent regulations make it	NO DATA FROM OECD	V. nota b	OECD: 2007 (2007, 2006, 2005, 2004, 2003, 2002, 2001, 2000)

		difficult to compare counts across countries; and changes in patent law over the years make it difficult to analyse trends over time. For further details on the methodology applied to patent indicators, please consult the following documentation : Triadic patent families methodology, OECD Patent Manual (2009), Patents by regions.			
57 - PCT_COPAT	PCT co-patent applications (fractional count; by inventor and priority year) - level	Other data characteristics: PCT co-patent applications (fractional count; by inventor and priority year) Unit of measure used: Count Key statistical concept: Patents are a key measure of innovation output, as patent indicators reflect the inventive performance of countries, regions, technologies, firms, etc. They are also used to track the level of diffusion of knowledge across technology areas, countries, sectors, firms, etc., and the level of internationalisation of innovative activities. Patent indicators can serve to measure the output of R and D, its productivity, structure and the development of a specific technology or industry. Among the few available indicators of technology output, patent indicators are probably the most frequently used. The relationship between patents as an intermediate output resulting from R and D inputs has been investigated extensively. Patents are often interpreted as an output indicator; however, they could also be viewed as an input indicator, as patents are used as a source of information by subsequent inventors. Like any other indicator, patent indicators have many advantages and disadvantages. The advantages of patent indicators are : patents have a close link to invention; patents cover a broad range of technologies on which there are sometimes few other sources of data; the contents of patent documents are a rich source of information (on the applicant, inventor, technology category, claims, etc.); and patent data are readily available from patent offices. However, patents are subject to certain drawbacks: the value distribution of patents is skewed as many patents have no industrial application (and hence are of little value to society) whereas a few are of substantial value; many inventions are not patented because they are not patentable or inventors may protect the inventions using other methods, such as secrecy, lead time, etc.;	NO DATA FROM OECD	V. nota b	OECD: 2007 (2007, 2006, 2005, 2004, 2003, 2002, 2001, 2000)

		the propensity to patent differs across countries and industries; differences in patent regulations make it difficult to compare counts across countries; and changes in patent law over the years make it difficult to analyse trends over time. For further details on the methodology applied to patent indicators, please consult the following documentation : Triadic patent families methodology, OECD Patent Manual (2009), Patents by regions. Other Aspects Other comments Note that for patent data, missing values are zero values			
58 - PCT_MILLION	PCT patent applications per million inhabitants (fractional count; by inventor and priority year) - level	Other data characteristics: PCT patent applications per million inhabitants (fractional count; by inventor and priority year) Unit of measure used: Count (per million inhabitants) Key statistical concept: Patents are a key measure of innovation output, as patent indicators reflect the inventive performance of countries, regions, technologies, firms, etc. They are also used to track the level of diffusion of knowledge across technology areas, countries, sectors, firms, etc., and the level of internationalisation of innovative activities. Patent indicators can serve to measure the output of R and D, its productivity, structure and the development of a specific technology or industry. Among the few available indicators of technology output, patent indicators are probably the most frequently used. The relationship between patents as an intermediate output resulting from R and D inputs has been investigated extensively. Patents are often interpreted as an output indicator; however, they could also be viewed as an input indicator, as patents are used as a source of information by subsequent inventors. Like any other indicator, patent indicators have many advantages and disadvantages. The advantages of patent indicators are : patents have a close link to invention; patents cover a broad range of technologies on which there are sometimes few other sources of data; the contents of patent documents are a rich source of information (on the applicant, inventor, technology category, claims, etc.); and patent data are readily available from patent offices. However, patents are subject to certain drawbacks: the value distribution	NO DATA FROM OECD	V. nota b	OECD: 2007 (2007, 2006, 2005, 2004, 2003, 2002, 2001, 2000)

		of patents is skewed as many patents have no industrial application (and hence are of little value to society) whereas a few are of substantial value; many inventions are not patented because they are not patentable or inventors may protect the inventions using other methods, such as secrecy, lead time, etc.; the propensity to patent differs across countries and industries; differences in patent regulations make it difficult to compare counts across countries; and changes in patent law over the years make it difficult to analyse trends over time. For further details on the methodology applied to patent indicators, please consult the following documentation : Triadic patent families methodology, OECD Patent Manual (2009), Patents by regions. Other Aspects Other comments Note that for patent data, missing values are zero values			
59 - PCT_GREEN	PCT patent applications (fractional count; by inventor and priority year) in green technologies - level	Other data characteristics: PCT patent applications (fractional count; by inventor and priority year) in green technologies Unit of measure used: Count Key statistical concept: Patents are a key measure of innovation output, as patent indicators reflect the inventive performance of countries, regions, technologies, firms, etc. They are also used to track the level of diffusion of knowledge across technology areas, countries, sectors, firms, etc., and the level of internationalisation of innovative activities. Patent indicators can serve to measure the output of R and D, its productivity, structure and the development of a specific technology or industry. Among the few available indicators of technology output, patent indicators are probably the most frequently used. The relationship between patents as an intermediate output resulting from R and D inputs has been investigated extensively. Patents are often interpreted as an output indicator; however, they could also be viewed as an input indicator, as patents are used as a source of information by subsequent inventors. Like any other indicator, patent indicators have many advantages and disadvantages. The advantages of patent indicators are : patents have a close link to invention; patents cover a broad range of	NO DATA FROM OECD	V. nota b	OECD: 2007 (2007, 2006, 2005, 2004, 2003, 2002, 2001, 2000)

		technologies on which there are sometimes few other sources of data; the contents of patent documents are a rich source of information (on the applicant, inventor, technology category, claims, etc.); and patent data are readily available from patent offices. However, patents are subject to certain drawbacks: the value distribution of patents is skewed as many patents have no industrial application (and hence are of little value to society) whereas a few are of substantial value; many inventions are not patented because they are not patentable or inventors may protect the inventions using other methods, such as secrecy, lead time, etc.; the propensity to patent differs across countries and industries; differences in patent regulations make it difficult to compare counts across countries; and changes in patent law over the years make it difficult to analyse trends over time. For further details on the methodology applied to patent indicators, please consult the following documentation : Triadic patent families methodology, OECD Patent Manual (2009), Patents by regions. Other Aspects Other comments Note that for patent data, missing values are zero values			
60 - PCT_ICT	PCT patent applications (fractional count; by inventor and priority year) in ICT - level	Other data characteristics: PCT patent applications (fractional count; by inventor and priority year) in ICT Unit of measure used: Count Key statistical concept: Patents are a key measure of innovation output, as patent indicators reflect the inventive performance of countries, regions, technologies, firms, etc. They are also used to track the level of diffusion of knowledge across technology areas, countries, sectors, firms, etc., and the level of internationalisation of innovative activities. Patent indicators can serve to measure the output of R and D, its productivity, structure and the development of a specific technology or industry. Among the few available indicators of technology output, patent indicators are probably the most frequently used. The relationship between patents as an intermediate output resulting from R and D inputs has been investigated extensively. Patents are often interpreted as an output indicator; however, they could	NO DATA FROM OECD	V. nota b	OECD: 2007 (2007, 2006, 2005, 2004, 2003, 2002, 2001, 2000)

		also be viewed as an input indicator, as patents are used as a source of information by subsequent inventors. Like any other indicator, patent indicators have many advantages and disadvantages. The advantages of patent indicators are : patents have a close link to invention; patents cover a broad range of technologies on which there are sometimes few other sources of data; the contents of patent documents are a rich source of information (on the applicant, inventor, technology category, claims, etc.); and patent data are readily available from patent offices. However, patents are subject to certain drawbacks: the value distribution of patents is skewed as many patents have no industrial application (and hence are of little value to society) whereas a few are of substantial value; many inventions are not patented because they are not patentable or inventors may protect the inventions using other methods, such as secrecy, lead time, etc.; the propensity to patent differs across countries and industries; differences in patent regulations make it difficult to compare counts across countries; and changes in patent law over the years make it difficult to analyse trends over time. For further details on the methodology applied to patent indicators, please consult the following documentation : Triadic patent families methodology, OECD Patent Manual (2009), Patents by regions. Other Aspects Other comments Note that for patent data, missing values are zero values			
61 - PCT_BIOTECH	PCT patent applications (fractional count; by inventor and priority year) in biotech - level	Other data characteristics: PCT patent applications (fractional count; by inventor and priority year) in biotech Unit of measure used: Count Key statistical concept: Patents are a key measure of innovation output, as patent indicators reflect the inventive performance of countries, regions, technologies, firms, etc. They are also used to track the level of diffusion of knowledge across technology areas, countries, sectors, firms, etc., and the level of internationalisation of innovative activities. Patent indicators can serve to measure the output of R and D, its productivity, structure and the development of a specific technology or industry.	NO DATA FROM OECD	V. nota b	OECD: 2007 (2007, 2006, 2005, 2004, 2003, 2002, 2001, 2000)

		Among the few available indicators of technology output, patent indicators are probably the most frequently used. The relationship between patents as an intermediate output resulting from R and D inputs has been investigated extensively. Patents are often interpreted as an output indicator; however, they could also be viewed as an input indicator, as patents are used as a source of information by subsequent inventors. Like any other indicator, patent indicators have many advantages and disadvantages. The advantages of patent indicators are : patents have a close link to invention; patents cover a broad range of technologies on which there are sometimes few other sources of data; the contents of patent documents are a rich source of information (on the applicant, inventor, technology category, claims, etc.); and patent data are readily available from patent offices. However, patents are subject to certain drawbacks: the value distribution of patents is skewed as many patents have no industrial application (and hence are of little value to society) whereas a few are of substantial value; many inventions are not patented because they are not patentable or inventors may protect the inventions using other methods, such as secrecy, lead time, etc.; the propensity to patent differs across countries and industries; differences in patent regulations make it difficult to compare counts across countries; and changes in patent law over the years make it difficult to analyse trends over time. For further details on the methodology applied to patent indicators, please consult the following documentation : Triadic patent families methodology, OECD Patent Manual (2009), Patents by regions. Other Aspects Other comments Note that for patent data, missing values are zero values			
62 - PCT_NANOTECH	PCT patent applications (fractional count; by inventor and priority year) in nanotech - level	Other data characteristics: PCT patent applications (fractional count; by inventor and priority year) in nanotech Unit of measure used: Count Key statistical concept: Patents are a key measure of innovation output, as patent indicators reflect the inventive performance of countries, regions, technologies, firms, etc. They are	NO DATA FROM OECD	V. nota b	OECD: 2007 (2007, 2006, 2005, 2004, 2003, 2002, 2001, 2000)

		also used to track the level of diffusion of knowledge across technology areas, countries, sectors, firms, etc., and the level of internationalisation of innovative activities. Patent indicators can serve to measure the output of R and D, its productivity, structure and the development of a specific technology or industry. Among the few available indicators of technology output, patent indicators are probably the most frequently used. The relationship between patents as an intermediate output resulting from R and D inputs has been investigated extensively. Patents are often interpreted as an output indicator; however, they could also be viewed as an input indicator, as patents are used as a source of information by subsequent inventors. Like any other indicator, patent indicators have many advantages and disadvantages. The advantages of patent indicators are : patents have a close link to invention; patents cover a broad range of technologies on which there are sometimes few other sources of data; the contents of patent documents are a rich source of information (on the applicant, inventor, technology category, claims, etc.); and patent data are readily available from patent offices. However, patents are subject to certain drawbacks: the value distribution of patents is skewed as many patents have no industrial application (and hence are of little value to society) whereas a few are of substantial value; many inventions are not patented because they are not patentable or inventors may protect the inventions using other methods, such as secrecy, lead time, etc.; the propensity to patent differs across countries and industries; differences in patent regulations make it difficult to compare counts across countries; and changes in patent law over the years make it difficult to analyse trends over time. For further details on the methodology applied to patent indicators, please consult the following documentation : Triadic patent families methodology, OECD Patent Manual (2009), Patents by regions. Other Aspects Other comments Note that for patent data, missing values are zero values			
63 - PCT_WREGION_PER	Percent of PCT co-patent applications	Other data characteristics: Percentage of PCT co-patent applications (fractional count; by inventor and priority year) that are done	NO DATA FROM OECD	V. nota b	OECD: 2007 (2007, 2006, 2005, 2004, 2003, 2002, 2001, 2000)

	(fractional count; by inventor and priority year) that are done within the region	within the region Unit of measure used: Percentage Key statistical concept: Patents are a key measure of innovation output, as patent indicators reflect the inventive performance of countries, regions, technologies, firms, etc. They are also used to track the level of diffusion of knowledge across technology areas, countries, sectors, firms, etc., and the level of internationalisation of innovative activities. Patent indicators can serve to measure the output of R and D, its productivity, structure and the development of a specific technology or industry. Among the few available indicators of technology output, patent indicators are probably the most frequently used. The relationship between patents as an intermediate output resulting from R and D inputs has been investigated extensively. Patents are often interpreted as an output indicator; however, they could also be viewed as an input indicator, as patents are used as a source of information by subsequent inventors. Like any other indicator, patent indicators have many advantages and disadvantages. The advantages of patent indicators are : patents have a close link to invention; patents cover a broad range of technologies on which there are sometimes few other sources of data; the contents of patent documents are a rich source of information (on the applicant, inventor, technology category, claims, etc.); and patent data are readily available from patent offices. However, patents are subject to certain drawbacks: the value distribution of patents is skewed as many patents have no industrial application (and hence are of little value to society) whereas a few are of substantial value; many inventions are not patented because they are not patentable or inventors may protect the inventions using other methods, such as secrecy, lead time, etc.; the propensity to patent differs across countries and industries; differences in patent regulations make it difficult to compare counts across countries; and changes in patent law over the years make it difficult to analyse trends over time. For further details on the methodology applied to patent indicators, please consult the following documentation : Triadic patent families methodology, OECD Patent Manual (2009), Patents by regions.			

		Other Aspects Other comments Note that for patent data, missing values are zero values			
64 - PCT_WCOUNTRY_PER	Percent of PCT co-patent applications (fractional count; by inventor and priority year) that are done within the country	Other data characteristics: Percentage of PCT co-patent applications (fractional count; by inventor and priority year) that are done within the country Unit of measure used: Percentage Key statistical concept: Patents are a key measure of innovation output, as patent indicators reflect the inventive performance of countries, regions, technologies, firms, etc. They are also used to track the level of diffusion of knowledge across technology areas, countries, sectors, firms, etc., and the level of internationalisation of innovative activities. Patent indicators can serve to measure the output of R and D, its productivity, structure and the development of a specific technology or industry. Among the few available indicators of technology output, patent indicators are probably the most frequently used. The relationship between patents as an intermediate output resulting from R and D inputs has been investigated extensively. Patents are often interpreted as an output indicator; however, they could also be viewed as an input indicator, as patents are used as a source of information by subsequent inventors. Like any other indicator, patent indicators have many advantages and disadvantages. The advantages of patent indicators are : patents have a close link to invention; patents cover a broad range of technologies on which there are sometimes few other sources of data; the contents of patent documents are a rich source of information (on the applicant, inventor, technology category, claims, etc.); and patent data are readily available from patent offices. However, patents are subject to certain drawbacks: the value distribution of patents is skewed as many patents have no industrial application (and hence are of little value to society) whereas a few are of substantial value; many inventions are not patented because they are not patentable or inventors may protect the inventions using other methods, such as secrecy, lead time, etc.; the propensity to patent differs across countries and industries; differences in patent regulations make it	NO DATA FROM OECD	V. nota b	OECD: 2007 (2007, 2006, 2005, 2004, 2003, 2002, 2001, 2000)

		difficult to compare counts across countries; and changes in patent law over the years make it difficult to analyse trends over time. For further details on the methodology applied to patent indicators, please consult the following documentation : Triadic patent families methodology, OECD Patent Manual (2009), Patents by regions. Other Aspects Other comments Note that for patent data, missing values are zero values			
65 - PCT_FREGION_PER	Percent of PCT co-patent applications (fractional count; by inventor and priority year) that are done with foreign regions	Other data characteristics: Percentage of PCT co-patent applications (fractional count; by inventor and priority year) that are done with foreign regions Unit of measure used: Percentage Key statistical concept: Patents are a key measure of innovation output, as patent indicators reflect the inventive performance of countries, regions, technologies, firms, etc. They are also used to track the level of diffusion of knowledge across technology areas, countries, sectors, firms, etc., and the level of internationalisation of innovative activities. Patent indicators can serve to measure the output of R and D, its productivity, structure and the development of a specific technology or industry. Among the few available indicators of technology output, patent indicators are probably the most frequently used. The relationship between patents as an intermediate output resulting from R and D inputs has been investigated extensively. Patents are often interpreted as an output indicator; however, they could also be viewed as an input indicator, as patents are used as a source of information by subsequent inventors. Like any other indicator, patent indicators have many advantages and disadvantages. The advantages of patent indicators are : patents have a close link to invention; patents cover a broad range of technologies on which there are sometimes few other sources of data; the contents of patent documents are a rich source of information (on the applicant, inventor, technology category, claims, etc.); and patent data are readily available from patent offices. However, patents are subject to certain drawbacks: the value distribution of patents is skewed as many patents have no	NO DATA FROM OECD	V. nota b	OECD: 2007 (2007, 2006, 2005, 2004, 2003, 2002, 2001, 2000)

		industrial application (and hence are of little value to society) whereas a few are of substantial value; many inventions are not patented because they are not patentable or inventors may protect the inventions using other methods, such as secrecy, lead time, etc.; the propensity to patent differs across countries and industries; differences in patent regulations make it difficult to compare counts across countries; and changes in patent law over the years make it difficult to analyse trends over time. For further details on the methodology applied to patent indicators, please consult the following documentation : Triadic patent families methodology, OECD Patent Manual (2009), Patents by regions. Other Aspects Other comments Note that for patent data, missing values are zero values			
66 - PCT_DOM_OWN	Domestic ownership of foreign patents = percent of PCT patents that have 1 or more foreign inventors and 1 or more domestic applicants in the total number of patents owned domestically (i.e. with 1 or more domestic applicants)	Other data characteristics: Domestic ownership of foreign patents = percentage of PCT patents that have 1 + foreign inventor(s) and 1 + domestic applicant in total # of patents owned domestically (i.e. with 1 + domestic applicant) Unit of measure used: Percentage Key statistical concept: Patents are a key measure of innovation output, as patent indicators reflect the inventive performance of countries, regions, technologies, firms, etc. They are also used to track the level of diffusion of knowledge across technology areas, countries, sectors, firms, etc., and the level of internationalisation of innovative activities. Patent indicators can serve to measure the output of R and D, its productivity, structure and the development of a specific technology or industry. Among the few available indicators of technology output, patent indicators are probably the most frequently used. The relationship between patents as an intermediate output resulting from R and D inputs has been investigated extensively. Patents are often interpreted as an output indicator; however, they could also be viewed as an input indicator, as patents are used as a source of information by subsequent inventors. Like any other indicator, patent indicators have many advantages and disadvantages. The advantages of patent indicators are : patents have a	NO DATA FROM OECD	V. nota b	OECD: 2007 (2007, 2006, 2005, 2004, 2003, 2002, 2001, 2000)

		close link to invention; patents cover a broad range of technologies on which there are sometimes few other sources of data; the contents of patent documents are a rich source of information (on the applicant, inventor, technology category, claims, etc.); and patent data are readily available from patent offices. However, patents are subject to certain drawbacks: the value distribution of patents is skewed as many patents have no industrial application (and hence are of little value to society) whereas a few are of substantial value; many inventions are not patented because they are not patentable or inventors may protect the inventions using other methods, such as secrecy, lead time, etc.; the propensity to patent differs across countries and industries; differences in patent regulations make it difficult to compare counts across countries; and changes in patent law over the years make it difficult to analyse trends over time. For further details on the methodology applied to patent indicators, please consult the following documentation : Triadic patent families methodology, OECD Patent Manual (2009), Patents by regions. Other Aspects Other comments Note that for patent data, missing values are zero values			
67 - PCT_FOR_OWN	Foreign ownership of domestic patents = percent of PCT patents that have 1 or more domestic inventors and 1 or more foreign applicants in the total number of patents invented domestically (i.e. with 1 or more domestic inventors)	Other data characteristics: Foreign ownership of domestic patents = percentage of PCT patents that have 1 + domestic inventor(s) and 1 + foreign applicant(s) in total # of patents owned by foreigners (i.e. with 1 + foreign applicant) Unit of measure used: Percentage Key statistical concept: Patents are a key measure of innovation output, as patent indicators reflect the inventive performance of countries, regions, technologies, firms, etc. They are also used to track the level of diffusion of knowledge across technology areas, countries, sectors, firms, etc., and the level of internationalisation of innovative activities. Patent indicators can serve to measure the output of R and D, its productivity, structure and the development of a specific technology or industry. Among the few available indicators of technology output, patent indicators are probably the most frequently used. The relationship between patents as	NO DATA FROM OECD	V. nota b	OECD: 2007 (2007, 2006, 2005, 2004, 2003, 2002, 2001, 2000)

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68 - BB_ACC	Percentage of households with access to broadband	Unit of measure used: Percentage of total households Key statistical concept: Households with broadband access at home. The definition of broadband varies across countries. For the ABS (Australia) is defined as an 'always on' Internet connection with an access speed equal to or greater than 256 Kilobits per second (Kbps). Source (http://abs.gov.au/AUSSTATS/abs@.nsf/DetailsPage/8146.02008-09?OpenDocument, ABS: TABLE 8146.0 - Household Use of Information Technology, Australia). For Statistics New Zealand broadband is a	NO DATA FROM OECD	V. nota b	OECD: 2009 (2009, 2008, 2007, 2006)

		high-speed connection to the Internet and is also referred to as non-analogue. For the purposes of the Household use of ICT questionnaires, broadband was self-identified by the respondent, and then the way the broadband was provided was asked, for example, via a satellite dish. Source (Source: The Household Use of Information and Communication Technology (ICT) Survey, http://www.stats.govt.nz/browse_for_stats/people_and_communities/households/householduseofict_hotp2009.aspx). For Eurostat broadband lines are defined as those with a capacity equal or higher than 144 Kbits/s. Various technologies are covered; ADSL, cable modem as well as other types of access lines. For the US Census Bureau (Current Population Survey) broadband is a DSL, cable modem, satellite, wireless (such as Wi-Fi), mobile phone or PDA, fiber optics.			

Normalized data

	Enablers factors												
	Human resources									Finance for innovation			Institutional support
Regions	Students of sec. sup. school and post sec. (not univer)	University students	PhD students	Population aged 20-24 with superior school diploma	Population with tertiary education per 100 population aged 25-64	Population aged 30-34 with university title	S&E (science and engineering) graduates aged 20-29	Participation in life-long learning per 100 population aged 25-64	R&D personnel	Inv. VC inv. in early-stage	VC investments in expansion/replacement	Number of venture capital investments	Public R&D expenditures (% of GDP)
Piemonte	0,578	0,441	0,436	0,327	0,354	0,393	0,748	0,135	0,848	0,114	0,055	0,175	0,254
V. d'Aosta	0,000	0,000	0,000	0,095	0,000	0,162	0,028	0,108	0,276	0,000	0,000	0,000	0,000
Lombardia	0,172	0,505	0,460	0,290	0,573	0,690	0,724	0,324	0,695	0,380	0,412	1,000	0,167
Liguria	0,609	0,519	0,662	0,852	0,963	0,850	0,710	0,757	0,714	0,099	0,000	0,018	0,489
Trent.-AA.	0,523	0,254	0,433	0,269	0,311	0,402	0,328	1,000	0,686	0,736	0,798	0,140	0,370
Veneto	0,781	0,347	0,442	0,534	0,280	0,341	0,512	0,405	0,667	0,002	1,000	0,140	0,239
Friuli-VG	0,797	0,703	0,867	0,615	0,256	0,431	0,796	0,676	0,800	0,483	0,147	0,421	0,503
Emilia-R.	0,703	0,807	0,627	0,678	0,683	0,764	0,951	0,649	0,800	0,099	0,130	0,193	0,377
Toscana	0,469	0,823	1,000	0,446	0,488	0,558	0,870	0,595	0,581	0,160	0,055	0,211	0,559
Umbria	0,359	0,871	0,622	1,000	0,622	0,755	0,526	0,730	0,371	0,990	0,137	0,351	0,624
Marche	0,641	0,654	0,583	0,639	0,537	0,541	0,697	0,000	0,352	0,134	0,000	0,088	0,244
Lazio	0,563	1,000	0,794	0,761	1,000	1,000	1,000	0,757	1,000	1,000	0,059	0,351	1,000
Abruzzo	0,469	0,917	0,509	0,622	0,659	0,692	0,406	0,270	0,305	0,000	0,067	0,000	0,428
Molise	0,547	0,586	0,198	0,531	0,463	0,679	0,000	0,649	0,124	0,000	0,007	0,000	0,295
Campania	0,266	0,469	0,381	0,187	0,207	0,000	0,493	0,108	0,467	0,000	0,045	0,000	0,617
Puglia	0,547	0,350	0,305	0,120	0,049	0,071	0,291	0,135	0,210	0,138	0,013	0,035	0,403
Basilicata	1,000	0,184	0,248	0,847	0,195	0,657	0,165	0,432	0,190	0,000	0,058	0,000	0,355
Calabria	0,172	0,313	0,281	0,514	0,390	0,665	0,421	0,432	0,000	0,206	0,000	0,035	0,270
Sicilia	0,313	0,412	0,502	0,000	0,207	0,060	0,288	0,081	0,219	0,291	0,000	0,035	0,475
Sardegna	0,391	0,416	0,367	0,089	0,110	0,204	0,355	0,514	0,162	0,418	0,035	0,035	0,452

	Firms activities				
	Network connections	**Innovative entrepreneurship**		**Exploitation of the research**	**Firms investments**
Regions	Innovative SMEs co-operating with others - % of all SMEs	Broadband access by firms	SMEs innovating in-house - % of all SMEs	EPO patents per million population	Business R&D expenditures - % of GDP
Piemonte	0,589	0,872	0,987	0,690	1,000
V. d'Aosta	0,444	0,996	0,739	0,452	0,331
Lombardia	0,558	0,848	1,000	0,891	0,619
Liguria	0,254	1,000	0,000	0,436	0,506
Trentino-A.A.	0,739	0,620	0,816	0,748	0,524
Veneto	0,574	0,677	0,986	0,766	0,484
Friuli-V.G.	0,590	0,884	0,928	1,000	0,587
Emilia-R.	0,689	0,807	0,948	0,990	0,626
Toscana	0,166	0,720	0,350	0,410	0,362
Umbria	0,701	0,797	0,687	0,147	0,142
Marche	0,720	0,564	0,587	0,511	0,209
Lazio	1,000	0,829	0,638	0,095	0,445
Abruzzo	0,000	0,639	0,150	0,176	0,271
Molise	0,585	0,000	0,055	0,010	0,025
Campania	0,068	0,610	0,115	0,059	0,344
Puglia	0,240	0,502	0,871	0,060	0,119
Basilicata	0,646	0,538	0,407	0,022	0,091
Calabria	0,226	0,472	0,037	0,000	0,000
Sicilia	0,592	0,570	0,219	0,034	0,142
Sardegna	0,232	0,512	0,554	0,053	0,020

	Results					
	Innovating firms				**Economical effects**	**New ideas development**
Regions	Technological (product or process) innovators - % of all SMEs	Non-technological (marketing or organisational) innovators -(% of all SMEs	Reduced labour costs resulting from process innovations - % of SMEs	Reduced use materials and energy resulting from process innovations - % of SME	Employment in medium-high & hightech manufacturing	Rate of birth of firms
Piemonte	0,948	0,725	0,912	0,458	1,000	0,452
V. d'Aosta	0,615	0,537	0,965	0,000	0,000	0,270
Lombardia	1,000	0,918	0,794	0,604	0,876	0,372
Liguria	0,183	0,315	0,280	0,037	0,362	0,503
Trentino-A.A.	0,938	0,969	0,961	1,000	0,286	0,000
Veneto	0,932	0,996	0,783	0,616	0,799	0,127
Friuli-V.G.	0,909	0,714	0,677	0,426	0,762	0,151
Emilia-R.	0,906	1,000	0,905	0,445	0,899	0,181
Toscana	0,341	0,447	0,332	0,256	0,413	0,385
Umbria	0,604	0,951	0,331	0,036	0,423	0,402
Marche	0,557	0,655	0,766	0,505	0,735	0,194
Lazio	0,747	0,945	0,867	0,566	0,312	1,000
Abruzzo	0,244	0,343	0,739	0,449	0,634	0,641
Molise	0,000	0,000	0,676	0,747	0,487	0,446
Campania	0,196	0,854	0,600	0,181	0,432	0,741
Puglia	0,830	0,789	1,000	0,794	0,240	0,575
Basilicata	0,534	0,320	0,964	0,420	0,539	0,270
Calabria	0,008	0,274	0,000	0,286	0,086	0,612
Sicilia	0,325	0,223	0,377	0,225	0,140	0,728
Sardegna	0,612	0,330	0,803	0,287	0,080	0,438

Part II - System of regional innovation from the viewpoint of self-sustainability

Chapter 4

Regional Innovation System and complexity

4.1 Complexity and Complex Adaptive Systems

Studies on complexity have involved researchers in several disciplines and with different aims.

As Langton (1992) argued, one of the fundamental aspects in the explanation of the life dynamics is the distinction between linear systems and not linear ones. In first ones, that are complicated systems, the system behavior is the sum of the parts behaviour. So - through the study of the parts behaviour - the behaviour of the whole system can be derived. Not linear systems, that are complex systems, do not respect the above idea: for not linear systems it isn't possible to transfer the understanding of the parts in the understanding of the whole system.

Complex systems are not linear systems because the interactions - among the parts - produce an emerging result which is different from the simple sum.

The starting conditions of a complex system is very significant for its evolution: small changes of the starting conditions can determine different results on the whole behavior, through not simple routes of propagation.

According to the characteristic of not linearity, the methodology for studying the complex systems must be different with respect to the analytic tradition: indeed, instead of starting from the analysis of the whole systems, it is necessary to begin from the study of single parts with the aim to find the whole behaviour (Langton, 1992).

Complex Adaptive Systems (CAS) represent one of the most recent frontiers within studies of systemic organizations. These systems are adaptive because of their capability to adapt itself (and, therefore, to transform itself) - with respect to internal or external changes - through a learning logic in their reorganization; in other words, a CAS is a set of connected or interdependent different agents with the capacity to alter or change learning from experience. In a CAS an agent may be a person, a species or an organization, among many others. These agents act by basing on their own schema and on surrounding knowledge and conditions.

CASs share some features. They are dynamic, non-linear systems, emergent, self-organizing and resilient:

- Dynamicity: CASs are characterized by their dynamic state originated by the connections among the agents and their fluctuations.
- Non-linearity: Change can be nonlinear and discontinuous. Small changes in variables can have small impacts at some times, and large impacts under other conditions. Conversely, the effects of large changes in variables can vary from negligible to large.
- Emergency: Feedback loops among agents can generate change or stability in the system. Two systems that initially are quite similar may develop significant differences over time. Because the context for each CAS is unique, and each CAS is context-dependent, each CAS is unique.
- Self-organization. Individual agents accommodate their behaviors with those of agents with whom they interact. Networks with complex chains of interaction allow large systems to develop a self-order; so, self-organization is the development of a self-order from caos through indirect coordination (stigmercy) among agents. Stigmercy depends on indirect signals developed by agents during their behaviour; a typical example of stigmercy is the behaviour of an ant colony: ants leave pheromone trails to home and to food; so, ants cooperate using an indirect form of communication and the whole colony build the best way to connect their home to food.
- Resilience. CASs exhibit the ability to alter themselves in response to feedback. They possess a range of coupling patterns helping organizations to survive over a

variety of environmental conditions. In other words, resilience is linked to capability of self-organization after a critical shock.

4.2 Complexity, economy and local development

According to Arthur *et al.* (1997), an economical system has to be considered as a CAS: indeed, these scholars argued that <<to describe the complexity approach, we begin by pointing out six features of an economy that together present difficulties for the traditional mathematics used in economics:

- Dispersed Interaction. What happens in the economy is determined by the interaction of many dispersed, possibly heterogeneous, agents acting in parallel. The action of any given agent depends upon the anticipated actions of to limited number of other agents and on the joined separate these agents co- created.
- No Global Controller. No global entity controls interactions. Instead, controls are provided by mechanisms of competition and coordination between agents. Economies actions are mediated by legal institutions, assigned roles, and shifting associations. Nor is there to universal competitor - to single agent that can exploit all opportunities in the economy.
- Cross-cutting Hierarchical Organization. The economy has many levels of organization and interaction. Units at any given level - behaviors, actions, strategies, products - typically serves as " building blocks" for constructing units at the next higher level. The overall organization is delays than hierarchical, with many sorts of tangling interactions (associations, channels of communication)

across levels

- Continual Adaptation. Behaviors, actions, strategies, and products are revised continually as the individualizes! agents accumulated experience - the system constantly adapts.
- Perpetual Novelty. Niches are continually created by new markets, new technologies, new behaviors, new institutions. The very act of filling to niche may provide new niches. The result is ongoing, perpetual novelty .
- Out-of-Equilibrium Dynamics. Because new niches, new potentials, new possibilities, are continually created, the economy operates to make from any optimum or global equilibrium. hnprovements are always possible and indeed occour regulary>>.

According to this framework, local development can't be analyzed through quantitative variables, but in more complex terms that involve economical and social processes.Therefore, economy and local development have to be studied within the complexity perspective.

4.3 Regional Innovation System as complex learning system

4.3.1 Development of the RIS conceptualization

Literature has highlighted that the interactions among researchers, innovators, producers, intermediaries of knowledge and other societal actors - in few words innovation actors - are able to produce systemic innovation (Cooke, 2001) and have positive influences for the economic development of related community (Woolcock, 1998).

The OECD "National Innovation Systems" book (1997) highlights that - since the 90's - literature showed the significance of the interactions among the people and institutions involved in innovation; so, the concept of innovation system has emerged among the others perspectives on territorial systemic innovation.
The innovation system approach helps to understand dynamics of innovation in a given system, and to identify the diversity of determinants of systemic innovation, thus offering a relevant framework for designing policies (OECD, 2011).

In the literature there are five conceptualizations of the innovation systems approach: Sectorial Innovation Systems (SIS), Technological Systems (TS), National Innovation Systems (NIS), Regional Innovation Systems (RIS) and global innovation system (fig. 4.1).

Breschi and Malerba (1987) define SIS as "the specific clusters of the firms, technologies, and industries involved in the generation and diffusion of new technologies and in the knowledge flows that take place amongst them". Carlsson and Stankiewicz (1991) define TSs as "networks of agents interacting in a specific technology area under a particular institutional infrastructure for the purpose of creating, diffusing and utilizing technology"; both SIS and TS stress the economic dynamics of technology development and the importance of technology flows. Freeman (1987) defines NIS as "the network of institutions in the public and private sectors whose activities and interactions imitate, import, modify and diffuse new technologies"; he suggests that nations differ not only in the quantity of innovations introduced but also in the methods by which these innovations are adopted and in their sectoral composition.

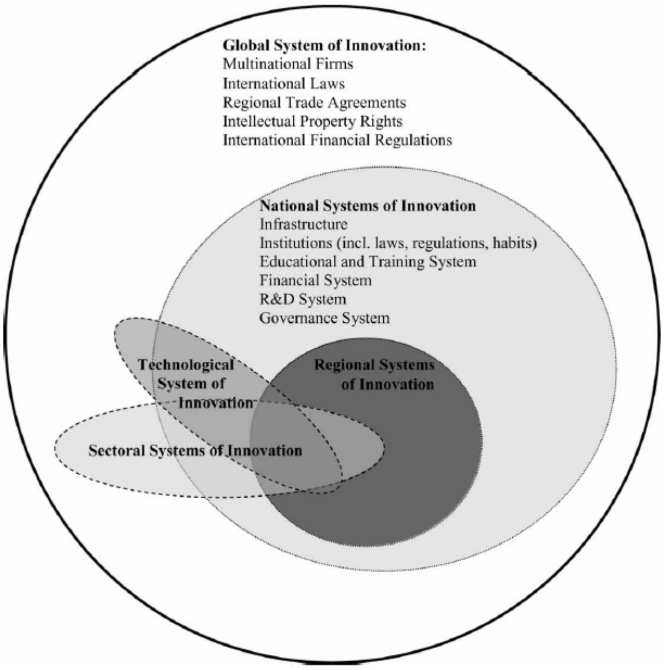


Fig. 4.1: Relationship among different systems of innovation. Source: Frenz M. and Oughton C., 2005

In recent years, literature has highlighted the critical role played by geographical proximity (Kirat, T. and Lung, Y., 1999; The IRE Working Group, 2008) and local institutional conditions (Trippl, M., 2006; The IRE Working Group, 2008) for the interactions among innovation actors and for the circulation of existing knowledge or the production of new knowledge and its economic exploitation. So, Regional Innovation System concept is emerged.

In particular, as highlighted in 1.3 section, it has been shown that regions are the most correct level for the definition of effective policies which are able to improve the interactions between innovation actors and, as consequence, which are able to get better the innovation capability of the related innovation system.

By now, due to the territorial dimension of innovation processes, to the importance of local institutional conditions and – still - to the systemic character of the cooperation and the mutual learning among innovation actors, Regional Innovation System is considered the most adequate framework to define the best policies which can improve the innovative capability of a territory.

4.3.2 Points of view on RIS

The RIS framework defines innovation as a cumulative and not-linear systemic process (Fischer, 2001). It results from the formal and informal, voluntary and involuntary interactions among different actors operating in the innovation system.

In an attempt to explore theoretically the organizational and institutional keys of the territorial systemic innovation, Cooke et al. (1997) proposed the concept of Regional Innovation System by taking into account the systemic character of innovation - from innovation systems approach - and the literature evidences of the sub-national dimension of innovation; within this framework, the above authors looked at RIS as a regional learning system that has moved itself from the learning attitude to adapt innovations, originating from elsewhere, to a "tutoring" disposition where there is the capability to innovate *de novo*. So, taking into account this rationale, these authors defined a RIS as a <<collective order based on microconstitutional regulation conditioned by trust, reliability, exchange and cooperative interaction>> (P. Cooke et al., 1997).

Similarly, for De Laurentis (2005) RIS is <<a set of institutions, both public and private, which produces pervasive and systemic effects that encourage firms within the region to adopt common norms, expectations, values, attitudes and practices, where a culture of innovation is enforced and a learning process is enhanced>>; accordingly, regional innovation is a learning process that benefits from the proximity of critical actors that can trigger this process.

By highlighting a different point of view, M. Fritsch (2003) looked at RIS as a system that exploit the advantage of the division of innovative labor among agents of innovation (within the system and also between "internal" innovation actors and the outer world); in the Fritsch M. (2003) idea, the interactions on innovation result in efficiency gains because they correspond to the basic hypothesis, in economic science, of gains linked to division of labor.

Again, but with a different point of view, Andersson M. and Karlsson C. (2006) referred to Regional Innovation Systems - where regional is associated to the concept of functional region (read 1.3 section) - as systems that are based on clusters of firms which are surrounded by supporting as well as complementary firms; firms are immersed in an atmosphere of resources that facilitate co-operation, knowledge transfer and knowledge spillover. Within their framework, Andersson M. and Karlsson C. (2006) emphasize the key role of firms clusters in the regional innovation systems, meaning for cluster <<a number of firms (within the same industry) that share the same location in space>>; in their opinion, indeed, clusters facilitate both knowledge transfer and knowledge spillovers as effect of the geographical and relational proximity of the firms; as Andersson M. and Karlsson C. (2006) looked at clusters like the contexts in whom the localized learning processes take place, they believed that clusters should be the core of a suitable regional industrial structure of RISs; at the same time, the above authors highlighted that clusters of firms are a necessary, but not sufficient, condition for the development of RISs because they stated that RISs have properties, not shared by clusters in general, as well as facilitating resources for cooperation, mutual trust and exchange of knowledge.

A further point of view on RISs rationale has been highlighted by F. Todtling and M. Trippl (2005); these authors, indeed, looked at RISs as key subsystems ("knowledge application and exploitation subsystem", "knowledge generation and diffusion susbsystem" and "policy subsystem"), characterized by intensive interactive relationships (within - and between - these subsystems) and linked by exchanges with extra-regional actors, that are embedded in a common regional socioeconomic and cultural setting.

By trying to summarize the several RIS definitions, the IRE Working Group defined RIS as a whole of economical, political and institutional relationship in a given geographical area which generates a collective learning process that gives rise to a rapid production, dissemination and use of knowledge (The IRE working group, 2008).

Obviousely, different RIS definitions are the synthesis of different points of view on RIS conceptualizations; indeed, at date, literature shows several conceptual frameworks on the RIS perspective (Asheim, Isaksen, 2002; Doloreux, 2002). In the following, we outline different points of view of someone of the most cited authors on this topic; so, we analyze difference on RIS's key success points, critical relationship, critical actors and conceptual models.

RIS Key success points: there are several ideas on key success points of the RIS perspective; in order to go deeper about this topic, first of all we need of a deepening on the significance of a loose coupling - among finance, learning and productive culture subsystems - that has been underlined in the pioneering work of P. Cooke *et al*. (1997); these authors stated - on the financial subsystem - the significance of government's budgetary availability for improving the region's capacity to mobilize its innovator agents; moreover, P. Cooke et al. (1997) asserted that financing of telecommunication and communication infrastructures is a very important task for promoting the multiple relations among the several innovation agents of the regional economy. Still, while the above authors emphasized the significance of firm's financing for innovation projects, they highlighted the presence of a certain degree of uncertainty, between potential lenders and borrowers, due to the lender's lack of information on innovation project. About the learning subsystem, P. Cooke et al. (1997) asserted the closed link between innovation and learning because <<there can be no change without previous learning>>; on this point, the authors stated that the most important requisite is cooperation among critical actors of innovation, that is among firms operating in formal or informal networks with other firms in their sector as customers, suppliers or partners, knowledge-centres such as universities and research institutes, contract research organizations and technology-transfer agencies, private business associations, chambers of commerce and public economic development, training and promotion agencies and, finally, government departments. Furthermore, P. Cooke et al. (1997) argued that regional learning systems are present in regions where all the critical actors of innovation are associative, <<meaning there is systemic, i.e., regular, two-way, interchange on matters of importance to innovation and the competitiveness of firms>>. Still, the above authors asserted that it may be spoken of a regional innovation system, instead of a regional learning system, if there is also the financial infrastructure for helping firms to invest the necessary qualities of capital to generate endogenous innovation.

About the productive culture subsystem, the work of P. Cooke et al. (1997) asserted that <<without embeddedness, there is no milieu (Maillat, 1998) within which the associational networks so crucial to interactive innovation can become institutionalized>>; in other words, P. Cooke et al. (1997) argued that - as training system's capacity and workforce's motivation to carry out reconversion are critical factors for adaptation to innovation (Sweeney, 1995) - productive cultural aspects are closely linked to systemic innovation. For productive cultural aspects they referred to culture of cooperation, associative culture, learning culture, experience and ability to carry out or incorporate, institutional changes, coordination and public/private consensus, productive culture, labor relations, cooperation at work, company commitments to social well being, productive specialization, existing interface mechanisms in the scientific - technological - productive - financial field, different types of learning capacity, social valorization of the use of science, university linked to the productive system, non-bureaucratized educational and training system linked to the productive system.

Partially according to key points of P. Cooke et al (1997), Fritsch M., (2003) argued that successful regional innovation systems need of a productive innovation culture. Similarly, Andersson M. and Karlsson C. (2006) stated the significance of an interactive learning process involving all the agents of innovation.

By highlighting a different viewpoint, F. Todtling and M. Trippl (2005) suggested – as key success point – the embeddedness of the key subsystems ("knowledge application and exploitation subsystem", "knowledge generation and diffusion susbsystem" and "policy subsystem") in a common regional socioeconomic and cultural setting.

By pointing the attention on several original outlooks, De Laurentis (2005) suggested the need of a local innovation culture and a rich innovation infrastructure <<ranging from specialist research institutes, to universities, colleges, and technology transfer agencies>>; furthermore, De Laurentis (2005) argued the significance of systemic linkages between firms and external sources as well as internal ones of knowledge, such as universities, research institutions and other intermediary organizations and institutions; as consequence, this scholar highlighted the important role played by regional government because it offers services and other mechanisms aimed at promoting inter-linkages among all the critical actors. Still, De Laurentis (2005) emphasized the key role played by mobility of skilled workers between firms and academic institutions; indeed, as skilled workers can be considered repository of skills and knowledge, this author argued that the mobility within different type of institutions allows flows and local diffusion of knowledge. <<As workers that embody relevant knowledge move locally, they help diffusing this knowledge through a certain region and industry>> (De Laurentis, 2005); more in depth on this point, De Laurentis (2005) highlighted the key role played by universities as <<key actors in this process of mobility and transfer, moving from a strict role of providers of skills>>. Finally, as labour mobility indirectly promotes the creation of bonds and links between firms and other institutions, De Laurentis (2005) also emphasized that labour mobility <<nurtures networking propensity>>.

RIS Critical relationship: Literature highlighted a general common view on critical relationship of RIS perspective. First of all on this topic, we underline that the seminal paper of P. Cooke et al. (1997) pointed the attention to trust, reliability, exchange and cooperative interaction as critical relationships. Similarly, M. Fritsch (2003) highlighted the significance of cooperative spirit and trust; again, M. Andersson. & C. Karlsson (2006) emphasized the significance of exchange of knowledge, mutual trust and cooperation; still, F. Todtling and M. Trippl (2005) sustained exchange of knowledge, resources and human capital as critical relationships of RIS perspective.

RIS ***Critical actors and conceptual models***: literature has also showed several viewpoints on critical actors and on RISs conceptual models.

According to Fritsch's conceptual model (fig. 4.2), RISs are characterized from the following actors: a) Public institutions for research, education and other forms of knowledge transfer - such as universities, public research institutions and transfer agencies - with the role to generate, accumulate and distribute information; b) manufacturing establishments with the role to commercialize the available knowledge; c) suppliers of business-oriented services - such as technical consulting services, business consulting services, financial services etc. - with the role to support innovation activities, in public research institutions and manufacturing establishments; d) the regional workforce with the role to supply its qualification and knowledge.

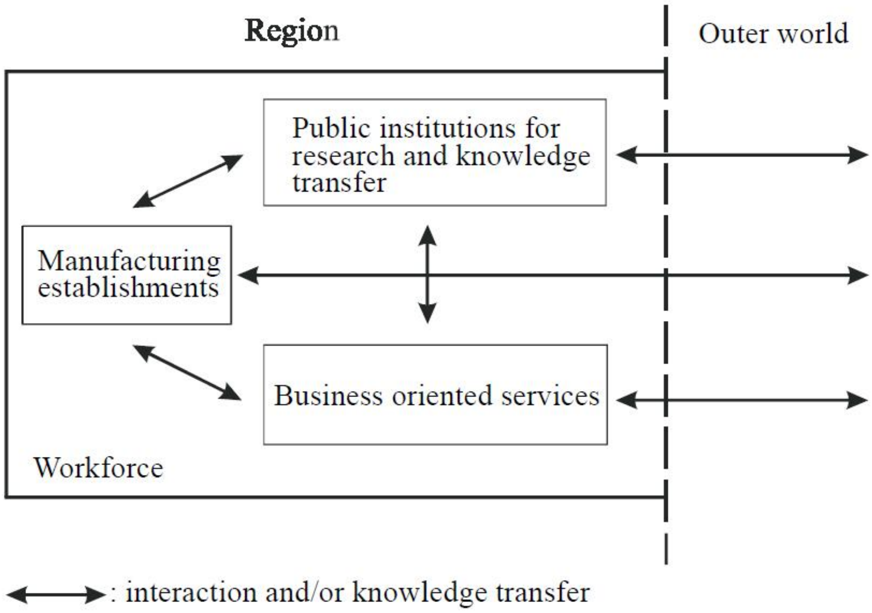


Fig.4.2 – M. Fritsch (2003) conceptual model

A different viewpoint has been proposed by Andersson M. and Karlsson C. (2006); indeed, in their RIS conceptual model (fig.4.3) there are firms clusters belonging to the functional region – with their specific knowledge – which have to be surrounded by supporting firms as well as complementary firms; moreover, there should be, around all the above firms, resources - aimed at facilitating cooperation, knowledge transfer and knowledge spillover - as well as formal rules (national and local), animators, conventions, social capital, physical infrastructures, technological infrastructures, knowledge infrastructures, venture capital and public financial support.

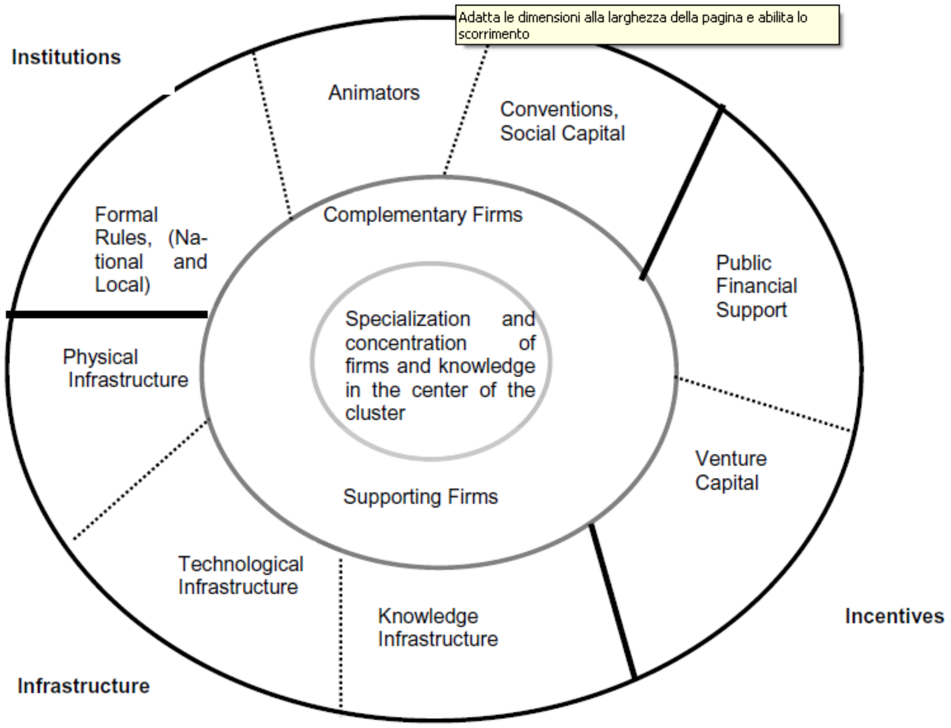


Fig. 4.3: Components of the RIS conceptual model according to Andersson M. and Karlsson C. (2006)

These scholars highlighted that their RIS conceptual model is <<more or less synonymous>> with the “regional networked innovation systems” which have been described in the literature of RIS tassonomy (Asheim and Isaksen, 2002); by referring to regional networked innovation systems, Andersson M. and Karlsson C. (2006) intended to focus the attention on the need of a strong supporting institutional infrastructure surrounding the clusters of firms in the core of the RISs, (i.e. on the need of a strong supporting infrastructure of R&D-institutes and other local organization that are involved in firms’ innovation processes).

With some differences from the above conceptual models, Todtling and M. Trippl (2005) presented their point of view on the RIS, as a modification of the Autio’s conceptual model (1998), through the identification of three subsystems (fig. 4.4) <<embedded in a common regional socioeconomic and cultural setting>>; the first one is the “knowledge application and exploitation subsystem” that is constituted by industrial companies linked - by horizontal and vertical networking - with customers, contractors, collaborators and competitors; the second one is “knowledge generation and diffusion susbsystem” that is constituted by institutions involved in the production and diffusion of knowledge and skills, such as technology mediating organizations, public research organizations, workforce mediating organizations and educational organizations; the last one is the “policy subsystem” that has the role of shaping regional innovation processes by formulating policy that facilitates interactions and flows of knowledge, resources and human capital between the other two subsystems. Furthermore, F. Todtling and M. Trippl (2005) highlighted the significance of extra-regional contacts, such as national and international policy actors and other innovation systems, for complementing ideas, knowledge and technologies not generated within the region; so, their RIS conceptual model includes an external system of actors interacting with the above three subsystems.

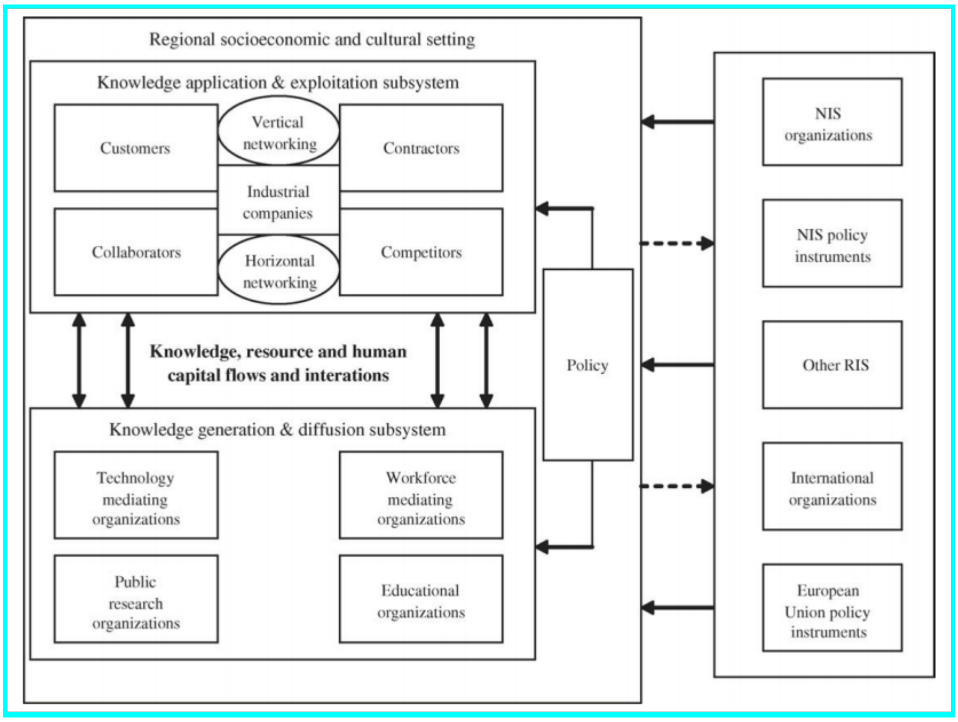


Fig. 4.4 – F. Todtling and M. Trippl (2005) conceptual model

Features	Authors: P. Cooke et al. (1997)	Authors: M. Fritsch (2003)
Rationale	RISs as regional learning systems that – by means of closed links between financial and productive culture subsystems - have moved from the learning attitude to adapt innovations originating from elsewhere to a "tutoring" disposition where there is the capability to innovate *de novo*.	RISs as systems that emphasizes closed interactions among innovation actors and takes into account the advantage of the division of innovative labor among agents of innovation within the systems and between "internal" innovation actors and the outer world.
Key success point	Loose coupling of three key subsystems: finance, learning and productive culture.	A productive innovation culture.
Critical actors	▪ Firms operating in formal or informal networks with other firms in their sector as customers, suppliers or partners. ▪ Knowledge-centres such as universities and research institutes. ▪ Contract research organizations and technology-transfer agencies. ▪ Private business associations. ▪ Chambers of commerce and public economic development. ▪ Training and promotion agencies. ▪ Government departments.	▪ Public institutions for research, education and other forms of knowledge transfer - such as universities, public research institutions and transfer agencies. ▪ Manufacturing establishments. ▪ Suppliers of business-oriented services - such as technical consulting services, business consulting services, financial services etc. ▪ The regional workforce. ▪ New innovative firms.
Critical relationship	Trust, reliability, exchange and cooperative interaction	Cooperative spirit and trust

Features	Authors: M. Andersson. & C. Karlsson (2006)	Authors: F. Todtling and M. Trippl (2005)
Rationale	RISs, where regional is referred to the concept of functional region, as systems that are based on clusters of firms which are surrounded by supporting as well as complementary firms; all of the above firms are immersed in an atmosphere of resources that facilitate co-operation, knowledge transfer and knowledge spillover.	RISs as key subsystems, characterized by intensive interactive relationships (within and between such subsystems) and linked by exchanges with extra-regional actors, that are embedded in a common regional socioeconomic and cultural setting.
Key success point	An interactive learning process.	Embeddedness of the key subsystems in a common regional socioeconomic and cultural setting.
Critical actors	▪ Firms (firms belonging to the regional clusters, complementary firms and supporting firms), ▪ Governmental institutions. ▪ Higher research institutes (universities, application-oriented and non-university research institutes). ▪ Financial institutions (venture capitalist, institutions of public financial support)	▪ "Knowledge application and exploitation subsystem" (industrial companies linked - by horizontal and vertical networking - with customers, contractors, collaborators and competitors). ▪ "Knowledge generation and diffusion susbsystem" (technology mediating organizations, public research organizations, workforce mediating organizations and educational organizations). ▪ "policy subsystem". ▪ Extra-regional actors (national and international policy actors and other innovation systems).
Critical relationship	Exchange of knowledge, mutual trust, cooperation.	Exchange (knowledge, resources and human capital).

table 4.1

Literature has also showed several varieties of RISs depending on the differences of industrial base of the region, knowledge base of a territory, propensity toward clustering, entrepreneurship structure and so on (Asheim, Isaksen, 2002; Asheim, Coenen, 2005; Doloreux, Parto, 2005; Tödtling, Trippl, 2005).

The abovementioned variety is showed in several empirical RIS configurations (Figure 4.5).

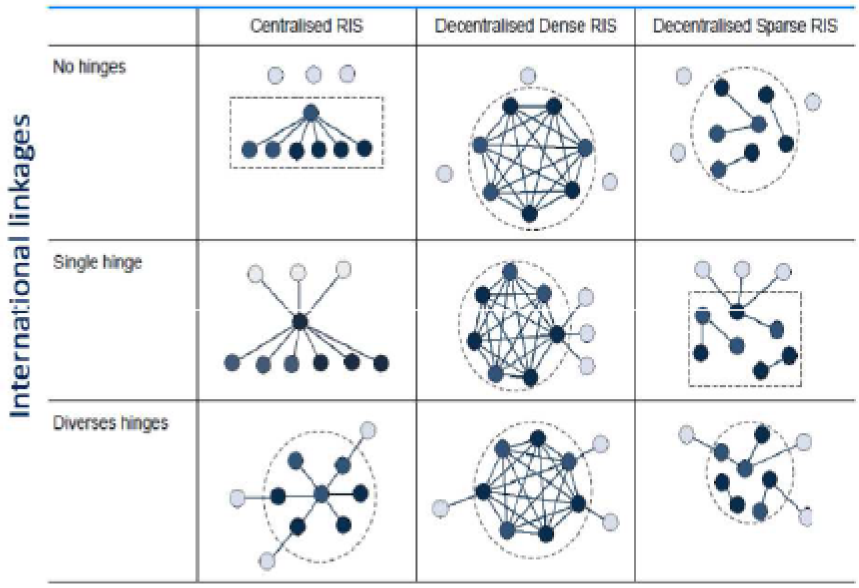


Fig. 4.5: RIS configurations from OECD (2011), "Regions and innovation policy", OECD publishing

The "old" theoretical debate - on what a RIS should be - has not been resolved yet; Indeed, according to Doloreux D. and Parto S. (2004), the "diverse variety of regional innovation system types creates a significant degree of 'definition confusion' and empirical validation issues, making it difficult for researchers and policy makers to foresee what a RIS is, or should be.

As emphasized in 1.4 section - and as emerged from this section - the approach <<suffers from the absence of an unified conceptual framework from which a universal, albeit very broad, model may emerge to guide research and policy" (Doloreux D. and Parto S., 2004).

4.3.3 RIS as complex learning system

There is a shared vision that RIS have to be a learning system; indeed, the IRE Working Group (2008) looked at RIS as a system that generates a collective learning process and highlighted that regional innovation has been associated with the idea of collective learning involving the creation and further development of common or shared knowledge among innovation actors. The OECD "Regions and Innovation Policy" book (2011) emphasized the significance of the interactive learning process among firms and between firms and other organizations; firms do not innovate in isolation, but in interaction with other organizational actors (OECD, 2011).

Literature has suggested that virtuous RISs are characterized by the presence of regional learning processes (Cities and Regions in the New Learning Economy, 2001, OECD publishing). Woolcock (1998) has argued that large stocks of social capital (namely norms, values and beliefs which are shared in everyday interaction within social networks and which enable the co-ordination of action to achieve desired goals) - in a given community or region - have positive consequences for economic development. However, other sorts of effects are possible too. In particular, problems arise where the current stock of social capital in a region becomes a constraint on the actions that should be done to meet effectively the demands emerging from the change of the economic circumstances. Indeed, the norms, values and beliefs of the social interactions reflect the past trajectory of development and such "path-dependency" may thus confine regions to development trajectories leading to low growth. Grabher (1993) suggested that, in these circumstances, it's necessary a substantial process of "unlearning", before new rounds of learning, adapted to emergent economic circumstances. Within this context Florida (1995) argued that the true significance of the "learning region" lies. The "learning region" constitutes a model towards which actual regions need to progress in order to respond most effectively to the challenges posed by the ongoing transition to a "learning economy"; the "learning region" can be viewed as an especially "virtuous" and effective variant of RIS and it can be specified in terms of the analytical apparatus of the RIS approach.

More generally, as emerged in chapter 1, systemic territorial innovation is constituted by a set of connected or interdependent innovation actors, with the capacity to alter or change learning from experience; the system as a whole is characterized by the emergence and self-sustainability concepts; so, as these typical features of the complexity science are also related to the RIS theoretical framework, according to Cooke P. (2012) and according to the above considerations on the RIS learning feature, we argue that a Regional Innovation System should be considered as a Complex Learning System.

4.4 Conclusions

Local development can't be analyzed through quantitative variables, but in more complex terms that involve economical and social processes. As consequence, economy and local development have to be studied within the complexity perspective.

RISs are complex systems resulting from the integration of a territorially embedded institutional infrastructure and a production system (Doloreux, 2002). The RIS framework defines innovation as a cumulative and not-linear systemic process (Fischer, 2001). It results from the formal and informal, voluntary and involuntary interactions between different actors operating in the innovation system.

The main idea in the RIS approach is that interactions among different local actors that have good reasons to interact - such as small and large firms, manufacturing and service companies, industries and universities, private and public agencies - should foster local learning processes. It has been suggested that the accumulation of technological processes occurs mainly on a local or regional level and that technological and knowledge spillovers tend to be geographically concentrated (Brenner, Grief, 2006). Geographical proximity (physical, economic, social) is important not only because of the reduction of physical distance (and associated transport and location costs), but also because it facilitates information exchange, lowers uncertainty, increases the frequency of interpersonal contacts, facilitates trust, diffusion of common values and beliefs, and promotes learning. By now, due to the territorial dimension of innovation processes, to the importance of local institutional conditions and – still - to the systemic character of the cooperation and the mutual learning between the innovation actors, Regional Innovation System is considered the most adequate framework to define the best policies for improving the innovative capability of a territory.

There is a shared vision that a RIS has to be considered as a learning system; indeed, the IRE Working Group (2008) looked at RIS as system that generates a collective learning process; furthermore, they highlighted that regional innovation has been associated with the idea of collective learning involving the creation and further development of common or shared knowledge among innovation actors. The OECD "Regions and Innovation Policy" book (2011) highlighted the significance of the interactive learning process among firms and between firms and other organizations; firms do not innovate in isolation, but in interaction with other organizational actors (OECD, 2011).

Generally speacking, as emphasized in chapter 1, systemic territorial innovation is constituted by a set of connected or interdependent innovation actors, with the capacity to alter or change learning from experience; the system as a whole is characterized by the emergence and self-sustainability concepts; so, as these typical features of the complexity science are also related to the RIS theoretical framework, according to Cooke P. (2012) and to the RIS learning feature, we argue that the a Regional Innovation System should be considered as a complex learning system.

But, also the RIS approach - like others theoretical frameworks on systemic regional innovation - "suffers from the absence of an unified conceptual framework from which a universal, albeit very broad, model may emerge to guide research and policy” (Doloreux D. and Parto S., 2004).

Doloreux and Parto (2004) have highlighted that to “engineer” the RIS it is necessary to specify what the institutions are and how they interact in different systems, at different scales, or at different levels; so, in order to give a contribution to “engineer” the RIS and to fill the literature gap about the absence of an unified conceptual framework, in chapter 5 and chapter 6 we suggest some further ideas on RIS as complex learning system.

Chapter 5

Social hypercycles of Regional Innovation System

5.1 Chemistry and Biology models for organizational studies

As highlighted by Albino V. (2005), thermodynamics studies have offered significant suggestions and analogies for economy and organization scholars. Particularly, the concepts of entropy, order, disorder and irreversibility represented and contributed to define metaphors and analogies that emphasize several complexity aspects of the organizational systems. Prigogine work (1984, 1997) is an extraordinary contribute that - jointly to Kauffmann's research (1993, 1995) - can represent foundations of the complexity science. More recently, Nonaka (1988), leaving from the study of japanese experiences, extended new conceptual models to business organization; this scholar argued that firms renovation consists in a process both of continuous evolution of existing organizational order and of novelty creation. Also for the enterprises it is possible to apply the Prigogine's ideas; indeed, a new order - or a new organization - can be spontaneously developed from not equilibrium and chaos. Organizations, like open systems, gain energy and informations from envirovment, and yield entropy. Accordingly, the thought evolution - guided by the change of the reference metaphors - is clear; for example, Nonaka (1988) referred to principles not belonging to classical organizational theories: *"The basic principles of imbalance dynamics did not emerge from organizational theories but from other basic disciplines. At present, the most noteworthy principles are those concerned with selforganization which emerged from natural sciences"*. So, there is a slow transition between the use of simple metaphors being derived from the natural sciences (particularly, from the chemistry and from the biology) and the construction of models able to explain the organizational complex phenomena.

On studies about dynamic systems applied to economical-productive themes, a significant contribution was given from the modeling of an industrial system as a system of chemical agents (Padgett *et al.*, 2003). The starting point of Padgett research is the hypercycle concept.

An hypercycle (fig. 5.1) consists of self-instructive units with two-fold catalytic function. Each intermediate - as autocatalyst - is able both to instruct its own reproduction and, in addition, to provide catalytic support for the reproduction of the subsequent intermediate.

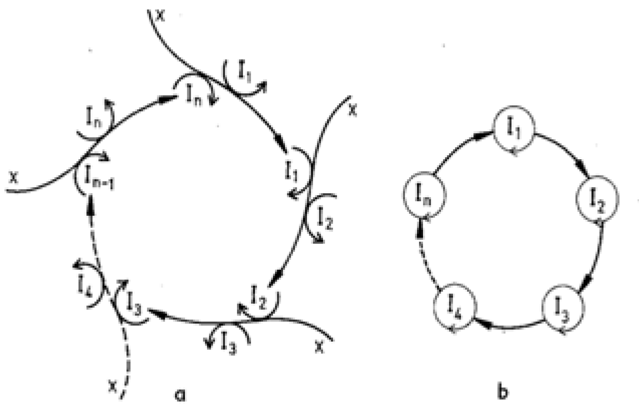


Figure 5.1: cyclic hierarchy of the hypercycle. Source: Eigen, M. and Schuster P., 1977

In every self-catalytic step of the hypercycle, a catalyst molecule is copied and a new product - that act as new catalyst for the subsequent hypercyclic reaction - is always produced. So, an hypercycle is constituted by a cycle of reactions that identically repeat themselves with a self-reinforcing nature.

As highlighted by Mckelvey B. (2005), self-organizing structures with self-catalytic nature are conceived as natural omnipresent phenomena, including organizational studied ones. For example, Padgett *et al.* (2003) conducted researches in which the chemical perspective of self-catalytic cycles was applied to the analysis of co-evolution of products and firms; these scholars highlighted that the viewing of economics as chemistry entails extraordinarily minimalist assumptions about economic production; indeed, according to this assumption there is no guiding intelligence; furthermore, the abovementioned scholars argued that a priori we could not expect much complex economic organization to be possible from randomly iterated rules, but the history of chemical and biological life on earth suggests that minimalist systems can generate complexity under the right circumstances: <<one place to turn for analytic inspiration is chemistry. From the chemical perspective, life is an interacting ensemble of chemicals that reproduces itself through time, in the face of turnover of its parts. Biological organisms are not fixed entities; they are autocatalytic networks of chemical transformations, which continually reconstruct both themselves and their physical containers. The origin-of-life problem, under this view, is how such an ensemble can self-organize, from a "soup" of random chemicals in interaction and flux>> (Padgett *et al.*, 2003).

So, accordingly to this framework and to the complexity nature of RIS, we sustain the need to adopt - within RIS theoretical framework - the following ideas suggested by literature on chemistry and biology complex phenomenologies:

1. As highlighted by figure 5.2, with defined conditions of temperature and pressure, the catalyst let the system to follow the alternative route of the activated intermediate with a smaller energy of activation (in other words, with a smaller energy barrier to surpass) with respect to the case of the not catalyzed reaction.

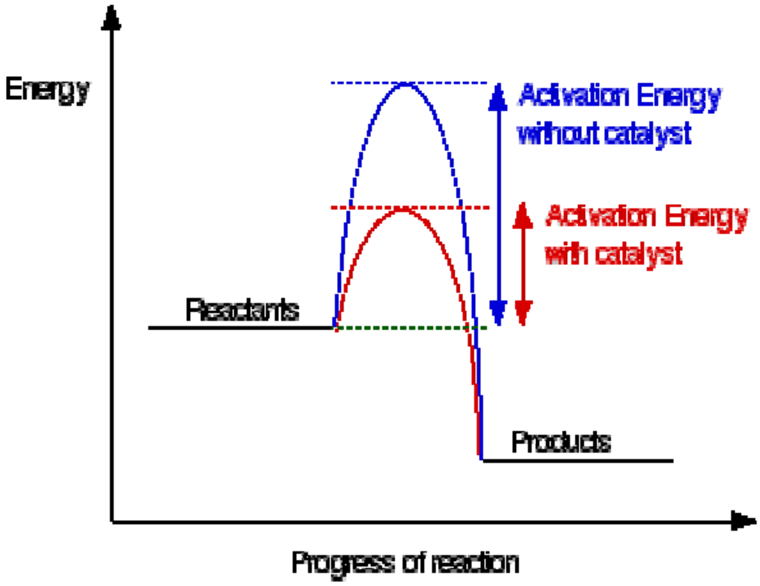


Fig. 5.2: Diagram of a catalytic reaction, showing the energy level depending on the reaction coordinate

Furthermore, framework conditions of a reactant system depend on the choices of the chemical operator, which defines reaction conditions in function of reactant system features (for example, in function of the solubility of reactants in a defined solvent) and in function of the predictable answers of the reactant system.

Likewise, with defined conditions of regional framework there are defined relational barriers (namely cognitive, organizational, social, institutional) among innovation actors. The presence of catalysts – to which the function to promote connections among other innovation actors can be associated - let the development of "activated network " among actors involved in the innovation network. The conditions of regional framework are determined by the choices of the governor; these choices continually change because of a continuous feedback cycle between top-down policies of the governor and bottom-up answers of the other innovation actors; accordingly, we sustain the need to adopt the evolutionary biology concept of "artificial"[1] - within the

[1] Artificial selection is the process - guided by the man instead of the nature - that produces artificial evolutive pression

RIS theoretical framework - with the aim to highlight the significance of the governor; in fact, notwithstanding the continuous feedback cycle between the top-down (that is, artificial) environmental pressures of the governor and the bottom-up (emergent) environmental answers of the exploiters, explorers and catalyst, the framework conditions - defined by the governor choiches - determine the direction of the feedback cycle, namely determine the virtuosity or the viciousness of the abovementioned cycle.

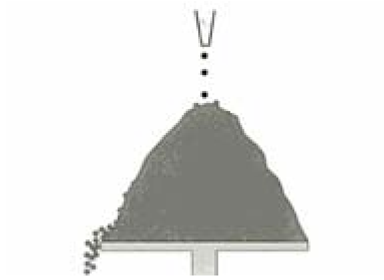
2. Eigen and Shuster (1977) showed that a mechanism able to explain molecular evolution should include the integration of different self-reproductive units in a cooperative system such as the hyperciclic one; according to these scholars, an hypercyclic structure produces acceleration of the evolution processes due to the growth speed of new, and casual, self-replicative units; indeed, the growth speed increase of new self-replicative units produces the significant increase of the chemical reaction probability. According to Eigen & Shuster (1977), this acceleration was indispensable to create the great number of different chemical agents of prebiotic conditions. Therefore, they argued that the hypercycle structure - constituted among prebiotic molecules - was indispensable for the evolution and, as consequence, for the development of the life.

Accordingly, we sustain that the evolutionary growth of the innovative regional capability requires cooperation of several producers of innovation in a self-catalityc system as the hypercyclic one.

3. Scholars argued – and experimentally showed – the significance of the self-organized criticality concept for the chemical system of prebiotic conditions and for other biological systems (Nykter *et al.*, 2008). Self Organized Criticality (SOC) is the system capability to evolve towards a critical point and to stay closed to such point.

From biology we know that variations of the system state - that is closed to its critical point - can go both towards the direction of a more dynamic state and towards the direction of a less one; in biological systems, for example, if a potential dynamic configuration is better than the current one, envirovment will select the first one. In other words, according to biology, a system in the self-organized criticality state can adapt itself and can converge towards the direction in which it will reach the optimal dynamic features.

A lot of systems live "on the edge of chaos", in the sense that they operate closed to a transition phase, namely closed to the critical point that separate two very different states. On the edge of chaos a small change can push the system towards a more chaotic behavior or - in the opposite direction – towards a more stable behavior. Example of this behavior is constituted by the Bak experiment (Bak *et al.*, 1987) of a round dish to which a lot of sand is continually added.



Source. Formicai, imperi, cervelli. Introduzione alla scienza della complessità. A. Gandolfi (2008)

Such conditions create a sand pile with slopes that will became progressively more hanging because of the new sand that continually is introduced from the top of the system. So, there will be avalanches from points with eccessive slope. Sand pile doesn't grow when sand quantity introduced from the top balances sand quantity that falls from the side of the dish. When last condition is achieved, the system reaches its critical state [2]

In this state the system is locally unstable (in several points), but the pile slope remains stable. Critical state acts as system actractor: if the current sand pile is lower than the sand pile of its critical state, the system will stretch out to grow until to reach the dimensions of the critical state. If we want to carry the sand pile over the critical state by introducing too much sand, avalanches of large dimensions will spontaneously restore the system to the critical state (Gandolfi, 2008). This equilibrium state is said as metastable state because it is related to a system in a temporary stable state or, in other words, it is related to the homeostasis state [3]; in fact, it is a metastable state because small perturbations are able to break this fragile stability.

Homeostasis is broken not only with critical perturbations but also when too many not critical changes are accumulated; in fact, after a first phase without effects, too many not critical changes let the system to reach an instability threshold beyond that the changes do themselves visible. Generally speacking this concept is typical of the complex systems of social sciences; a classic example of this phenomenon in social sciences is constituted by the discontent - accumulated in a society - that can grow slowly, and without visible results, until surpassing a critical threshold (beyond this one the people rebels).

Typically, after a period of stability in which the not critical perturbations have been neutralized, the system reaches a well-known crisis of instability: the catastrophic bifurcationn condition. During last one condition the system is in a chaotic state in

[2] The critical state is an unstable state situated in the critical point (at the boundary between order and disorder); in correspondence of the critical point, very small events can be amplified from correlations going through the whole system; so, small events can also produce very large effects. At the critical point a small perturbation affects all the system.

[3] Homeostasis is the capability of the biological and environmental systems to resist changes and to remain in an equilibrium condition; when a critical perturbation impact the system - that is in its homeostasis step - the equillibrium conditions is broken and this system develops an omeoresis step in which it evolves until the achievement of a new homeostatic state.

which the future of the system is unpredictable. When a fluctuation wins (with respect to other fluctuations), the system is catapulted in a new homeostatic state.

Accordingly to this theoretichal framework and to the idea of RIS as complex adaptive system, we sustain that RIS lives on the edge of chaos in a state of Self-Organized Criticality. So, the level of Regional Innovation Value Criticality (RIIC) is the key parameter as well as Self-Organized Criticality is the key parameter of complex systems; when the "envirovmental" conditions are stable (namely, when there is absence of critical perturbations), the level of Regional Innovation Value Criticality is in the homeostatic equilibrium; with critical perturbations there is the development of an omeoretic step in which the level of RIIC changes suddenly; such omeroretic phase persists until the achievement of a new homeostatic equilibrium (with the related stabilization of the RIIIC level); more in general, the level of Regional Innovation Value Criticality (RIIC) is in a metastable equilibrium; this state depends on conditions of framework; such RIIC level, therefore, continually can grow, or decrease, depending - respectively - on virtuous pertubations, or vicious, operated by the "artificial-emergent" feedback cycle; as consequence, the synergistic effects of top-down policies and bottom-up answered can lead to catastrophic bifurcations that represent the key alternatives of the evolutionary path; "artificial-emergent" feedback cycles belonging to the virtuous type depends on governor policy; in other words, the governor can push the RIS in the choice of the best path in every catastrophic bifurcation (the verb "to push" is consistent with the idea that virtuosity, or viciousness, of the above mentioned feedback cycles is determined by governor choiches); therefore, virtuous cycles create the evolutionary path. On the contrary, with "artificial-emergent" feedback cycles belonging to viciousness type, the level of Regional Innovation Value Criticality decreases. Ideally, by always promoting choice of the best path - namely by pushing the system in an effective evolutionary path - governor fosters a continuous increase of the level of Regional Innovation Value Criticality.

4. Kauffman (1993, 1995) claimed for the theory of the emergence of <<collectively autocatalytic sets>> of molecules in order to explain the origin of molecular evolution. Such theory has found experimental support also [Kauffman,

2011). According to Kauffmann, life is emerged as consequence of a large collective autocatalysis derived from a critical combination of molecular species; with the collective autocatalysis, each species is reproduced thanks to the catalysis operated by other species. The whole set of molecules, therefore, is self-sustainable.

Furthermore, Kauffmann emphasized the existence of a critical number of catalytic molecular interactions: when such critical number is surpassed, there is the development of the collective autocatalysis (Kauffman 1995).

Accordingly, first of all we sustain that within the RIS theoretichal framework there is the need to consider if the critical variety of innovation actors has been achieved; this is a necessary requirement, but not a sufficient one for the development of Self-Sustaining Regional Innovation; indeed, in addition to the critical variety it is necessary the development of a critical number of interactions among the actors of innovation.

5. Kauffman (1995) referred to connection property of the random graphs in order to calculate the threshold that should be surpassed for the development of a giant cluster of cycles among interactions: for example, if we decide to casually join dyadic knots with cords, a connected giant cluster will be created when a mathematically definite threshold is surpassed; when a connected giant cluster is created, all the knots result attainable across connections of the system. For large numbers (N) of knots, a giant cluster is created when the number of connections is greater than N/2, namely when interactions among number of connections and number of knots is greater of ½ (such number represents the threshold of a giant cluster constituted from interconnections between dyadic knots only). When the connections number becomes greater than knots number, cycles - joined among them in a giant cluster - begin to create itself (Kauffmann, 1995)

Furthermore, Kauffmann, showed that giant cluster of prebiotic molecules, as intrinsic and emerging property of the connecting graph, is self-catalytic and self-sustainiable. [Kauffman, 2011)

Generally speacking, Kauffmann's model suggests that the self-catalytic cycles - joined between them in a giant cluster - are developed when ratio between the number of interactions (number of cords) and the total number of actors (knots) go over to a certain threshold. So, this model, adapted to the case of several typologies of innovation actors that interact in an hypercyclic system, can represent a criterion to discriminate between a self-catalytic RIS (when a specific threshold is surpassed) and not (when the relevant threshold isn't surpassed).

In fact, by operationalizing the above phenomenon we can numerically estimate the level of Regional Innovation Value Criticality and, therefore, we can numerically evaluate if the system is in the self-sustainable state, or not, by using the following formula:

$$C_{SS} = I_e / I_t$$

where:

C_{SS} = condition with respect to the target of systemic self-catalytic state;

I_e = number of effective interaction by the time considered (level of current RIIC);

I_t = number of Kauffmann's threshold interactions by the time considered (level of RIIC threshold);

In order to numerically calculate the level of RIIC it is necessary to use indicators which are representative of the number of connections - by the unity of time - among innovation actors (a critical indicator could be, for example, number of innovation projects, by the unity of time, among actors of innovation). Therefore, we argue that to evaluate the Regional Innovation Value Criticality it would be necessary to develop specific indicators through specific surveys (like the CIS one). From the methodological point of view, as argued before it is also necessary - first of all - to evaluate if the critical variety of innovation actors is satisfied by the region in observation; indeed, in absence of such critical variety there can't be systemic innovation (therefore, in last case, estimating of the RIIC has no sense).

5.2 Social hypercycles of Regional Innovation System

According to the literature idea of RIS as complex adaptive system, we sustain that RIS are characterized from the resilience concept, namely from the existence of a social homeostatic equilibrium of cohesion - in the development state or in the underdevelopment one – that self-sustains itself and that breaks itself with the coming of critical perturbations; further support of this idea is provided by Boerlijst and Hogeweg (1990) that mathematically showed the strong stability of hypercycles.

In order to give an explanation of the RIS resilence feature, we introduce the idea of the presence of social hypercicles within RIS, namely the idea of the existence of self-sustaining cycles of social cohesion among innovation actors of RIS. So, according to several scholars (Padgett J. *et al.,* 2003; Watts and Binder, 2013), we claim for the adoption of the hypercycle concept - within the RIS theoretichal framework - as concept that is able both to represent the abovementioned self-sustaining cycles of social cohesion and to interpret the inefficiency of innovation policies adopted from less developed regions; indeed, last regional innovation scoreboard of European Commission (European Commission, 2014) have showed few regions for which their innovative capability is varied in a significant manner; clearly, these regions must have implemented innovation policies not useful to critically pertubate their social system of cohesion; in other words, such innovation policies didn't destroyed the forces that - implicitly - act against innovation evolution.

Summarizing our idea, resilience of the regional innovative capability depends on the existence of social hypercycles, namely on the existence of self-sustaining homeostatic cycles of social cohesion in a well-working state or in a bad-working one; these homeostatic cycles self-sustain itself and break itself with the coming of critical perturbations.

5.3 Conclusions

By adopting some interpretations on complex phenomenologies of chemistry and evolutionary biology, we have found several pillars from which a new conceptual RIS model can be derived:

1. With defined conditions of regional framework there are defined relational barriers (namely cognitive, organizational, social, institutional) among innovation actors. The presence of catalysts – having the function to promote connections among other actors of innovation - let the development of "activated network " among innovation actors involved in the network.

2. The conditions of regional framework are determined by choices of the governor; these choices continually change because of a continuous feedback cycle between top-down policies of the governor and bottom-up answers of the other innovation actors; therefore, we suggest to use the concept of "artificial" within the RIS framework with the aim to underline that framework conditions (defined by the governor) determine virtuosity, or viciousness, of the abovementioned feedback cycle.

3. The evolutionary growth of the innovative regional capability requires cooperation of several producers of innovation in a self-catalityc system as the hypercyclic one.

4. RIS is a complex adaptive system that lives on the edge of chaos in a state of Self-Organized Criticality. The level of Regional Innovation Value Criticality (RIIC) is the key parameter; when the "envirovmental" conditions are stable (namely, when there is absence of critical perturbations), the level of Regional Innovation Value Criticality is in the homeostatic equilibrium; with critical perturbations there is the development of an omeoretic step in which the level of

RIIC changes suddenly; such omeroretic phase persists until the achievement of a new homeostatic equilibrium (with the related stabilization of the RIIIC level); more in general, the level of Regional Innovation Value Criticality (RIIC) is in a metastable equilibrium; this state depends on conditions of framework; therefore, such RIIC level can continually grow, or decrease, depending - respectively - on virtuous pertubations, or vicious, operated by the "artificial-emergent" feedback cycle; as consequence, the synergistic effects of top-down policies and bottom-up answered can lead to catastrophic bifurcations that represent the key alternatives of the evolutionary path; "artificial-emergent" feedback cycles belonging to the virtuous type depend on governor policy; in other words, the governor can push the RIS in the choice of the best path in every catastrophic bifurcation (the verb "to push" is consistent with the idea that virtuosity, or viciousness, of the abovementioned feedback cycles is determined by governor choiches); therefore, virtuous cycles create the evolutionary path. On the contrary, with "artificial-emergent" feedback cycles belonging to viciousness type, the level of Regional Innovation Value Criticality decrease. Ideally, by always promoting choice of the best path - namely by pushing the system in an effective evolutionary path - governor fosters a continuous increase of the level of Regional Innovation Value Criticality.

5. The critical variety of innovation actors is a necessary requirement, but not a sufficient one for the development of Self-Sustaining Regional Innovation; indeed, in addition to the critical variety it is necessary the development of a critical number of interactions among the actors of innovation.

6. The self-catalytic cycles - joined between them in a giant cluster - are developed when ratio between the number of interactions (number of cords) and the total number of actors (knots) go over a certain threshold. This phenomenon can represent a criterion to discriminate between a self-catalytic RIS (when a specific threshold is surpassed) and not (when the relevant threshold isn't surpassed). In fact, by operazionalizing the above phenomenon we can

numerically estimate the level of Regional Innovation Value Criticality; from the methodological point of view - as argued before - to achieve this objective it is necessary - first of all - to evaluate if critical variety of innovation actors is satisfied by the region in observation; in absence of such critical variety there can't be systemic innovation (therefore, in last case, estimating of the RIIC has no sense); if the requirement of the critical variety of innovation actors is satisfied for the region in observation, we can determine the Regional Innovation Value Criticality - in analogy to the quantity of sand (by the unity of time) that falls from the dish in the Bak experiment - as number of effective interaction by the time considered. We can also estimate the condition with respect to the target of systemic self-catalysis state; such condition is evaluable by using the following formula:

$$C_{SS} = I_e / I_t$$

where:

C_{SS} = condition with respect to the target of systemic self-catalytic state;

I_e = number of effective interaction by the time considered (level of current RIIC);

I_t = number of Kauffmann's threshold interactions by the time considered (level of RIIC threshold);

7. The Regional Innovation System is characterized by the presence of social hypercycles, namely by the presence of homeostatic cycles of social cohesion in a well-working state or in a bad-working one; these homeostatic cycles self-sustain itself and break itself with the coming of critical perturbations.

Chapter 6

Modeling RIS as Complex Adaptive System

6.1 Modeling territorial innovation systems as CAS: the state-of-art

There is a growing body of literature (Quadrio Curzio and Fortis, 2002; Lombardi, 2003; Squazzoni and Boero, 2002; Testfastion, 2003) referring to territorial systemic innovation (industrial districts, milieux innovateurs, local productive systems, regional clusters) as Complex Adaptive Systems (CAS).

Despite main concepts (like heterogeneous agents, self-organization, adaptation and co-evolution, non linearity and emergence) of complexity science have been used from a theoretical point of view to characterize territorial systemic innovation, we claim that these concepts are poorly explored from a practical point of view; indeed, Hall A. and Clarck N. (2010) argued that "enthusiasm for the conceptual aspects of an innovation systems perspective tended to obscure rather than clarify what complexity looked like in practice"; to fill this gap, these scholars sustained the need of specific methodological approaches because approaches mostly applied to study them are not completely adequate to their recognized complexity.

Agent-Based Modeling (ABM) is one of most suited methodological approaches to analyze CASs (Heath et al, 2009) and, more recently, agent-based simulation has been increasingly recognized as a useful tool to support policy making in different fields and at different levels (OECD, 2009).

ABM is a very powerful methodology through which a system is modeled as a set of autonomous agents that interact to each other and with the environment; this technique is a computational method (Gilbert, 2007) to model and simulate complex systems made by several agents.

Within ABM simulation, each agent takes decisions on the basis of a set of rules; so, each agent is characterized from a specific behaviour; the whole system develops the emergence of some macro-social level from interactions and relationship at the micro-social level among agents.

Modeling and simulating complex agent-based systems let to explore - in a virtual laboratory - the dynamic behavior of a system or a phenomenon that could be difficult to investigate through the observation in the real word; furthermore, it's possible to performe generative experiments (Epstein and Axtell, 1996)aimed at establishing if a set of micro-specifications is able to determine the emergence of observed, plausible or eventually unexpected macroscopic regularities; in other words, it is possible to develop new theories from the bottom-up experiments of ABM; moreover, throug ABM it is possible to solve formal problems that are not analytically tractable (Gilbert and Terna, 2000).

Focusing on territorial systemic innovation, simulation models available in the literature mostly refer to local clusters of small and medium firms (such as traditional neo-marshallian industrial disticts or high-tech industrial clusters). Table 6.1 reports a list of articles referring to computational simulative models of localized systems of economic and organizational actors.

These papers have been identified by filtering - simultaneously - with respect to the use of computational simulative methods coherent with the theoretical Complex Adaptive Systems approach and with respect to the object of computational modeling; more precisely on last filter dimension, only papers describing models on spatial productive/economic organizational systems have been considered (industrial districts, industrial clusters, firms networks, regional clusters, regional innovation systems, innovation networks).

ID	Paper	Object of investigation	Research topic/questions	Purpose of the computational modeling	Level of empirical validation	Computational method
1	Brenner, 2001, "Simulating the Evolution of Localised Industrial Clusters-An Identification of Basic Mechanisms"	Industrial Cluster	To identify mechanisms (accumulation of know-how, start-ups and spin-offs, spillovers, cooperation, public opinion, …) able to support or alternatively hinder the emergence of a localized industrial cluster of firms	Policy Advice	Partially validated against reality (it is qualitatively showed that some simulation results reproduce some real-world stylized facts)	Cellular Automaton
2	Boero and Squazzoni, 2002, "Economic Performance, Inter-Firm Relations and Local Institutional Engineering in a Computational Prototype of Industrial Districts"	Industrial District	To analyze what factors affect the economic performance of a district and to identify which "local institutional arrangements" could promote the adaptation of firms toward the external environment	Theory Building	Not validated against reality	Agent-Based Modeling
3	Zhang, 2003, "Growing Silicon Valley on a landscape: an agent-based approach to high-tech industrial clusters	Industrial Cluster	To study factors determining the emergence of high-tech localized clusters Silicon Valley like	Theory building	Partially Validated against reality (it is qualitatively showed that some simulation results reproduce some real-world stylized facts)	Agent-Based Modeling
4	Boero et al., 2004, "Micro Behavioural Attitudes and Macro Technological Adaptation in Industrial Districts: an Agent-Based Prototype"	Industrial District	To explore the effects of different social attitudes of the firms on the collective capability to adapt to different technological scenarios	Theory Building	Not validated against reality	Agent-Based Modeling
5	Borrelli et al, 2005, " Inter-Organizational Learning and Collective Memory in Small Firms Clusters: An Agent-Based Approach"	Industrial District	To analyze the impact of different socio-cognitive coordination mechanisms on Industrial Districts' performances	Theory Building	Not validated against reality	Agent-Based Modeling

6	Albino et al., 2006, "Innovation in industrial districts: an agent-based simulation model"	Industrial District	To study how innovation and learning processes in Industrial Districts have to be modified to assure their survival in a highly competitive environment	Theory Building	Not validated against reality	Agent-Based Modeling
7	Giardini et al., 2008, "A model for simulating reputation dynamics in industrial districts"	Industrial District	To study the effects of transmission of social evaluations on the production quality of an industrial district	Theory building	Not validated against reality	Agent-Based Modeling
8	Lozano S., Arenas A., 2007, "A Model to Test How Diversity Affects Resilience in Regional Innovation Networks"	Regional Innovation Cluster	To explore how diversity of organizational characteristics of nodes in a regional innovation cluster affects the adaptation of the system to environmental dynamism	Theory building/confirmation	Partially validated against reality (the model is built according to some empirical evidence)	Agent-Based Modeling
9	Albino et al., 2007, "Supply chain cooperation in industrial districts: A simulation analysis"	Industrial District	To analyze the benefits of diverse forms of supply chain cooperation with respect to different industrial districts configurations and with reference to changing scenarios	Theory confirmation/building	Partially validated against reality (the model is built according to some empirical evidence)	Agent-Based Modeling

Table 6.1: computational simulative models of territorial innovation systems. Source: working paper on systemic regional innovation as CAS (Ponsiglione C. and Zollo G., 2015)

As showed in table 6.1, studies mainly refer to industrial districts or clusters. The computational methodology mostly emerged in this literature stream is the Agent-Based Modeling (Cellular Automaton method is used in only one paper, but this technique is recognized as a precursor of ABM).

Analyzed literature of table 6.1 seems to be particularly fragmented; indeed, very different aspects of territorial productive/economic systems are analyzed and the connection among different models is weak or lacking. This characteristic has been outlined also in Fagiolo et al. (2006) with respect to agent-based models generally developed in economics.

Summarizing, we can argue that Agent-Based Modeling has been recently used to analyze phenomenologies of territorial development but, at date, agent-based models on systemic regional innovation haven't been developed yet; indeed, models developed by literature are only focused on specific aspects of a RIS, but not on the system as a whole. So, we can highlight that currrent studies on territorial systemic innovation are non coeherent - from the point of view of the numerical methodology - with recognized complexity of these systems.

6.2 RIS as Regional Artificial Ecosystem of Self-Sustaining Innovation

As highlighted in 1.3 section, the ideal geographical dimension of systemic innovation is the regional one; furthermore, previous chapters sustain that RISs- considered as the most adequate theoretical frameworks for the analysis of regional systemic innovation - are complex learning systems characterized by social hypercycles, namely by the presence of homeostatic cycles of social cohesion in a well-working state or in a bad-working one; these homeostatic cycles self-sustain itself and break itself with the coming of critical perturbations only.

As also highlighted in previous chapters, literature on RISs - that is highly dispersed in several conceptualizations - is characterized by the absence of a shared and unified conceptual model (Doloreux, parto, 2004)

This section is aimed at contributing to fill this gap in order to develop a new unified conceptual framework of RIS; with this aim, first of all, in the following we identify - in the theoretical and empirical RIS literature - the common elements characterizing main RIS conceptualization of literature; secondly, based on literature analysis of previous chapters, we propose a new conceptual model of a self-sustaining regional innovation system.

Common elements of several RIS conceptualizations adopted for the development of a new self-sustaining RIS theoretical framework:

Literature identifies a number of diverse actors (Muller, Zenker, 2001; Chung, 2002; Keune et al., 2004) usually involved in innovation processes at the systemic level. Some typical examples are represented by Universities, Research Centres, Public and Private laboratories and their combinations (eg Regional Competencies Centres), Firms, Liaison Offices, Science Parks and Technology Incubators, Trade Associations, Chambers of Commerce, Districts, and Clusters, Regional Innovation Agencies; so, first block of our proposed conceptual framework is constituted by the presence of heterogeneous key actors that - autonomously - interact in a networked complex learning system.

Networks' studies (Powell *et al.* 1996; Uzzi, 1996; Podolny and Page, 1998) showed that the presence of collaboration networks among different typologies of actors with different competencies is able to create value and innovation. The presence of systemic collaboration networks among all key actors allows for the systemic circulation of knowledge among nodes with different competencies and, as consequence, it supports the production of valued knowledge. Several examples, as the Silicon Valley case, showed that the presence of a network characterized by high quality of nodes and high density of links has a positive impact both on the creation of new knowledge and on the speed of knowledge transfer inside the system (Saxenian, Hsu, 2001; Bathelt, Malmberg, 2004); so, this type of network produces fast circulation of (new or existing) knowledge in the RIS. According to this framework, second block of our conceptual framework is represented by the networked system of relationships among all key actors involved in innovation processes.

Collective learning is not a linear process and cannot be estimated summing up the learning behaviour of each actor of the network (The IRE Working Group, 2008); so, third block of our proposed conceptual framework is constituted by the presence of a complex learning system, that is a system in which a "social synergy" (Schwandt, 1997) exists and value is added to the knowledge creation process. An interesting representation of learning systems (organizational learning systems) is provided by Schwandt and Marquardt (2000): based on Parsons' functional social model, Schwandt (1997) defined organizational learning as "a system of actions, actors, symbols and processes that enables an organization to transform information into valued knowledge which in turn increases its long-run adaptive capacity".

Schwandt's model includes four action subsystems (Figure 6.1):

• The Environmental Interface Subsystem performs as a collection of interdependent activities and actions that responds to signals from both the inside and outside of the organization determining the information it seeks and disperses;

• The Action-Reflection Subsystem defines the relationship between the organization's actions and the examination of those actions, whichenable it to assign meaning and create useful knowledge for the organization;

• The Dissemination/Diffusion Subsystem exists to transfer information and knowledge among the other subsystems of the organizational learning system (internal focus);

• The Meaning and Memory Subsystem - provides the foundation from which the other subsystems draw guidance and control. It maintains the mechanisms, which create the criteria for the judgment, selection, focus, and control of the organizational learning system.

These four subsystems provide an analytical framework for describing and evaluating the dynamic functions of an organization's learning system.

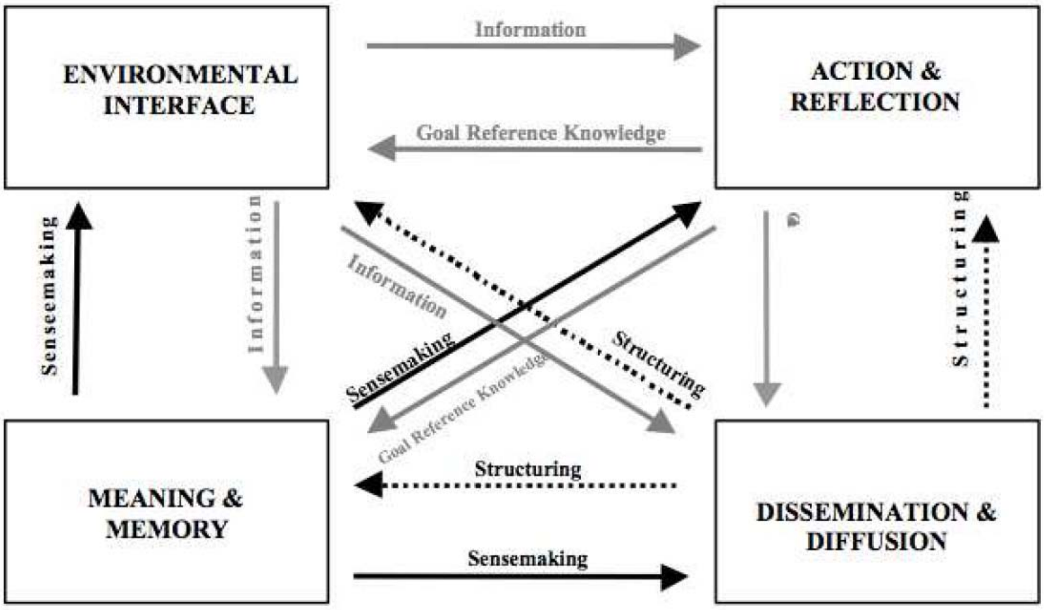


Figure 6.1: Schwandt (1997) learning system

Theoretical framework of a self-sustaining RIS:

From the building blocks above mentioned and from the Schwandt's learning system conceptual model it is possible to identify a new conceptual framework that can be useful to analyze the performance and the self-sustainability level of a RIS. In our idea, a conceptual model of a self-sustaining RIS is characterized by the following subsystems:

a) The producers of **knowledge (**knowledge is understood as coverage of knowledge areas and problem solving competences): this set of players is the subsystem of the EXPLORERS, made by subjects that explore the boundaries of knowledge producing new ideas, new methods, new techniques made available to small and medium enterprises (SMEs) and to the other players. Some typical examples are represented by Universities, Research Centres, Public and Private Laboratories and their combinations (eg Regional Competencies Centres), and big companies operating in technological sectors.

b) The producers of **market value:** this set of players is the subsystem of the EXPLOITERS, made by subjects that are able to transform knowledge into value for market (namely firms, especially SMEs).

c) **The mediators** of innovation: this set of players is the subsystem of the CATALYSTS or facilitators in the complex process of transfer, adaption and utilization of knowledge. Some typical examples are represented by Liaison Offices of the Universities, Science Parks and Technology Incubators, Trade Associations, Chambers of Commerce, Districts, and Clusters.

d) The creator of **framework and rules**: this actor play the role of GOVERNOR of the system, according to the guidelines of the Regional Government; it is usually represented by a regional innovation agency that, typically, has the following missions: 1) create a "one-stop shop" as a first layer front-office for SMEs; 2) organize and coordinate the Regional network of suppliers of innovation services in order to i) link the regional system to international networks, ii) improving scientific and technological competencies of the Region in order to attract new investments, iii) develop an integrated communication system on innovation issues, iiii) develop structured methodologies and systems of relationships between knowledge producers and the network of innovation services providers.

Hence, in our hypothesis these four actors have to interact with each other and with external actors (namely with the explorers, exploiters, catalysts and governors not belonging to the same region) through a systemic collaboration network, as showed in the Figure 6.2. In our conceptual model, each actor interacts with the others providing them with different contents. The explorers give knowledge (namely new ideas/methodology/products/processes, problem solving competences and so on). The exploiters, namely the firms, provide the network with economic value. The role of catalysts is to give links and, finally, the Governor provides the system with the formal and informal framework of rules.

This proposed model conceptualize the idea of global emergent competences arising from an hypercycle of self-sustaining interactions of new sources and new opportunities (to be exploited) among the innovation actors; so, within this conceptualization the RIS can be viewed as regional ecology of self-sustaining innovation by adopting the concept of "ecology of innovation" proposed by David and Metclaf (2008)

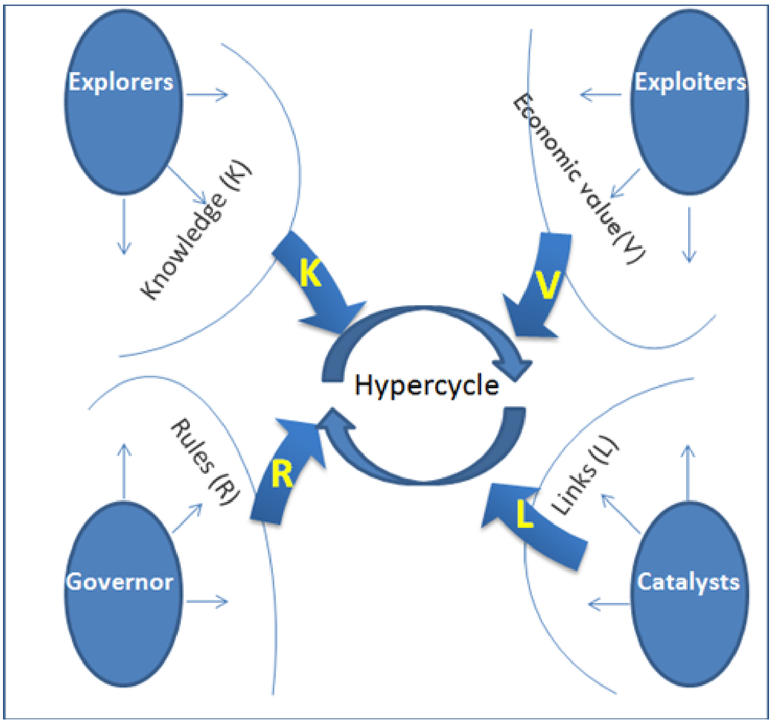


Fig. 6.2: RIS as self-sustaining ecology of regional innovation
K= Knowledge, L= Links, V= Value, R= Framework of Rules

These scholars suggested that the term “innovation systems” is misleading because it emphasizes static and durable institutional structures. Indeed, under the development of “innovation systems” there are emergent properties of an ecology of innovation, resulting from the formation of mutually reinforcing inter-organizational relationships between individual and organizational entities specialized in functional capabilities.

The fusion of innovation ecology perspective with innovation system perspective claims for the combination of emergent innovation strategies with planned innovation strategies. The characteristics of these strategies are summed up in table 6.2.

Emergent innovation	**Planned innovation**
Nonlinear relationships	Linear relationships
Critical mass thresholds	Marginal variations
Influence through iterative feedback	Influence as result of planned strategy
Novel and probabilistic world	Predictable world
Focus on variation	Focus on averages
Local control	Global control

Table 6.2 - Emergent vs. planned innovation strategies

But, by evocating further concepts deriving from biology, in our new RIS conceptualization we also introduces the concept of "artificial" with the aim to highlight the significance of the governor; in fact, as highlighted in chapter 5, notwithstanding the continuous cycle of feedback between the top-down (that is, artificial) environmental pressures of the governor and the bottom-up (emergent) environmental answers of other innovation actors, the framework conditions - defined by the governor choiches - determine the direction of the feedback cycle, namely determine the virtuosity or the viciousness of the abovementioned cycle.

In few words we state that an effective Regional Innovation System should be viewed as **Regional Artificial Ecosystem of Self-Sustaining Innovation** where the self-sustainability represents the key concept because it focuses on the self-development of innovation over time. Our proposed conceptual model represents a complex adaptive system characterized by the presence of social self-sustaining cycles.

In our idea, the Regional Artificial Ecosystem of Self-Sustaining Innovation has to be taken as reference conceptual framework in order to better represent both the effectiveness of emergent interactions among innovation actors, both the self-sustainability level of the whole system and the role of the governor for pushing the RIS in the choice of the best evolutionary path.

As highlighted in chapter 5, within our new RIS conceptualization the Regional Innovation Value Criticality (RIIC) is the numerical key because its numerical determination let to understand if the system is in a self-sustaining state, or not.

In order to numerically calculate the RIIC value it is necessary to use indicators which are representative of the number of connections - by the unity of time - among innovation actors (a good indicator could be, for example, number of innovation projects, by the unity of time, among actors of innovation). Therefore, we argue that to evaluate the Regional Innovation Value Criticality it would be necessary to develop specific indicators by means specific surveys (like the CIS one).

After the empirical determination of the RIIC for an observed region, we can know if this RIS is in the self-sustaining state by using the following formula:

$$C_{SS} = I_e / I_t$$

where

C_{SS} = condition with resepct to the self-sustaining state of the observed region

I_e = number of effective connections, among innovation actors, by the unity of time;

I_t = number of Kauffmann's threshold connections (see chapter 5), among innovation actors, by the unity of time;

- If C_{SS} >= 1, then the observed RIS is in the self-sustaining state;
- If C_{SS} < 1, then we know the distance of the observed RIS from the self-sustaining state

Chapter 7

Conclusions and future developments

We conclude that an effective Regional Innovation System should be viewed as **Regional Artificial Ecosystem of Self-Sustaining Innovation** where the self-sustainability represents the key concept because it focuses on the self-development of innovation over time. Our proposed conceptual model represents a complex adaptive system characterized by the presence of social self-sustaining cycles.

In our idea, the Regional Artificial Ecosystem of Self-Sustaining Innovation has to be taken as reference conceptual framework in order to better represent both the effectiveness of emergent interactions among innovation actors, both the self-sustainability of the whole system and the role of the governor for pushing the RIS in the choice of the best evolutionary path.

Within our new RIS conceptualization, the Regional Innovation Value Criticality is the numerical key becuse its numerical determination let to understand if the system is in the self-sustaining state, or not.

In order to numerically calculate the level of RIIC it is necessary to use indicators which are representative of the number of connections - by the unity of time - among innovation actors (a critical indicator could be, for example, number of innovation projects, by the unity of time, among actors of innovation). Therefore, we argue that to evaluate the Regional Innovation Value Criticality it would be necessary to develop specific indicators by means specific surveys (like the CIS one).

We state that the increase over time of the Regional Innovation Value Criticality for regional hypercycles of innovation should become the goal for any regional innovation policy. Our claim is that the definition of this goal should dramatically change the philosophy of current tools supporting the analysis of systemic regional innovation and the assessment of regional policies; indeed, as highlighted in the previous chapters, for regions not surpassing their specific self-catalytic threshold the evaluation of the level of Regional Innovation Value Criticality let to measure the distance from the Self-Sustaining state; for self-sustaining regions, the assessment of the RIIC level let to evaluate the distance from an ideal value. So, the definition of the RIIC level let policy makers also to measure the distance of systemic regional innovation from specific future target. On the contrary, all current tools for measuring regional innovation looks at the past only; indeed, they makes evaluations on improvements with respect to the past.

Our claim is that tools oriented to measure the effectiveness of policies for regional systemic innovation should evaluate not only the improvement from the past, but also the distance from the target. So, it should be necessary to develop methodologically stronger scoreboard that aims to measure the level of local resources and competencies; in order to become methodologically stronger, current scoreboards should overcome the lack of an underlying model of the regional innovation process; furthermore, by considering the significance of relationships among innovation actors and by evaluating that regional systemic innovation is due to the emergence of Regional Innovation Value Criticality, it should necessary to add new tools in order to analyze regional systemic innovation - respectively - also from the point of view of the network analysis and from the point of view of the complexity science; so, we claim for the development of a mapping tool - able to measure the social, cognitive, institutional embeddedness of regional systemic innovation - and an ABM simulation tool able to evaluate current patterns of innovation and to perform what-if analyses.

Concluding, as future developments of this study we sustain the opportunity to develop a combination of operational models (scoreboards, mapping tools and ABM tools) to operationalize the Regional Artificial Ecosystem of Self-Sustaining Innovation; indeed, the synergistic use of the above operational models let us to evaluate the gaps of competences to fill, the evolutionary path of current policies and the most effective policies to implement. So, these tools should let us to answer to the following questions:

- What are the current level and the critical mass of local resources and competencies able to sustain the regional cycles of innovations?
- What is the current pattern of social, cognitive, institutional interactions in which the regional pattern of innovation is embedded?
- How long is the distance between the current pattern and the target one?
- How much effective are current innovation policies?
- What are the most effective policies to implement?

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