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PROSPETTIVE E STRUMENTI PER LO SVILUPPO DI SISTEMI REGIONALI DI INNOVAZIONE AUTO- SOSTENIBILI

Luca IANDOLI[1], Francesco PALUMBO[2], Cristina PONSIGLIONE[3], Cristina TORTORA[4], Giuseppe ZOLLO[5]

SOMMARIO

Il presente lavoro intende contribuire al dibattito che, in letteratura e soprattutto nel contesto europeo della pianificazione strategica per lo sviluppo e l'innovazione, si sta svolgendo sin dalla metà degli anni '90 sul tema dei modelli e degli strumenti a supporto dell'innovazione regionale. Il focus è, quindi, rappresentato dai Sistemi Regionali di Innovazione. Gli obiettivi specifici del contributo sono i seguenti: i) presentare un modello concettuale di Sistema Regionale di Innovazione auto-sostenibile; ii) evidenziare le implicazioni che, in termini di strumenti di valutazione e di supporto alle politiche regionali, tale modello determina; iii) mostrare una prima applicazione del modello interpretativo proposto alla classificazione delle Regioni Europee (livello NUTS2), al fine di far emergere le potenzialità di strumenti di misura della capacità innovativa ispirati al principio dell'auto-sostenibilità rispetto agli strumenti che, in ambito europeo, sono ritenuti di riferimento.

[1] Associate Professor, University of Naples Federico II, Dept. of Industrial Engineering, Piazzale Tecchio 80, 80125 Naples, e-mail: iandoli@unina.it.
[2] Full Professor, University of Naples Federico II, Department of Political Science, Via Leopoldo Rodinò 22, 80138 Napoli, e-mail: francesco.palumbo@unina.it.
[3] Assistant Professor, University of Naples Federico II, Dept. of Industrial Engineering, Piazzale Tecchio 80, 80125 Naples, e-mail: ponsigli@unina.it (corresponding author).
[4] Post-doctoral Research Fellow, Department of Mathematics and Statistics, University of Guelph, Canada, e-mail: ctortora@uoguelph.ca.
[5] Full Professor, University of Naples Federico II, Dept. of Industrial Engineering, Piazzale Tecchio 80, 80125 Naples, e-mail: giuzollo@unina.it

1. Introduction

The territorial dimension of innovative processes has been widely recognized and outlined by scholars since the beginning of eighties (Aydalot, 1986; Becattini, 1979; Moulaert, Sekia, 2002). At the same time, the diffusion around the world of successful districts before and of technological clusters and innovation networks later raised in the middle of nineties a new attention of policymakers in Regional Innovation Systems (RISs) (Doloreux, Parto, 2004). Regional level is considered the most appropriate policy level for developing systemic innovation (Cook et al, 1997; Tödtling, Trippl, 2005). The cultural, institutional, social, cognitive proximity of relevant actors involved in the innovation social game play a major role in favouring positive results of innovative process. This point of view has been adopted by policy makers at both national and supranational level.

Many projects have been developed in the field of EU regional innovation policy. Among these, three main documents are representative: 1) the EU *Report 2020* (EC, 2010a); the *Barca Report to Commissioner for Regional Policy Danuta Hubner "An Agenda for a Reformed Cohesion Policy"* (Barca, 2009); the EU document *Regional Policy Contributing to Smart Growth in Europe* (EC, 2010b). EU *Report 2020* puts forward three mutually reinforcing priorities: smart growth, sustainable growth, and inclusive growth. The above three key points of the Europe 2020 agenda seem as lacking of an explicit territorial dimension. This lack is filled by the two other documents cited above. The *Barca Report* argues that a place-based development policy is superior to alternative strategies that do not make explicit their territorial focus. The *Barca Rep*ort proposal for EU Regional Policy Reform for the period 2014-20 is based on ten pillars, some of them are particularly relevant for Regional Innovation Policies. Pillar 1: An innovative concentration on core priorities and a conservative territorial allocation; Pillar 6: Promoting experimentalism and mobilizing local actors; Pillar 7: Promoting the learning process: a move towards prospective impact evaluation. The third document *Regional Policy Contributing to Smart Growth in Europe* (EU, 2010b) emphasizes the role of regions for the innovation process: "To reach the Europe 2020 objective of smart growth, the full innovation potential of EU regions needs to be mobilised. Innovation is important for all regions; for advanced ones to remain ahead and lagging ones to catch up"(EC, 2010b, p. 3). It is important to remember the broad concept of innovation adopted in the document and the policy orientation to stimulate innovation: "not only new or improved products and processes, but also services, new marketing, branding and design methods and new forms of business organisation and collaborative arrangements". 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 (the last regional scoreboard has been Pro Inno Europe

RIS 2012) that have been used as a reference point by innovation policy makers across the EU. The above scoreboards were aimed at assessing the national/regional innovation performances by evaluating the factors playing a role in the innovation process. The ranking and the classification of regions and countries proposed by Pro Inno Europe– as explained by the same authors of the scoreboards (Hollanders, Van Cruysen, 2008) - is based on a composite indicator that is not related to any specific model of innovation. The absence of a model beyond the evaluation of Pro Inno Europe Regional Innovation Scoreboards of innovation performances is a critical point shared by many theoretical and practical approaches. In fact, due to the lack of an unified conceptual framework on RISs, in literature there is no universal accepted model to guide research and policy (Doloreux , Parto , 2004).
This paper aims at filling this gap. The main idea beyond this research is to propose a new perspective in framing Regional Innovation Systems, by complementing the existing dominant literature and political perspectives with a "missing piece": the "self-sustaining cycle of innovation". Based on the perspective of "self sustainability" we develop a theoretical framework of Self-Sustaining Regional Innovation Systems (SSRISs) useful to develop new assessing and evaluation tools of innovation performance of regions able to better and effectively support policy makers. The research questions we attempt to answer are: i) Which is the model beyond a successful and self-sustaining RIS? ii) How to assess the capability to self-sustain of Regional Innovation Systems? In order to answer to these research questions we firstly analyse the literature on RISs and review the state-of-the art in the policy framework at regional level. Secondly, we identify the essential constituting elements, or building blocks, of the RIS conceptual framework. Thirdly, we propose and test - by statistical analysis - a model representing a potential successful and self-sustaining RIS. Finally, we rank the European Regions (NUTS2) according to the validated model and, thus, we propose an alternative clustering with respect to that of Pro Inno Regional Innovation Scoreboard 2009, in order to show the potential of the proposed theoretical and methodological approach in assessing the innovative performance of Regions

2. Regional Innovation Systems: the state-of the art and beyond

2.1 The diverse variety of Regional Innovation Systems

It is well known that the innovation of a territory is a complex and systemic process that involves a variety of actors - including researchers, producers and various intermediaries of knowledge - exchanging tacit and codified knowledge and learning mutually (Cooke, 2001).
In the literature there are four conceptualizations of innovation systems: *i)* National Innovation Systems (NIS), *ii)* Regional Innovation Systems (RIS), *iii)* Sectoral Innovation Systems (SIS) and *iv)* Technological Systems (TS). In the last 20 years, the literature has

highlighted the critical role played by geographical proximity and local institutional conditions for the production of new knowledge and its economic exploitation. This fact has contributed to increase the attention not only of scholars but also of policy makers on Regional Innovation Systems. The RIS approach integrates two different aspects: the territorial dimension of innovation processes and the systemic character. The emphasis on the territorial dimension of the regions is due to several reasons. Most important among them is that innovation systems are most easily observed at the regional level, since the geographic distance decreases the frequency of interaction among the actors of innovation. Informal routines and norms, that are specific of each region, are argued to play an essential role in the behavior of firms and in the type of collaboration among them. In addition, tacit and non-codified knowledge is a fundamental factor in the innovation process. Closeness and face-to-face contacts are prerequisites for the exchange of this kind of knowledge. The second important aspect is the systemic character resulting from social interactions between different territorial actors that are based on relationships of trust and reciprocity and that are able to generate, disseminate and apply new technologies (Lundvall, 1992).The above aspects constitute key elements of the several RIS definitions in literature. The IRE Working Group defines 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 (IRE, 2008). Asheim and Isaksen (2002) define RISs as regional clusters that are supported by surrounding organizations. They argue that RISs are mainly constituted by two key elements: (1) firms in the regional core cluster and, 2) an institutional infrastructure. The most obvious reason to focus on clusters is that they (as well as geographical proximity in general) tend to facilitate the key points made in the systemic approach, namely learning through interaction. At the same time, there is a substantial difference between the concepts of "regional clusters" and "regional innovation systems". A regional cluster is a "geographic concentration of firms often developed through local entrepreneurial activity" (Isaksen, 2001), while the "regional innovation system is seen as having a more planned and systemic character" and it requires "more knowledge organizations involved in innovation cooperation". Since the innovation is a mainly localised process, RISs have different characteristics in different regions, due to specific learning trajectories embedded in different institutional settings (Isaksen, 2001) and on the regional industrial specializations (Andersson, Karlsson, 2004). Innovation systems in high-technology regions are most likely different from the innovation systems in regions specialized in traditional industries. Moreover, RIS can also be very different between regions with similar industrial structures, according to different industrial policies and regulations (Tiwari, Buse, 2007). According to Doloreux and Parto (2004) there is a diverse variety of RISs. Indeed, the literature shows that there are several empirical RIS configurations. The implication of this diversity is that there is no one-size-fits-all policy that can be applied to any region (Tödtling,

Trippl, 2005). Rather, policies should be accommodated to industrial endowment, local research institutions, innovation culture and political system.

2.2 Three major perspectives in framing Regional Innovation Systems

Within this policy framework three perspectives are relevant to catch the state of art of innovation policies, instruments and tools: 1) the Learning Region Perspective; 2) The Smart Specialization Perspective; 3) The Pattern of Innovation Perspective. The Learning Region Perspective envisages how actors, sharing the same local context, learn to cooperate with each other in addressing economic and social innovation (Lundvall, 1992; Lundvall, Johansson, 1994; Florida, 1995; OECD, 2001). These actors include enterprises, customers, producers, consultants, research institutes and universities, etc. Through repeated interactions the local community learns, moving forward the socioeconomic 'system' . Thus, communication and cooperation between different actors are critical factors enabling people to learn. Regional institutions should promote the development of human resources and the formation of stable and efficient collaborations among regional actors (Gustavsen et al., 2007). The second perspective of Smart Specialization focuses on local knowledge resources. It suggests that a region should specialize in R&D and innovation relevant for its economy and competitiveness. The specialization seeks the concentration of resources upon focused knowledge development and acquisition. The Smart Specialization perspective advocates different policies for core and peripheral regions (Foray et al., 2011). Core regions, that are at the scientific and technological frontier, can invest in the invention of a General Purpose Technology (GPT), while peripheral 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 regional economy. By so doing, a peripheral region becomes 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 Smart Specialization Perspective, 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 to have blended entrepreneurial knowledge, which combines knowledge about science, technology and engineering with knowledge of market growth potential, competitors, production systems, and the whole set of inputs, services and competencies required for launching a new activity. This knowledge is dispersed and fragmented. Thus the entrepreneur plays a very crucial role to integrate it in a competitive business idea. The Pattern of Innovation Perspective (Camagni, Capello, 2012) is based on the assumption that different regions explore different cognitive and social spaces, leading to different patterns of innovation. Furthermore, "self-reinforcing feedbacks from innovation to knowledge and from economic growth to innovation and knowledge play an important role in innovation

processes. The impact of science on innovation does not merely resides in the creation of new opportunities to be exploited by firms, but rather in increasing research productivity and therefore the returns of R&D, through the solution and exploitation of technical problems, elimination of research directions that have proven wrong from a scientific perspective and provision of new research technologies" (ESPON 2012). The Pattern of Innovation Perspective claims that in some regions only a subset of necessary knowledge may be present. Consequently, lacking knowledge should be acquired from outside.

2.3 Beyond the state-of-the-art

David and Metcalf (2007) suggest that the term "regional innovation system" is misleading because it emphasizes static and durable institutional structures. Indeed, regional innovation capabilities are emergent properties of an ecology of innovation, resulting from the formation of mutually reinforcing inter-organizational relationships between individual and organisational entities specialised in functional capabilities. Within the "regional innovation ecology" framework there is a combination between emergent and planned innovation processes. Our simple idea is that the lack of understanding of a synergy between emergent and planned aspects of innovation limits the effectiveness of tools and instruments for observing and measuring smart specialization and regional innovation patterns. Foray et al. (2009) emphasizes that "Without measurement activities leading to the production of indicators and the regular collection of systematic data, smart specialisation is hardly visible and policies have no way to track progress, assess structural transformations and compare performance. So policies will just abandon the field."(Foray et al., 2009, p. 6).

We state that the creation of tools and instruments that help policy makers and relevant actors of innovation to put in practice the theoretical contributions of the three perspectives of learning region, smart specialization and innovation pattern needs of a missing piece: the concept of self-sustaining regional innovation system. In other words the Regional Innovation System should be considered as a Complex Adaptive System (CAS). The regional innovation system as a CAS implies 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 molecule, a species or an organization, among many others. These agents act based on their own schema and surrounding knowledge and conditions. CASs share some features. They are dynamic, non-linear systems, emergent, self-organizing and resilient. This introduction of a CAS concept requires complementing the key concepts of the above perspectives with new ones. In particular it is necessary to integrate:

- Patterns of innovation with self-sustaining cycles of innovation: a self-sustaining cycle of innovation is able to reproduce resources and competencies necessary to sustain innovation in time.

- Critical mass of resources with a self-sustaining criticality: to produce innovation critical resources must react to external information and interact very quickly. To display this behaviour the social system should possess an internal tension (criticality) which renew itself after any innovation.

Our idea is that the implementation of a self-sustaining innovative complex adaptive system should be the goal of any regional innovation policy. And that instruments and tools oriented to measure and evaluate the effectiveness of Regional Innovation Systems should evaluate not the improvement from the past, but the distance from the target.

3. The Self-Sustaining Regional Innovation System: a conceptual model

Few contributions in the RIS literature support the idea of the existence of a shared and universal conceptual framework (Doloreux, Parto, 2004) helping in implementing a successful innovation system. Instead, the literature suggests that RISs models are very different with respect to a number of elements: the industrial base of the region, the knowledge base of a territory, the propensity toward clustering, the entrepreneurship structure and so on (Asheim, Isaksen, 2002; Asheim, Coenen, 2005; Doloreux, Parto, 2005; Tödtling, Trippl, 2005). Furthermore, despite the widespread consensus on the need to develop models to analyse lagging regions, few contributions are provided on this issue in the literature (Tödtling, Trippl, 2005). In the followings we aim at defining the main elements of a conceptual framework representing a potential successful and self-sustaining RIS, based on conceptualizations of RISs proposed by literature and on major perspectives outlined above.

Literature identifies a number of diverse actors (Muller, Zenker, 2001; 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. The first block of the model is, thus, represented by the different categories of agents that, autonomously and interactively, participate and contribute to the learning and innovation process of a Region. The second block of the conceptual framework is represented by the networked system of relationships among all key actors involved in innovation processes. This network is typically characterized by high density and high quality. The high density is related to the number of nodes and to the number of links among them. The high quality refers to the level of competencies of nodes. In fact, networks' studies (Powell et al. 1996; Uzzi, 1996; Podolny, Page, 1998) show 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 a consequence, supports the production of valued knowledge. Several examples of successful innovation systems, as the Silicon Valley case, show 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). This type of network produces fast circulation of new and high quality knowledge in the RIS and can explain the value emerging from most successful RISs of the world. The third block of the 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. In this kind of system, collective learning is not a linear process and cannot be estimated summing up the learning behaviour of each actor of the network (IRE Working Group, 2008).

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:

- *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, which enable 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.

Finally, based on the building blocks above mentioned and on the Schwandt's learning system model it is possible to identify a conceptual framework useful to analyze the performance and the capability of self-sustainability of RISs. A potential successful and self-sustaining RIS model is characterized by the following subsystems:

a) The producers of *knowledge*: 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 SMEs and to the other players. Some

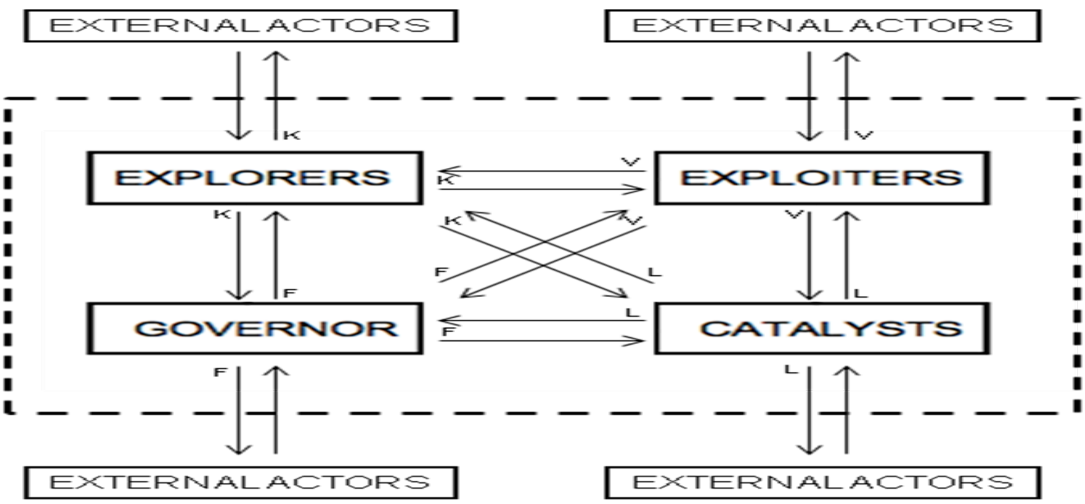
typical examples are represented by Universities, Research Centres, Public and Private Laboratories and their combinations (eg Regional Competencies Centres), and big companies operating in technological sectors.

b) The producers of *market value***:** this set of players represents the EXPLOITERS, made by subjects that are able to transform knowledge into value for market (namely firms, especially small and medium enterprises).

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.

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 1. In the proposed model, each actor interacts with the others providing them with different contents. The explorers give knowledge (namely new ideas/methodology/products/processes 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 framework of formal and informal rules.



K= Knowledge, L= Links, V= Value, F= Framework.

Figure 2 - RIS as a networked complex learning system

4. Methodology

In this section we describe the methodological approach and the tools used to analyze the innovation capacity and the self-sustainability of RISs, based on the conceptual framework presented above. As the conceptual framework has been developed, the second step is to identify key indicators to be associated to the elements of the conceptual framework. The selection of innovation indicators and their association to the elements of the conceptual model allows us in: 1) better formalize the conceptual framework and validating it; 2) performing a comparative analysis of the innovative behaviour of some RISs in Europe. Key indicators are the 16 used by Pro Inno Regional Innovation Scoreboard 2009. This choice has been made to ensure the availability of numerical data and also to guarantee the comparison between different metrics used to analyze the innovation of Regions in Europe. More in depth, the steps of our methodological approach are the followings: 1) operationalization of the models' blocks according to literature suggestions and to indicators definitions of Pro Inno RIS 2009 (the output of this stage is the association between the 16 Pro Inno Regional Innovation Scoreboard 2009 indicators and the models 'blocks); 2) check for consistency and unidimensionality of each group of indicators based on data provided by Pro Inno Regional Innovation Scoreboard 2009 (the output of this stage is an association between each block of the model and a coherent group of indicators); 3) Application of Structural Equation Modelling (SEM) to estimate the relations among each block and his indicators, and among the model blocks; 4) Identification of a composite indicator representing the capability of self-sustainability of RISs and clustering analysis usable to perform comparative analyses.

4.1 Models' blocks and indicators

The analysis here performed is strictly based on the Pro Inno Europe Regional Innovation Scoreboard 2009 (RIS 2009), taking into account data of 2004 (source: RIS_2009_Annex_4 PRO Inno Europe). Pro Inno RIS 2009 provides a comparative assessment of innovation performance across the NUTS 2 (Nomenclature of Territorial Units for Statistics 2) Regions of the European Union. Pro Inno RIS 2009 benchmarking analysis is grounded on the dimensions/indicators listed in table 1. In our analysis each actor of our conceptual framework has been characterized by a corresponding latent variable representing the specific resource produced and provided to the system by the above actor. In table 3 we report the associations. Pro Inno RIS 2009 indicators of the table 1 have been associated to the latent variables of table 2. These associations, listed in table 3, have been based on the suggestions provided by literature and according to the indicators definitions of Pro Inno RIS 2009.

Table 1 - Pro Inno RIS 2009 indicators

Dimensions	*Indicators*
Enablers	Tertiary education
	Life-long learning
	Public R&D expenditures
	Broadband access by firms
Firm activities	Business R&D expenditures
	Non-R&D innovation expenditures
	SMEs innovating in-house
	Innovative SMEs collaborating with others
	EPO patents
Outputs	Product and/or process innovators
	Marketing and/or organizational innovators
	Resource efficiency innovators (Labour; Energy)
	Employment in medium-high & high-tech manufacturing
	Employment in knowledge-intensive services
	New-to-market sales
	New-to-firm sales

Table 2 - Associations actors-latent variables

Actor	*Latent variable*
Explorers	Knowledge
Exploiters	Economic value
Catalysts	Link
Governor	Framework and Rules

Table 3- Associations among latent variables and indicators before the unidimensionality test

Actors	Latent variables	Pro Inno RIS 2009 Indicators	Literature or elements supporting latent variable-indicator association
Explorers	Knowledge	Public R&D expenditures	Pro Inno RIS 2009 indicator definition
		Employment in knowledge intensive services	Pro Inno RIS 2009 indicator definition
Exploiters	Economic value	Business R&D expenditures	Pro Inno RIS 2009 indicator definition
		Non R&D expenditures	Pro Inno RIS 2009 indicator definition

		SMEs innovating in house	Pro Inno RIS 2009 indicator definition
		Product and/or porcess innovators	Pro Inno RIS 2009 indicator definition
		Marketing and/or organisational innovators	Pro Inno RIS 2009 indicator definition
		Resources efficiency innovators (labour; energy)	Pro Inno RIS 2009 indicator definition
		Epo patents	Pro Inno RIS 2009 indicator definition
		New to market sales	Pro Inno RIS 2009 indicator definition
		New to firm sales	Pro Inno RIS 2009 indicator definition
Catalysts	Link	Innovative SMEs cooperating with ohers	Pro Inno RIS 2009 indicator definition
		Employment in knowledge intensive services	Pro Inno RIS 2009 indicator definition
Governor	Framework and Rules	tertiary education	Measuring Innovation (2010), OECD Publishing
		lifelong learning	Brine J., (2006)
		Public R&D expenditures	Woodward D., Figueiredo O., Guimaraes P., (2006)

The latent variables can be estimated only if each block has an internal consistency and if it is unidimensional. For this reason, before applying any model, some tests have been done. Basing on the results of the unidimensionality test, some variables have been excluded from the analysis in order to obtain the unidimensionality of each block (the final list of variables is shown in the global model represented in figure 3).

4.2 Technical issues: Structural Equation Modelling

Structural Equation Models (SEMs) allow us to assess and interpret complex interrelated dependence relationships as well as to include the measurement error on the structural coefficients. In other words, SEMs refer to a class of methodologies that seeks to represent hypotheses about summary statistics derived from empirical measurement in terms of a smaller number of "structural" parameter defined by hypothesized underlying model (Kaplan 2009). These models aim at representing a causal process through a series of structural equations that can be modelled to represent the theory under study.

According to the formulation of Jöreskog (Jöreskog, 1973) a SEM consists of two parts: measurement model and structural model. Measurement model focuses on the relations among observed variables and latent variables, identified as a block; structural model focuses on the relations among latent variables. Model parameters are generally estimated using maximum likelihood estimations, however alternative estimations have been proposed in the literature. In the most recent specialized literature, ever more frequently, authors consider two

approaches in the SEM analysis: classical SEM approach and PLSPM (Partial Least Squares Path-Modelling) approach. Classical SEMs are also referred as Covariance Based SEM (CBSEM), actually they are based on the Covariance Matrix analysis and they are usually implemented for confirmatory analysis. Classical SEMs are generally defined to test a causal model hypothesis, they must be defined under the usual multivariate normality assumptions and they imply the existence of a strong theoretical model hypothesis (Esposito-Vinzi et al, 2010). PLSPMs are also called Variance Based SEM (VBSEM) and they mainly aim at rebuilding a summary latent variable in term of variance. Partial Least Squares estimation permits to relax the multi-normality assumptions, there are not basic assumptions on the population and it can works with small samples. For this reason PLSPMs are also referred as 'soft modelling'; PLSPMs are considered exploratory analysis tools rather than confirmatory ones. In the case of the proposed conceptual model, both VBSEM and CBSEM could have been implemented; we have decided to implement the VBSEM to evaluate the relations among observed variables and to estimate the value of the latent variables for each European Region. In both approaches (CBSEM and VBSEM), dealing with measurement model, a very ticklish point is the choice of the type of relation among the latent variable and its corresponding set of manifest variables. The relation can be formative or reflective. We refer to Tenenhaus et al. (2008) for a more exhaustive description of the implication of this choice. In this context the reflective mode has been considered more appropriate because it reflects the structure of the problem. All observed variables contribute to cause the latent variable but the interrelations are unknown. Using reflective mode the weights of each observed variable are estimated using a simple linear regression where the manifest variables are the dependent variables and the latent variable is the independent one. Each observed variable has been assigned to a latent one basing on the study of literature and on logical coherence (see § 4.1).
In the following chapter we present the main results of the PLSPM. One main reason has led us to adopt a PLSPM modelling: we propose a newly defined causality structure in the systemic innovation, we believe that an PLSPM is more helpful to have an exploratory analysis. PLSPM requires that all the units have the same model. However, in a regional context we cannot assume that all the regions have the same innovation model but we can say that there are groups, or clusters, of regions that follow the same model. A traditional way dealing with this issue consists of estimating separate models for groups of regions that have been obtained by external clustering techniques. A different approach consists in estimating a global model and than performing a cluster analysis either on the manifest or on the estimated latent variable scores. Both models don't group units according to differences in the model structure. The first method finds clusters of homogeneous regions according to their score for manifest variables without taking into account their relation and their structure. The clustering and the PLS path modelling steps have different goals and optimize different criteria. Applying PLS path modelling on the clusters does not necessary lead to different models.

Moreover, the basic assumption of cluster analysis, uncorrelated variables, is not respected so a clustering method cannot be applied. On the other hand, clusters obtained by applying cluster analysis on the latent variable scores leads to clusters homogeneous for the average of latent variables. For example it is possible to find a cluster containing all the best innovators but the clusters are not necessary characterized by different models. Moreover, the basic assumption of the PLS path modelling is the homogeneity of the model for the units that is in contrast with the clustering assumption.
REBUS-PLS (REsponse Based procedure for detecting Unit Segments in PLS-PM), according to PLS-PM features, does not require distributional hypotheses and permits to identify local models that are different in terms of both structural and measurement models.
In this proposal, REBUS-PLS is adopted to find clusters of regions characterized by differences in the model. It is distribution-free coherently with PLS basic principles and accounts for heterogeneity in both the structural and the measurement models (Esposito-Vinzi et al. 2008). The aim of REBUS-PLS is to detect sources of heterogeneity in both the structural and the measurement model. It is obtained through the definition of an ad hoc distance based on the sum of squared residuals. For each cluster the latent variables are estimated. The method has been applied on the dataset described in the § 4.1. The model has been estimated using the software R+6, the package 'plspm' (Sanchez, Trinchera 2013) implement the REBUS-PLS method.

5. Application and results

The use of PLSPM requires some conditions: before applying the method the internal consistency and the unidimensionality of each block of variables have to be verified. The internal consistency implies that each variable is maximally correlated with the latent variable associated to it. Cronbach Alpha is a measure of internal consistency (Miller, 1995). The unidimensionality of each block is measured whit Dillon-Goldstein (DG) Rho (Shmitt, 1996). The coefficients are significant for every block as shown in table 4. It is worth to note that only one variable is assigned to the latent variable Links, so the coefficients are not computed. Each variable is maximally correlated with its belonging block, the model is well specified, and the theoretical assumptions, on which the assignations of variables to block are based, have been confirmed. Basing on the dendrogram (fig. 2), we have chosen to divide the data into 3 clusters of regions. The height of the dendrogram is a measure of the diversity of the clusters, three clusters brings to the higher diversity. For each cluster a model has been estimated. PLSPM does not optimize a global function. To evaluate the goodness of the model several measures can be used; the most commonly used is the R2. However, Tenenhaus et al. (2004) proposed a more suitable measure of global quality: the Goodness of

[6] http://cran.r-project.org/

Fit (Gof). It measures how well the model reproduces the observed Covariance Matrix. For each cluster the quality of the global model is very high. The results are shown in table 5.

Table 4- Internal consistency and unidimensionality measures.

Latent Variable	Dimension	Cronbach Alpha	D.G. Rho (ACP)
Knowledge	2	0,813	0,915
Economic Value	5	0,851	0,895
Links	1		
Framework	2	0,699	0,871
Innovation	10	0,892	0,912

The reliability of each latent variable is measured by the communality. The communality measures the percent of variance, in a given variable, explained by all the factors jointly. Taking into account all the latent variables the communality is never under 40%. The quality of the model is high.

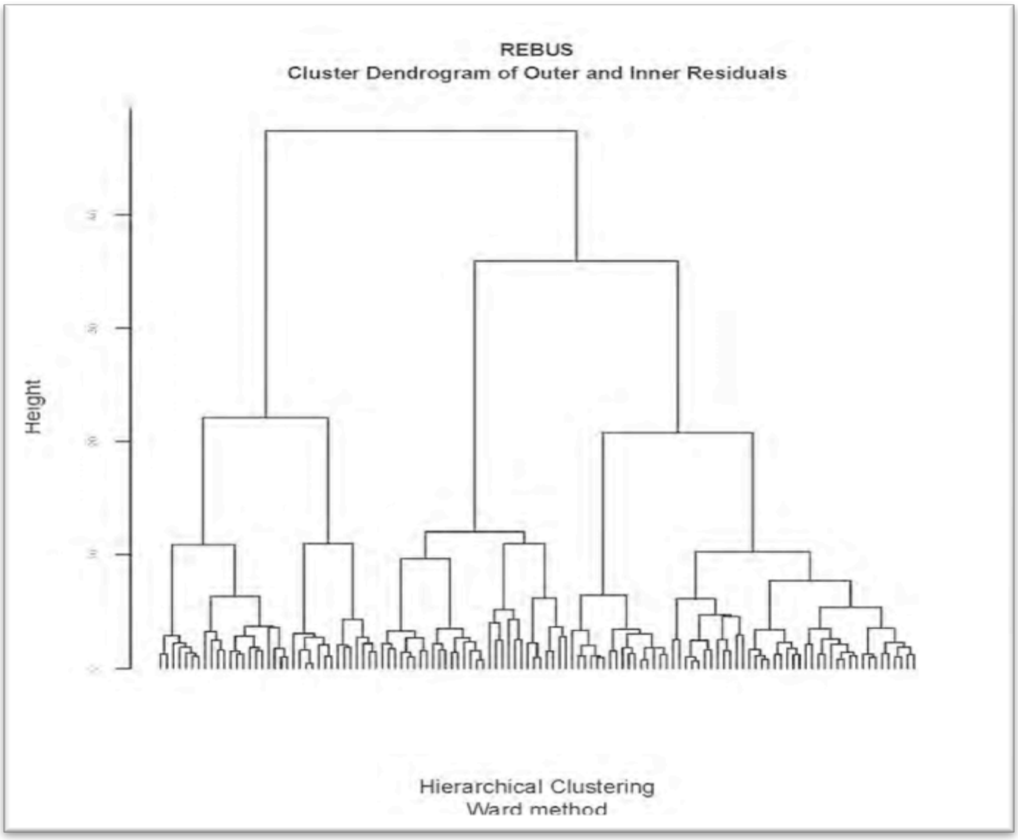


Figure 2- Dendrogram of regions

Table 5- Quality measures

QUALITY			
	Cluster 1	**Cluster 2**	**Cluster 3**
Communality Knowledge	0.82785	0.87774	0.82893
Communality Economic Value	0.43439	0.80684	0.65728
Communality link	1	1	1
Communality Framework	0.72352	0.81724	0.89303
Communality Innovation	0.40505	0.73759	0.47720
GoF	0.82347	0.92080	0.87818

The global model is represented in fig. 3. The contribution of each latent variable to the Innovation for clusters can be seen in fig. 4. In cluster 1 the weights have the lowest difference. If compared with the other clusters, cluster 1 gives the least importance to the Economic Value and the highest importance to the Knowledge.

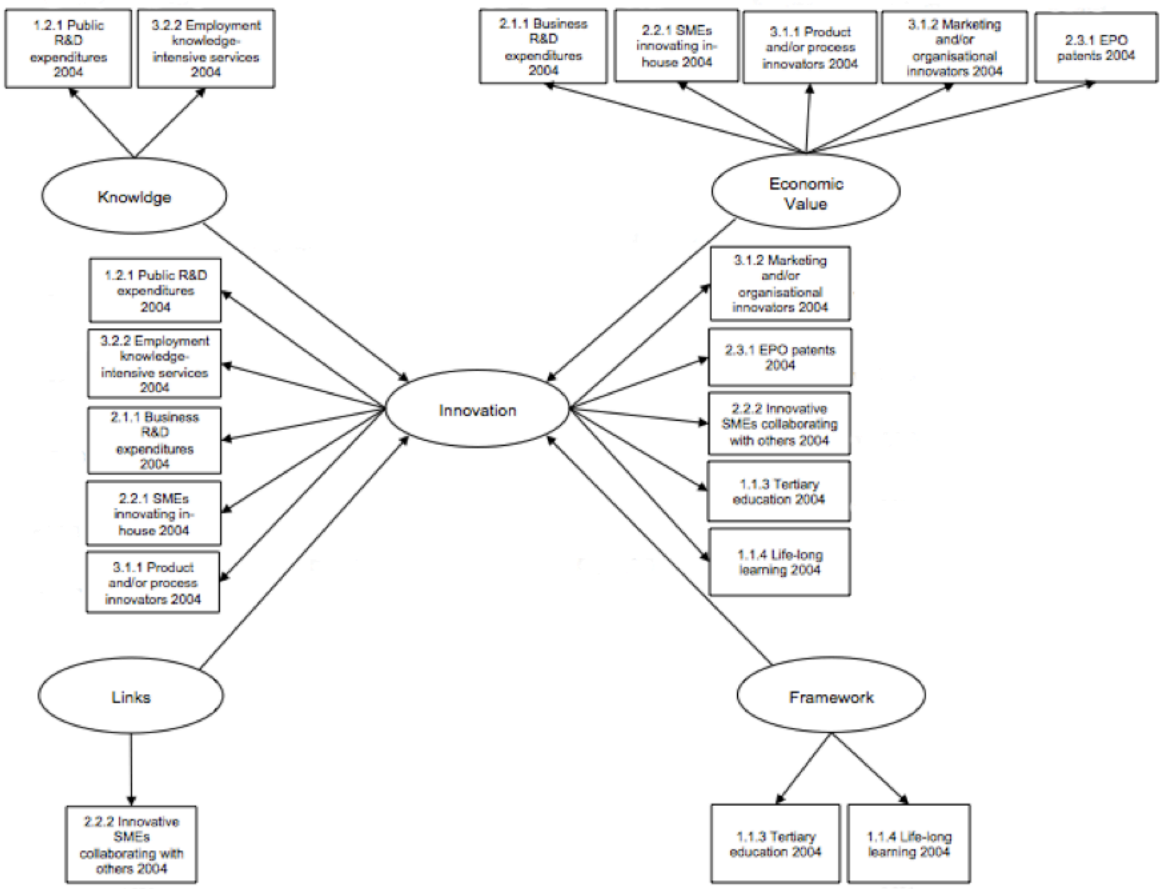


Figure 3- Global Innovation Model

Cluster 2, compared with the other ones, is characterized by the least importance attributed to Knowledge and Framework. The test on the differences among coefficients reveals a significant difference between clusters 1-3 and 2-3. Table 6 shows the average values (standardized) of each latent variable for each cluster. It confirms that cluster 3 is different from the others. Regions of cluster 3 are at the average the highest innovators; they present high Economic Value and high Link. Regions of clusters 1 and 2 are not high innovators. Regions belonging to cluster 1 show high values for the variable Knowledge, regions of cluster 2, instead, are characterized by high values of Link and Framework. It seems that the Framework is not relevant in determining the capability of regions to create an effective and self-sustaining innovation system. The results of clustering also show that the availability of a “knowledge potential” is not sufficient to generate self-sustaining and effective innovation systems. Most effective systems seem to be those in which the entrepreneurial system is a cooperative and interconnected system able to create active links not only among firms of the region but also between producers of knowledge and knowledge exploiters.

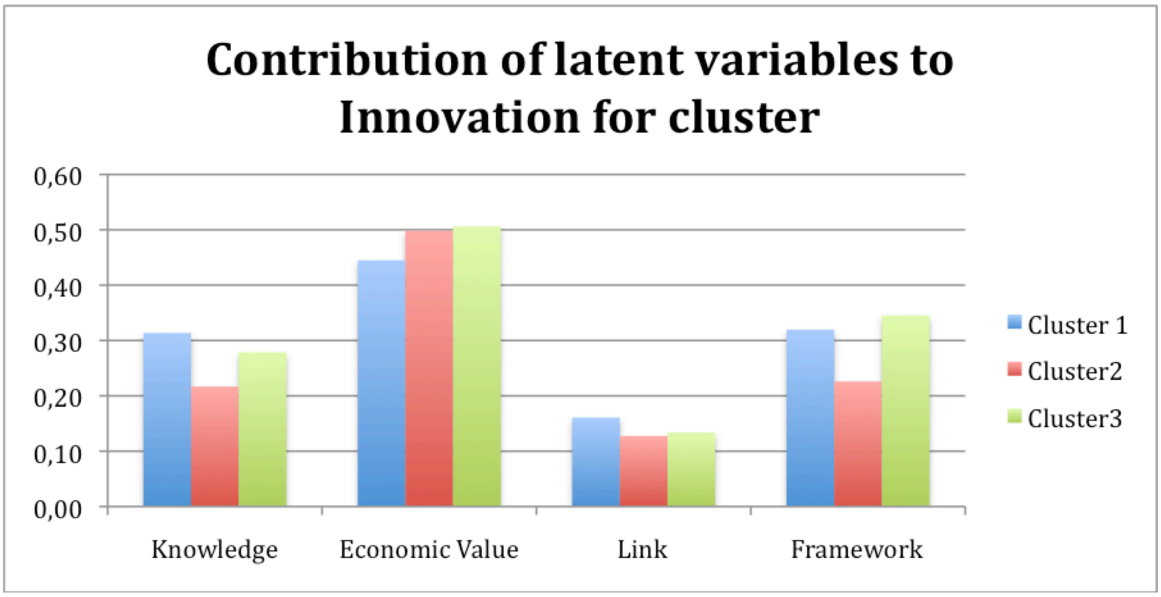


Figure 4 Contribution of each latent variable to Innovation for cluster

Table 6- Average values of latent variables for clusters

AVERAGE VALUES					
	Innovation	Knowledge	Economic Value	Link	Framework
Cluster 1	-0.1415	0.0431	-0.2129	-0.2605	-0.0575
Cluster 2	-0.1253	-0.1464	-0.3097	0.1154	0.2038
Cluster 3	0.3385	0.0973	0.6440	0.2499	-0.1388

The regions belonging to each cluster are detailed in table 8. The third column for each cluster is the global measure of innovation. It is worth to note that in cluster 1 there are, mainly, regions of: Spain, France, Italy, Poland and Norway. Cluster 2 is mainly characterized by: North of Spain, North-West of Poland, Romania and United Kingdom. The countries belonging to clusters 3 are: Czech Republic, North of Italy, Austria, Portugal and Finland.
We have also performed a preliminary comparison between the classification of Regions provided by ProInno Europe RIS 2009 and our ranking and clustering of Regions. If we consider the ranking of Regions with respect to the global innovation score the differences between our ranking and that proposed by Pro Inno RIS 2009 are not significant. But if we consider the clusters proposed by Pro Inno RIS 2009 (5 clusters based on the global

innovation score) and our clusters the differences are large in some cases. For example, some Regions classified by Pro Inno as high innovators do not belong to our third cluster, which is the cluster showing the highest average value of innovation score. It is due to the fact that our clusters are built according to differences that Regions show in their model of innovation. The possibility to compare the regions not only with respect to the level of innovation but also with respect to the structure of their innovation model could be more effective to support policy makers.

Table 8 Cluster membership for each region and innovation measure

Cluster 1			**Cluster 2**			**Cluster 3**		
fi1a	Pohjois-Suomi	1.69	ukj	South East	1.85	fi18	Etelä-Suomi	2.38
no01	Oslo og Akershus	1.68	fi13	Itä-Suomi	1.56	fi19	Länsi-Suomi	2.30
fr1	Île de France	1.40	be1	Région de Bruxelles-	1.54	be2	Vlaams Gewest	1.94
no06	Trøndelag	1.34	uki	London	1.48	ukh	Eastern	1.86
no05	Vestlandet	0.80	ukk	South West (ENGLAND)	1.27	at1	Ostösterreich	1.71
es3	Comunidad de Madrid	0.79	ukm	Scotland	1.18	cz01	Praha	1.53
fr6	Sud-Ouest	0.65	ukf	East Midlands (ENGLAND)	1.14	at3	Westösterreich	1.32
fr7	Centre-Est	0.56	ukd	North West (ENGLAND)	1.09	at2	Südösterreich	1.26
si02	Zahodna Slovenija	0.53	uke	Yorkshire and The Humber	1.01	pt17	Lisboa	0.83
ite4	Lazio	0.53	ukg	West Midlands (ENGLAND)	0.89	itd2	Provincia Trento	0.71
no03	Sør-Østlandet	0.50	ukl	Wales	0.88	itc4	Lombardia	0.60
no04	Agder og Rogaland	0.46	be3	Région Wallonne	0.81	itd5	Emilia-Romagna	0.58
es22	Comunidad Foral de Navarra	0.44	ukc	North East (ENGLAND)	0.75	itc1+itc2	Piemonte + Valle d'Aosta	0.42
fr4	Est	0.33	ukn	Northern Ireland	0.60	itc3	Liguria	0.36
fr8	Méditerranée	0.32	es21	Pais Vasco	0.59	cz06	Jihovýchod	0.33
sk01	Bratislavský kraj	0.28	es24	Aragón	-0.02	no07	Nord-Norge	0.32
es51	Cataluña	0.27	es41	Castilla y León	-0.08	itd4	Friuli-Venezia Giulia	0.27
fr5	Ouest	0.12	pl12	Mazowieckie	-0.16	ite2	Umbria	0.15
cz02	Strední Cechy	0.10	es63	Ciudad Autónoma de Ceuta (ES)	-0.32	itd3	Veneto	0.10
es52	Comunidad Valenciana	-0.01	ro32	Bucuresti - Ilfov	-0.39	itd1	Provincia Bolzano-Bozen	0.07

ite1	Toscana	-0.06	es11	Galicia	-0.46	es62	Región de Murcia	-0.03
itf1+itf2	Abruzzo + Molise	-0.07	pl51	Dolnoslaskie	-0.61	no02	Hedmark og Oppland	-0.15
fr3	Nord - Pas-de-Calais	-0.20	pl63	Pomorskie	-0.68	cz07	Strední Morava	-0.19
si01	Vzhodna Slovenija	-0.21	pl11	Lódzkie	-0.82	pt16	Centro (PT)	-0.26
fr2	Bassin Parisien	-0.31	pl41	Wielkopolskie	-0.90	cz03	Jihozápad	-0.27
es12	Principado de Asturias	-0.35	bg4	Yugozapadna i yuzhna centralna Bulgaria	-1.04	cz08	Moravskoslezsko	-0.35
cz05	Severovýchod	-0.41	sk02	Západné Slovensko	-1.06	pt18	Alentejo	-0.41
itf3	Campania	-0.43	pl42	Zachodniopomorskie	-1.12	pt11	Norte	-0.55
pl21	Malopolskie	-0.44	sk03	Stredné Slovensko	-1.19	itg2	Sardegna	-0.67
es61	Andalucia	-0.49	pl43	Lubuskie	-1.22	pt15	Algarve	-0.78
ite3	Marche	-0.50	sk04	Východné Slovensko	-1.38	pt2+pt3	Regiãos Açores + Madeira (PT)	-0.88
es7	Canarias (ES)	-0.55	ro12	Centru	-1.50	cz04	Severozápad	-0.88
es23	La Rioja	-0.58	ro11	Nord-Vest	-1.51	pl34	Podlaskie	-1.01
itf4	Puglia	-0.60	ro42	Vest	-1.64	pl52	Opolskie	-1.09
itg1	Sicilia	-0.62	ro31	Sud - Muntenia	-1.64			
es13	Cantabria	-0.65	ro41	Sud-Vest Oltenia	-1.74			
es43	Extremadura	-0.69	bg3	Severna i iztochna Bulgaria	-1.80			
pl22	Slaskie	-0.72						
pl31	Lubelskie	-0.74						
es53	Illes Balears	-0.78						
es42	Castilla-la Mancha	-0.85						
itf5	Basilicata	-0.86						
itf6	Calabria	-0.89						
pl61	Kujawsko-Pomorskie	-0.91						
pl32	Podkarpackie	-1.14						
pl33	Swietokrzyskie	-1.15						
pl62	Warminsko-Mazurskie	-1.24						
ro22	Sud-Est	-1.58						
ro21	Nord-Est	-1.67						

5.1 Validation of the model

To validate the results the same model was applied on regional data for the year 2006 and on national data of years 2007 and 2008. It is important to note that for the years 2007-2008 regional data are not available and for the more recent years there are too many missing data. The quality measures confirm the good adaptation of the model to the data in the years 2006-2008 (table 9).

Table 9- Quality measures

QUALITY			
	Cluster 1	**Cluster 2**	**Cluster 3**
GoF 2004	0.82347	0.9208	0.87818
GoF 2006	0.82347	0.9208	0.87818
GoF 2007	0.83901	0.9285	0.86511
GoF 2008	0.87916	0.82135	0.94549

The global model for each year is represented in figures 5-8. The coefficients of the model in 2004 and 2006 are exactly the same; instead from 2006 to 2008 some coefficients change. More specifically: the weight of the Knowledge on the Innovation decreases and the same happens to the weight of the Framework. The weight of the Economic Value on the Innovation, instead, increases. However, these variations cannot be considered significant.

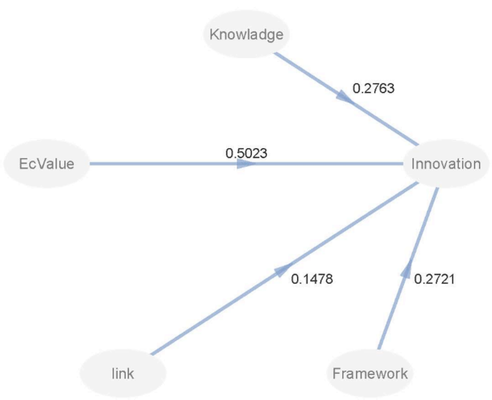


Figure 5 Global Model 2004

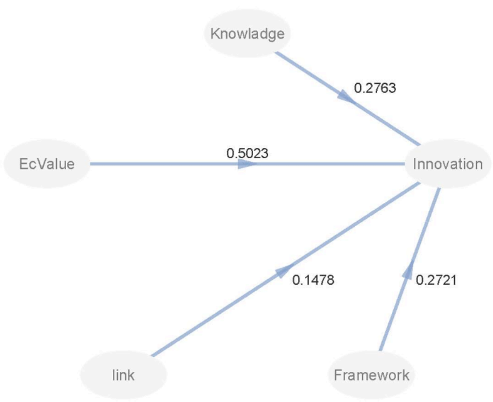
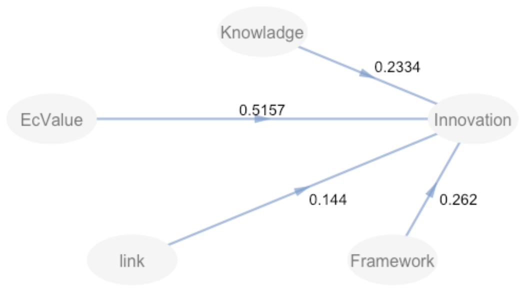


Figure 6 Global Model 2006



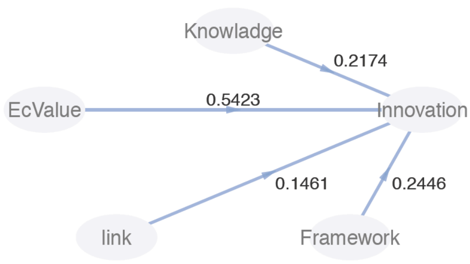


Figure 7 Global Model 2007

Figure 8 Global Model 2008

6. Conclusions

The aim of this paper was to present a conceptual framework representing a Self-Sustaining Regional Innovation System. This framework is the core of a more extended set of models and tools we aim to develop in order to support policymakers in understanding, assessing and supporting the development of Regions in Europe, in particular lagging regions.

The conceptual framework we propose here has been also validated statistically, giving us the possibility to present a cluster analysis of 120 European Regions based on differences in the structure of their innovation model. The paper has been mostly focused on the building up of the interpretative model and, as a consequence, an extensive analysis of ranking and clustering results has not been made. Our aim, at this stage of the research, was to frame the theoretical problem and to start to identify a methodological approach. The final objective of this research is to create a more complete platform to support policymakers in analyzing and supporting Regions with development gaps. Future steps of the research will concern some theoretical, methodological and practical aspects. From a theoretical point of view, we aim at identifying not only the impact of resources (knowledge, economic value, links, framework) on the innovation performance, but also the relationships among the actors producing the resources, using a social network analysis approach.

From a methodological point of view, next steps of the research will focus on the identification of additional indicators to better characterize the building blocks of the model.

From a more practical point of view, next stage of the research will be devoted to focus on lagging European Regions in order to better clarify the reasons beyond their reduced innovation capacity in terms of self-sustainability.

7. References

Andersson M., Karlsson C., (2004). Regional Innovation Systems in Small & Medium – Sized *Regions in the Emerging Digital Economy: Entrepreneurship, Clusters and Policy*. Berlin, Springer-Verlag.

Asheim B., Coenen L., (2005) Knowledge bases and regional innovation systems: Comparing Nordic clusters., *Research policy*, 34, 8, 1173-1190

Asheim B., Isaksen, A., (1996). Location, Agglomeration and Innovation: Towards Regional Innovation Systems in Norway, STEP Report R-13, Oslo.

Asheim B., Isaksen, A., (2002). Regional Innovation Systems: The Integration of Local 'Sticky' and Global 'Ubiquitous' Knowledge. *Journal of Technology Transfer*, 27, 77-86.

Barca F. (2009), "An Agenda for the Reformed Cohesion Policy", Report to the Commissioner for Regional Policy, Brussels, April

Brenner, T. and Greif, S. (2006): The Dependence of Innovativeness on the Local Firm Population – An Empirical Study of German Patents, *Industry and Innovation*, 13, 21-39.

Breschi, S. & Malerba, F., (1997). Sectoral systems of innovation. *Systems of Innovation.* Pinter. London.

Brine J., (2006). Lifelong learning and the knowledge economy: those that know and those that do not – the discourse of the European Union. *British Educational Research Journal*, 32, 5, 649-665.

Camagni R., Capello R. (2012), "Regional Innovation Patterns and the EU Regional Policy Reform: Towards Smart Innovation Policies, Paper presented at the 52° ERSA Conference in Bratislava, 21-24 August 2012.

Carlsson B., Stankiewictz R., (1991). On the nature, function and composition of technological systems. *Journal of Evolutionary Economics*, Volume 1, Number 2, 93-118.

Cooke, P. (2001). From Technopoles to Regional Innovation Systems: The Evolution of Localised Technology Development Policy", Centre for Advanced Studies, University of Wales, Vol. XXIV:1.

David P. A., Metcalfe S., (2007) "Universities and public research organisations in the ERA", Draft Report (v.3) prepared for the Knowledge for Growth (K4G) Expert Group, EC (DG-Research), June 8

Doloreux D., (2002). What we should know about regional systems of innovation. *Technology in Society*, 24, 243-263

Doloreux D., Parto S., (2004). Regional Innovation System: A Critical Synthesis. *UNU-INTECH Discussion Paper Series 2004-17*, United Nation University, Maastricht, The Nederlands.

Doloreux D., Parto S., (2005). Regional innovation systems: Current discourse and unresolved issues. *Technology in Society*, 27, 2, 133-153.

EC – Commission of the European Communities, (2010a). Europe 2020. A Strategy for Smart, Suitable and Inclusive Growth, Communication from the Commission, COM(2010) 2020.

EC – Commission of the European Communities, (2010b). Regional Policy Contributing to Smart Growth in Europe, COM(2010)553, Brussels.

EC - Commission of the European Communities, (2011). Research and Innovation Strategies for Smart Specialization - COHESION POLICY 2014-2020. Factsheet available on line: http://ec.europa.eu/regional_policy/sources/docgener/informat/2014/smart_specialisation_en.pdf.

ESPON, (2012). "Knowledge, Innovation, Territory (KIT)", Final Report available on line http://www.espon.eu/main/Menu_Projects/Menu_AppliedResearch/kit.html.

EspositoVinzi V, Trinchera L, Squillacciotti S, Tenenhaus M (2008) REBUS-PLS: A response-based procedure for detecting unit segments in PLS path modelling. Appl StochModels Bus Ind 24(5):439–458.

Esposito-Vinzi, V., Trinchera, L. and Amato, S. (2010). PLS Path Modeling: From Foundations to Recent Developments and Open Issues for Model Assessment and Improvement. In Handbook of Partial Least Squares, V. Esposito-Vinzi, W. W. Chin, J. Henseler and H. Wang Eds., Springer Heidelberg.

Fischer M., (2001). Innovation, knowledge creation and systems of innovation. The Annals of Regional Science, 35, 2, 199-216.

Florida R., (1995), "Toward the Learning Region", Futures, 27, 527-536.

Foray D., David P., Hall B., (2009). "Measuring Smart Specialisation: The concept and the need for indicators", available on line: http://www.iktimed.eu

Foray D., David P. A., Hall B. H. (2011). "Smart specialization From academic idea to political instrument, the surprising career of a concept and the difficulties involved in its implementation", MTEI Working Paper, November

Freeman, Ch., (1987). Technology policy and economic performance, Lessons from Japan; SPRU, Pinter Publishers, London.

Gustavsen B., Nyhan B. and Ennals R., (2007). "Learning together for local innovation: promoting learning regions", Cedefop Reference series 68 Luxembourg: Office for Official Publications of the European Communities.

Hollanders, H., Tarantola S., Loschky A, (2009). *Regional Innovation Scoreboard (RIS) 2009*. Pro Inno Europe.

Hollanders H., van Cruysen A., (2008). Rethinking the European Innovation Scoreboard: A New Methodology for 2008-2010. *Pro Inno Europe Thematic Papers*

Innovating regions in Europe. Final report of IRE Working Group. (2008). *Effective regional innovation systems*

Isaksen, A., (2001). Building Regional Innovation Systems: Is Endogenous Industrial Development Possible in the Global Economy? *Canadian Journal of Regional Science*, 1, 101-120.

Hollanders H., van Cruysen A., (2008). Rethinking the European Innovation Scoreboard: A New Methodology for 2008-2010. Pro Inno Europe Thematic Papers

Jöreskog K.J. (1973): A general method for estimating a linear structural equation system. In A.S. Goldberg & O.D. Ducan (Eds.), *Structural equations models in the social sciences*, New York:Academic Press: 85-112

Kaplan D. (2009): Structural Equation Modeling, Foundations and Extensions. *Advanced Quantitative Techniques in Social Sciences Series* (10).

Keune M., Kiss J.P., Tóth A., (2004) Innovation, actors and institutions: change and continuity in local development policy in two Hungarian regions, *International Journal of Urban and Regional Research*, 28, 3, 586–600

Lundvall, B., (1992). *National systems of innovation. Toward a theory of innovation and interactive learning.* Pinter London.

Lundvall B., Johansson, (1994). "The Learning Economy ", Journal of Industry Studies, 1(2), 23-42

Miller M.B. (1995). Coefficient alpha: A basic introduction from the perspectives of classical test theory and structural equation modeling. *Structural Equation Modelling* 2(3): 255-273

Muller E., Zenker A., (2001). Business Services as Actors of Knowledge Transformation: the Role of KIBS in Regional and National Innovation Systems. *Research Policy*, 30, 9, 1501–1516.

OECD, (2001). "Cities and Regions in the New Learning Economy".

OECD publishingOECD, (2010). Measuring innovation. OECD publishing.

OECD, (2011). Regions and Innovation Policy. *OECD Reviews of Regional Innovation*.

Powell W. W., Koput K. W., Smith-Doerr L., (1996). Inter-organizational collaboration and locus of the innovation: networks of learning in biotechnology. *Administrative science quarterly*, 41, 116-145.

Podolny, J. M., Page, K. L. (1998). Network forms of organization. *Annual Review of Sociology*, 24: 57-76.

Sanchez and Trinchera L. (2013). plspm http://cran.r-project.org/

Saxenian A., Hsu J. Y., (2001). 'The Silicon Valley-Hsinchu Connection: Technical Communities and Industrial Upgrading', *Industrial and Corporate Change,* 10, 4, 893–920

Schwandt, D. R. (1997). Integrating strategy and organizational learning. In Shrivastava P., Huff A. S., Dutton J. E., (Series Eds.), Walsh J. P., Huff A. S., (Vol. Eds), *Advances in Strategic Management: Organizational learning and strategic management*. 14, 337-359

Schwandt D.R., Marquardt M. J., (2000). *Organizational learning. From world-class theories to global best practices. Boca Raton: St. Lucie Press.*

Schmitt M. (1996): Uses and abuses of coefficient alpha. *Psychological assessment* 8(4): 350.

Tenenhaus M.(2008), Component-Based Structural Equation Modelling, *Total Quality Management & Business Excellence* 19 (7–8): 871–886

Tiwari R., Buse S., (2007). Barriers to Innovation in SMEs: Can the Internationalization of R&D mitigate their effects?, Working paper 50, Hamburg University of Technology, Germany.

Tenenhaus M, Amato S, Esposito Vinzi V (2004). A global goodness-of-fit index for PLS structural equation modelling. In: Proceedings of the XLII SIS scientific meeting. pp 739–742.

Tödtling F., Trippl M., (2005). One size fits all? Towards a differentiated regional innovation policy approach. *Research Policy*, 34, 1203-1219

Uzzi B., (1996). The sources and consequences of embeddedness for the economic performance of organizations: The network effect. *American sociological review*, 61, 674-698.

Woodward D., Figueiredo O., Guimaraes P., (2006). Beyond the Silicon Valley: University R&D and high-technology location. Journal of Urban Economics, 60, 15-32.

ABSTRACT

This paper aims at contributing to the debate of scholars and policymakers on models and instruments to support regional innovation. The focus is represented by Regional Innovation Systems. The specif contributions of this work concern: i) the presentation of a conceptual framework of Self-Sustaining Regional Innovation Systems; ii) the discussion of some implications that this model could produce in terms of measurement tools to support policymakingat; iii) the presentation of a first application of the proposed interpretative model to the clustering of European Regions (level NUTS2), in order to preliminary show some advantages offered by the proposed measurement tool with respect to metrics assumed as a reference in the European policy framework.