Openness, internationalization and innovation effectiveness in regional innovation systems

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Globalizazioa, produktu eta zerbitzuen ezagutza-intentsitatea, eta Regional Innovation Systems (RIS) elkar indartzen duten hiru kontzeptu dira. Ezagutza kodetua globalki eskuragarri bilakatzen da, isileko ezagutzari funtsezko eginkizuna esleituz lehiakortasun globala lortzeko erregio edo eskualdeetan. Azken horren mugikortasun mugatua da indar nagusia ekonomiaren eskualde-kontzentraziorako, eta kanpo-eginkizuna berriz erabakigarria da bi motako ezagutzarako, nazioartekotzea eta irekitasuna alderdi osagarriak direlarik.

Giltza-Hitzak: Berrikuntza. Nazioartekotzea. Irekitasuna. Isilekoa. Kodetua. Ezagutza-distantzia. RIS.

La globalización, la intensidad en el conocimiento de los productos y servicios, y los Sistemas Regionales de Innovación (SRI) son tres conceptos de refuerzo. El conocimiento codificado se vuelve disponible en todo el mundo, asignando a los conocimientos tácitos un papel clave a la hora de lograr una competitividad global de las regiones. La escasa movilidad de éstas últimas es la principal fuerza impulsora de la concentración regional de la economía, mientras que la función externa es determinante para ambos tipos de conocimiento, siendo la internacionalización y la apertura aspectos complementarios.

Palabras Clave: Innovación. Internacionalización. Apertura. Tácito. Codificado. Distancia Cognitiva. SRI.

La mondialisation, la connaissance approfondie des produits et services et les Systèmes Régionaux d'Innovation sont trois concepts de renforcement. Le savoir codifié devient disponible au niveau mondial et les connaissances tacites acquièrent un rôle-clé pour gagner en compétitivité globale au niveau des régions. La mobilité limitée de ce dernier facteur constitue la principale force de concentration régionale de l'économie, tandis que le rôle externe est déterminant à la fois pour l'internationalisation et les aspects complémentaires d'ouverture.

Mots-Clés : Innovation. Internationalisation. Ouverture. Tacite. Codifié. Distance cognitive. Systèmes Régionaux d'Innovation.

1. INTRODUCTION

Pluralism with inclusive political institutions allowing broad participation is according to Daron Acemoglu, author of the book "*Why nations Fail?*" (ACEMOGLU & ROBINSON, 2012), for which he has been nominated as a candidate to receive the Nobel Prize in 2012, key to achieve higher economic growth. This paper offers an explanation to this relationship based on how the external environment influences the innovation performance of a RIS. The role of external codified knowledge flows form will be analyzed, here internationalization, as well as the role of tacit knowledge with external background will be examined, referred to it as openness. Moreover, correlations between these two knowledge types are compared to determine the degree of significance and analyzed according to the economic development stage of the RIS. The answer to these questions will provide us with a first criterion to determine the importance of the external role in the innovation process. A theory to determine direction of causality is presented that need to be examined empirically in future research.

In relation to the external role in innovation, the European Innovation Scoreboard has commissioned a research study on the relationship between innovation and internationalization, which showed a clear association at all levels of analysis, in particular between innovation and outward Foreign Direct Investment (FDI) as well as between innovation and foreign human resources (FILIPPETTI, 2009). Nevertheless, it could not show the direction of causality. As a consequence, internationalization policies cannot be clearly formulated. A detailed analysis of the knowledge types involved and its interaction would provide more information and enable a clear understanding of the interactions. In fact, the role of the external environment in innovation systems has not received in the literature the attention one would expect, given the recognition that globalization has received in European Commission (EC) policy documents including the Lisbon Agenda, referring to globalization as one of the four most important challenges for the European Union. Globalization is considered as the key in the process of transformation to a knowledge and service economy that is as profound as the earlier changeover from agriculture to industry (COMMUNITIES, 2008).

Bathelt's et al concept of knowledge creation in clusters and its relation to spatiality is most prominent in the literature of external linkages (BATHELT, MALMBERG, & MASKELL, 2004). Knowledge creation in a successful cluster is based on local buzz, which represent the informal information exchange within a cluster, and is fueled by global knowledge pipelines. The two information exchanges are complementary and lay the foundation for a competitive cluster. Furthermore, –together with the phenomenon of globalization–, it has been observed that the more knowledge intensive economic activities are, the more these economic activities seem to concentrate in few locations around the world (MASKELL & MALMBERG, 1999). A logical explanation to this phenomenon might built on Polany's essay on *The logic of tacit Inference* (Michael POLANYI, 1966). He described the characteristics of knowledge, referring to tacit knowledge as knowledge that cannot be written down, whereas

codified knowledge is knowledge written down in a codebook (P. COHEN & STEINMUELLER, 2000), see also (MALERBA & ORSENIGO, 2000)). Both knowledge types are needed and complement each other during the process of its creation (NELSON, 1982). Therefore, since economic activities are increasingly based on knowledge, and the easier it is for economic agents to access knowledge from anywhere in the world, the more important gets the information that cannot be accessed.

Nevertheless, the flow of codified knowledge might be conditioned by the absorptive capacity of the Regional Innovation System (RIS), being the ability to identify, assimilate and exploit knowledge from the environment (W. M. COHEN & LEVINTHAL, 1990). The pivotal role that tacit knowledge has taken, leads to geographical concentration, since its exchange requires frequent face-to-face meetings (PARRILLI, 2011b). Hence, globalization, knowledge intensity and regionalization of the innovation process are three aspects of the same coin. Nooteboom (NOOTEBOOM, 2000) claimed that an "optimal cognitive distance" is needed as a means to favor innovation. According to Boschma et al (BOSCHMA, 2010), cognitive distance refers to the degree of overlap between two actors concerning their knowledge bases.

Nooteboom acknowledged that close proximity in cognitive distance ensures high absorption capacity, but if knowledge bases are too similar, then the likelihood of an innovative recombination is lower than when two divergent knowledge bases are merged. There is an apparent trade-off between increasing absorptive capacity by reducing cognitive distance to external knowledge bases, and the need for a certain cognitive distance to enable an innovative recombination of that knowledge, which led to the formulation of the proximity paradox (BROEKEL & BOSCHMA, 2012):

While proximity may be a crucial driver for agents to connect and exchange knowledge, too much proximity between these agents on any of the dimensions might harm their innovative performance.

The hypothesis of this paper is based on the assumption that this paradox can be explained by differentiating the codified from the tacit part of knowledge. The argument is that depending on the knowledge type involved, i.e. codified or tacit knowledge, cognitive distance between knowledge bases has to be reduced or increased to enhance innovation performance. Efforts to decrease the cognitive distance of the codified knowledge base between the RIS and external knowledge would increase absorptive capacity. Knowledge could travel large distances with little transaction costs. On the other hand, tacit knowledge bases can only be exchanged locally through face-to face contacts (HILDRUM, 2009; PARRILLI, 2011b). Hence, tacit knowledge cannot travel through space or is associated with very high coordination costs. At the local level however, coordination costs are less important and counterbalanced by the beneficial aspect of a potential innovative recombination of divergent knowledge bases.

The paper will examine in the next chapter the literature of the RIS. Tacit knowledge, which plays a key role in a competitive innovation system,

is characterized by its limited geographic mobility. Therefore, RIS is a key concept, which is reinforced by the increased knowledge intensity of products and services on the one hand and the globalization process on the other. The third chapter will review the literature on knowledge creation that induces innovation in firms and organizations. The fourth chapter will provide a review of the literature on the role of the external environment in the innovation process. Chapter five will present the model and findings based on national data in the European Union of 2008. The paper determines the drivers of innovation by relating it to innovation outputs. We will conclude the findings in chapter six and determine future research lines.

2. REGIONAL SYSTEMS OF INNOVATION

A Regional System of Innovation (RIS) is the idea that a relationship can be established between the knowledge actors and the place (LORENTZEN, 2009). Cooke was first using the concept with the idea that (COOKE, 1992), within a state, a great diversity may exist that support the need for a more differentiated analysis at a sub-national level. Until then, Innovation Systems were mentioned in relation to the Nation State. Freeman (FREEMAN, 1987), Nelson et al. (NELSON, 1982), Lundvall in 1992 (LUNDVALL, 1992), are among the most cited authors. The most important aspect to be taken into account in the regionalization of the innovation concept is that economic specialization –through production systems organized worldwide–, together with economy activity increasingly based on knowledge –and therefore increasing importance of geographically limited tacit knowledge–, are the main reasons why globalization and regionalization are reinforcing each other.

According to Cooke, a RIS would be in place if and when the regional production structure (the 'knowledge exploitation subsystem') and the regional support infrastructure (the 'knowledge generation subsystem') were systematically engaged in interactive learning (COOKE, 2001). Under this rather strict definition, only 4 out of 11 European regions analyzed in the EC funded REGIS project could claim to be one (COOKE, 2000). While Cooke claims that the existence of a RIS is rather the exception than the rule, others state that all regions have some kind of a RIS in place (BUNNELL & COE, 2001), referring to it as part of a Global Production Network (GPN). In fact, less consideration has been given to the potentials of the information and transportation technologies in linking people and places across the globe, reducing geographical, societal (which stands for the different societal mechanisms and structures that motivate actors to share goals) and cognitive (that covers cultural and technological mindsets that enable understand each other) proximity. Local and regional policies should enable access to global knowledge, focusing on societal mobility resources (infrastructure), or relational capabilities of local firms (language or technology skills).

The paper not only focuses on the role of internationalization in a RIS, thus building on the above mentioned neglected case, but also takes into account the external role at the local level. Internationalization can be activities of

innovation collaboration with companies located in foreign countries, outward Foreign Direct Investment (FDI) or participation in expert exchange programs. Openness interferes with the local tacit base, with globalization bringing different knowledge bases into the regional innovation systems. Since tacit knowledge is immobile by definition (HILDRUM, 2009), openness refers to the idea that non-native aspects that are available locally increase the cognitive distance of the tacit knowledge base. By increasing the cognitive distance of the tacit knowledge base, innovative performance might increase as a result of merging divergent tacit knowledge bases (NOOTEBOOM, 2007). Immigration might be a typical example, be it recent or not, highly qualified or not, but also inward FDI –by bringing in new working methods into the RIS– or variables that provide us hints on the acceptance level of foreign sourced ideas. Another valuable aspect of this analysis is that it offers the RIS literature a dynamic approach taking into account economic development stage of the territory. Catching-up territories could be differentiated to highly innovative ones. Hence, the critic of the RIS literature as being too static would be tackled (UYARRA, 2010). The next section will deal in detail with the knowledge bases involved in the innovation process.

3. KNOWLEDGE IN THE INNOVATION PROCESS

Empirical results show that innovation and economic growth figures are strongly correlated in the regions of the EU. Input variables of innovation including public and private investment in R&D&i are with a value of 0.87 strongly correlated to innovation output indicators including patents and publications (NAVARRO, 2011). Input variables refer to knowledge, i.e. knowledge that precedes innovation (PARRILLI, 2011b), and since innovation activity is among other strongly correlated to economic growth[1], policy activity, or activities in the firms to increase productivity, is dedicated to support the creation of knowledge to enable innovation taking place.

Knowledge can be embedded in the region or reside externally, it can be tacit or codified (Michael POLANYI, 1966). According to Polanyi, the process of acquiring tacit knowledge is equivalent to the process by which humans orient themselves in unknown territory and make sense of the world. Cultural misunderstandings are typical examples resulting from different tacit knowledge bases. People interiorize particulars about new phenomena that they perceive into subsidiary consciousness. He argued, sharing of tacit knowledge is about people jointly creating a social environment. It is about people assisting one another in discovering new things and in solving new kinds of problems. Several forms of communication and interaction –such as the exchange of educational textbooks and manuals, skillful instruction, demonstration, imitation and the

1. Economic growth is one of many beneficial outcomes of innovation, which can also help in reducing the resource intensity of the economy or be related to societal improvements. Economic growth though is probably the greatest incentive for actors to engage in this activity.

accumulation of individual and shared practical experience– play important and complementary roles.

Codified knowledge is knowledge that has been written down and whose principles are in codes, rules, procedures in textbooks. Furthermore, everything that is articulable is codifiable, and everything that has been articulated is actually codified. Lundvall et al. (B. Å. LUNDVALL, JOHNSON, & LORENZ, 2002) classify individual knowledge into *know-what, know-why, know-who*, and *know-how*. *Know-what* are facts, *know-why* are laws in motion in nature, *know-who* is the social ability to communicate and co-operate with different kinds of people, *know-how* is the ability to do something. While *know-what* and *know-why* may be obtained through reading books, attending lectures and accessing data bases, the two other categories are more rooted in practical experience, these are only partly codifiable and typically developed and kept within the borders of the individual firm.

Haruyama (HARUYAMA, 2009) explained the relationship with an example from the biotechnology sector, stating that codified knowledge is the activity of publishing in journals; its implementation though requires tacit knowledge. For instance the invention of hybrid corn, which is a superior corn, was not adaptable immediately to other locations. Creating adaptable hybrid corns required a superior knowledge of the technique and the location. The more experience was gained through adapting corns, the higher the tacit knowledge that was required to successfully adapt the corns to the location. Tacit technology here is the ability to use and create new technologies.

Nonaka (Nonaka & Takeuchi, 1995) suggest that knowledge is created and applied through a process of social interaction in which tacit knowledge is shared by socialization, translated into explicit knowledge, combined with other elements of explicit knowledge and finally internalized into tacit knowledge. Complementarities of tacit and codified elements of knowledge are often what matters most, a fact that nearly all authors stress in their analysis (COE, HESS, YEUNG, DICKEN, & HENDERSON, 2004; Cohendet et al, 2000; NONAKA & TAKEUCHI, 1994; Michael POLANYI, 1966) Cowen et al (2000), (COE, et al., 2004; JENSEN, JOHNSON, LORENZ, & LUNDVALL, 2007; PARRILLI, ARANGUREN, & LARREA, 2010). While some RIS or firms may rely more on one knowledge type than the other, depending on their economic specialization and development stage, no one can rely on one knowledge-type alone. In fact, many authors have theorized on the optimum balance of tacit and codified knowledge (AMIN & COHENDET, 2004; JENSEN, et al., 2007), stressing the impossibility of substitution.

The importance to distinguish between tacit and codified knowledge in relation to Innovation Systems is important when considering its geographic mobility. Globalization, encouraged by the intrusion of advanced technologies in economic activity –mainly Information and Communication Technologies (ICT) and Transport–, together with the transition of the economy towards a learning economy (LUNDVALL & JOHNSON, 2002), has made it possible that first, mobile codified knowledge is more accessible than in the past, and second,

that knowledge creation is increasingly dependent on immobile tacit knowledge. As a logical consequence, the more knowledge intensive economic activities are, the more these economic activities seem to concentrate in few locations around the world (MASKELL & MALMBERG, 1999).

Access to codified knowledge does not necessarily mean that the firm is able to make productive use of it. Cohen et al. (W. M. COHEN & LEVINTHAL, 1990) refers to absorptive capacity and defines it as the firm's ability to identify, assimilate and exploit knowledge from the environment. By investing in R&D, not only the knowledge base is increased, but also the cognitive distance to other firms' and organizations' knowledge bases is reduced. Presence of well-developed internal capabilities and resources in form of infrastructure, education, universities, other manufacturing sites, trained human resources, etc. will also enhance the absorptive capacity of the firm. The greater the cognitive distance, the higher the coordination costs and the need for local collaboration. However, it was observed that a minimum cognitive distance is required to ensure novel recombination of knowledge bases (BROEKEL & BOSCHMA, 2012).

Nooteboom's research on strategic alliances of firms has found out that innovative performance increase when resource heterogeneity is combined (NOOTEBOOM, 2007). Nooteboom interpreted resource heterogeneity in terms of the cognitive distance between the firms that hold these different resources. Nevertheless, large cognitive distance requires frequent meetings, which reduce the geographic scope of the knowledge exchange. Close proximity of cognitive distance between actors increase absorptive capacity in firms or regions. At the same time, a too close proximity of cognitive distance could result in knowledge lock-in. In his empirical work Nooteboom found out that in the case of exploiration activities, the need for cognitive distance is more important than for exploitation activities. The more knowledge involved, the larger the cognitive distances needed to find novelty according to his empirical analysis.

Boschma (2009) further elaborated on this idea distinguishing four forms of proximity (cognitive, geographical, social and organizational) and found interesting results applied on case-studies in the aircraft industry in the Netherlands (BROEKEL & BOSCHMA, 2012). Geographically close partners that have divergent knowledge bases are likely to increase firms' innovation performance. Therefore, reducing cognitive distance between actors has an unclear effect for innovation activities. It reduces coordination costs, but potential for novel innovative recombination is also reduced. From the above authors we can conclude and formulate our hypothesis: Cognitive distance should be reduced to increase the absorptive capacity and enable the flow of distant, codified knowledge. At the same time, cognitive distance should be increased of geographically close, tacit knowledge. The external role is relevant in both processes and its role in the innovation process will be explained more in detail in the next chapter.

4. THE EXTERNAL SOURCES OF KNOWLEDGE IN THE INNOVATION PROCESS

The European Innovation Scoreboard has commissioned a study investigating the relationship between innovation and internationalization (HOLLANDERS, TARANTOLA, & LOSCHKY, 2009). All variables analyzed where correlated, particularly outward Foreign Direct Investment (FDI) and international Human Ressource (HR) have shown strong correlation with innovation output variables. The apparent relevance of internationalization in the innovation process and the significant knowledge gaps that persist in this area is not reflected by the research activity. Only between 0.1% and 3% of all innovation papers are related to internationalization[2]. Our work examines the external role in RIS by differentiating between internationalization and openness. The benefit of the external role in regionalized innovation systems in our model is twofold. On the one hand, RIS establish networks to receive external knowledge in codified form (based on Global Knowledge Pipelines (BATHELT et al, MALMBERG, & MASKELL, 2004)). On the other, RIS open up to improve the tacit knowledge base locally to increase the cognitive distance internally and allow the merger of distant cognitive, but geographically close knowledge bases to create innovate reconfigurations (based on (BROEKEL & BOSCHMA, 2012)).

The literature on innovation and the external role can be distinguished weather it is the firm, the cluster or the innovation system (national or regional) that is the focus of analysis (CARLSSON, 2006). Moreover, analysis has been formed around certain concepts that can be described as the tools or the conditions through which knowledge is conveyed, including Global Commodity Chains (GCC), Global Value Chains (GVC), and Global Production Networks (GPN) (YEUNG, 2011). Most research is based on Bathelt's exercise (BATHELT, et al., 2004) on clusters and global knowledge pipelines. Two information exchanges, local buzz and global knowledge pipelines, form two complementary sources of information that lay the foundations for a competitive cluster. More specifically, local buzz is continuous information and communication exchange due to accidental or organized meetings, face-to-face contacts, co-presence, co-location of people and firms, and even gossip, rumors. This leads to a similar interpretative scheme and mutual understanding of new knowledge and technologies. The main feature of local buzz is that it is received almost automatically, spontaneous and leads to a fine grained information transfer. Knowledge exchange through global knowledge pipelines occurs consciously and systematically, it needs trust and time and is therefore costly. Moreover, communication through global knowledge pipelines is characterized by great uncertainty. Common institutions have to be built up, procedural rules defined with constant revision and refinement. Global knowledge pipelines are embedded in different cultural environments and socio cultural settings,

2. Around 0.1% of innovation titles in EBSCO literature search are related to internationalization, while 3% if searched in Google Scholar text search. The literature on innovation and internationalization is steadily increasing though, with higher percentages for latest article searches.

which call for effective integration. They may prevent clusters from over-embeddedness, i.e. a too close linkage between firms which may result in knowledge lock-in. External linkages may serve as fuel even in worldwide clusters of excellence to develop new ideas and serve as a pool of external knowledge. The larger the number of firms in a location, the more vibrant and valuable the local buzz, which increases the potential to establish a well developed global knowledge pipeline, which in turn makes the local buzz more valuable and refined.

This stream of literature is in the great majority focusing on the role of acquisition of external knowledge of codified form. RIS are by definition incomplete, in that many, if not most, of the relevant networks, components and functions for innovation in regional firms are extra-regional and, correspondingly, 'the probability that local ties can offer all complementary resources is low'. Hence, RIS knowledge development need to be complemented with external knowledge. The degree of knowledge that can be transported through the pipelines depend on the sophistication of the knowledge pipelines, which has been analyzed under the GCC, GVC and GPN concepts, and the absorptive capacity in the RIS. The lower the cognitive distance of the RIS to the outside world, the better the flow of codified knowledge through the global knowledge pipelines (NOOTEBOOM, 2007).

Furthermore, the previous chapter has stressed the complementary role of codified knowledge and its tacit counterpart. Since no RIS can monopolize all knowledge, it certainly would be valid for the tacit knowledge as well. Therefore, tacit knowledge also needs constant development and upgrading, also through external sources. Based on the importance of tacit knowledge for the competitive position of a RIS, as has been elaborated in the second chapter, it is of particular importance that all available sources for its sophistication is exploited. Hunt (HUNT & GAUTHIER-LOISELLE, 2008) has assessed the impact of skilled immigration on innovation measured by U.S. patents per capita. His empirical investigation could find out, that immigration could boost innovation indirectly through positive spillovers on fellow researchers through the achievement of critical mass in specialized research areas and the provision of complementary skills in management and entrepreneurship. Other studies on openness point into the same direction. Saxenian and others (PHELPS & Wood, 2006; SAXENIAN, 2002; STORPER, FAROLE, & RODRIGUEZ-POSE, 2011; YEUNG, 2011) have all pointed out the critical role of transnational communities for the innovation performance. The role of the transnational communities and migration for the transfer and building of tacit knowledge has also been investigated by Williams and Parrilli (PARRILLI, 2011a; WILLIAMS, 2007). Both stress the importance of the migrant force of skilled human capital as a driver of the local entrepreneurial spirit in very knowledge intensive regions including the Silicon Valley, and suggest that the heterogeneity of social capital is an important factor to enhance creativeness and innovation. Immigrants bring tacit knowledge into a region in form of values, views, way of thinking, that are valuable and that can be exploited.

Different tacit knowledge bases assure different interpretative schemes of the same codified external knowledge. The diversity of conclusions creates the nutrient medium to recombine the knowledge through social interaction, while making it innovative and unique (BROEKEL & BOSCHMA, 2012). Internationalization and openness might form two complementary forces very valuable to increase innovation performance in the territories. Furthermore, the analysis offers a dynamic approach depending on the economic development phase of the RIS. Graph 1 provides examples of variables and indicators that intend to decrease the cognitive distance of the codified knowledge base to external codified knowledge bases –to improve absorptive capacity and enable flow of distant codified knowledge–, and increase the cognitive distance of tacit knowledge bases –to increase innovation potential by novel innovative reconfigurations through a merger. This list is not exhaustive. Internationalization indicators include outward FDI, research and innovation collaboration, participation in exchange programs and others. Regarding tacit knowledge, external role refers to openness and, contrary to the internationalization variables, do play a role in increasing the cognitive distance of tacit knowledge bases inside the RIS. Inward migration, inward FDI or tolerance could be indicators that contribute to its increase. Tools that support the exchange of tacit knowledge include vocational training activities, cluster strength index, urban population among others.

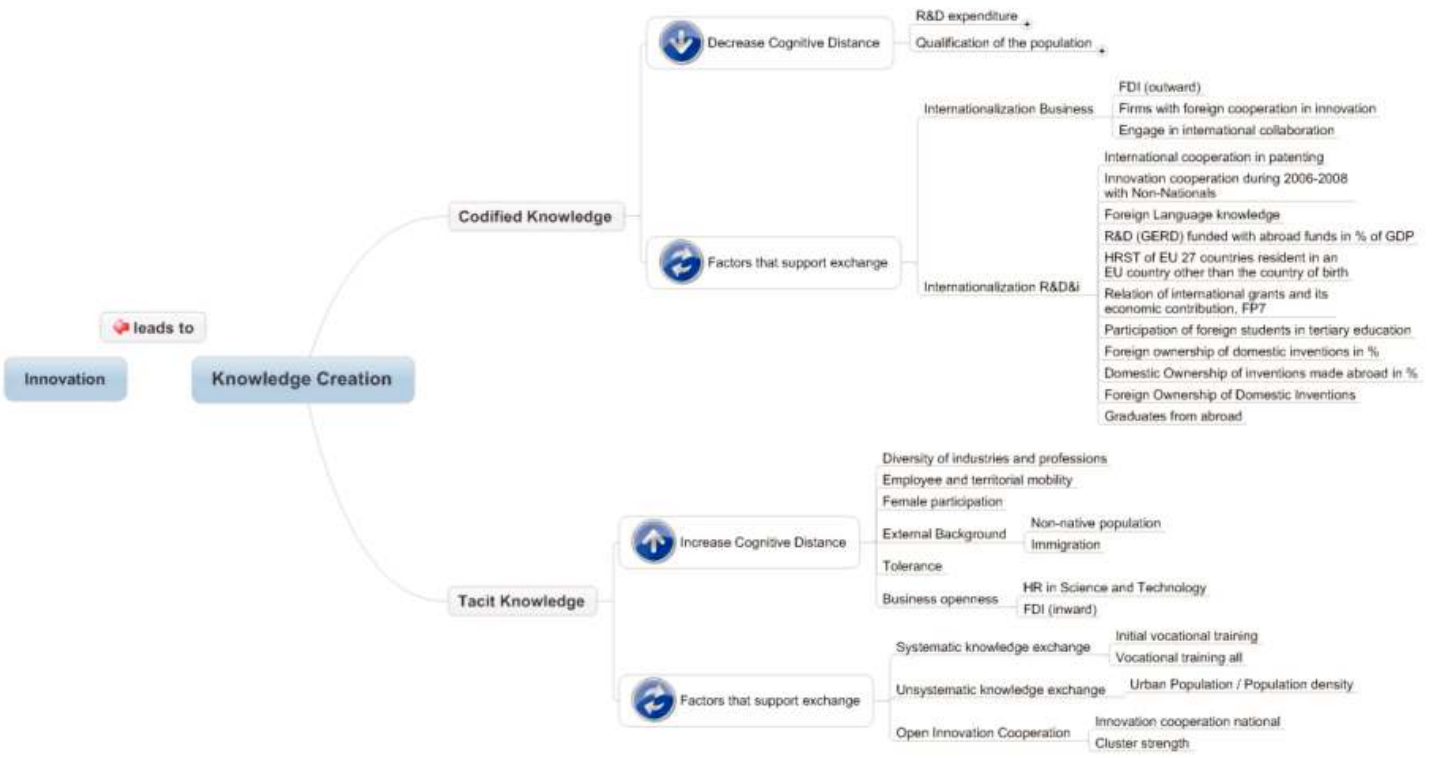
5. MODEL

Data sample in this first analysis are in the great majority 2008 data from the EU-27 member states. Unfortunately, most data is not available at regional level. Nevertheless, this first analysis will provide us with hints on the validity of the concept, which can be used for further analysis at the RIS level in future case studies or for the analysis of specific indicators.

In line with our hypothesis, tendencies and relationships at the RIS level should be stronger than at the national level, result of the regionalization aspect of the economy due to the increasing importance of the tacit knowledge base. Therefore, a relationship that can be observed at national level should be a very strong indicator that this relationship is also valid at regional level. Variables have been selected according to the theory outlined above and are summarized in table 1.

First, tacit knowledge indicators that have been selected relate to external influences provided by openness, separating variables into one that indicates external background in general and another that relates to business operations. These indicators increase the cognitive distance of the tacit knowledge base within the territory. Secondly, codified knowledge variables have been selected that decrease cognitive distance between the codified knowledge base of the country and those located externally, therefore, increasing absorptive capacity of the country. Moreover, indicators have been selected that provide information on internationalization of the business and a last one only related to internationalization of R&D&I activities.

Graph 1. Knowledge, Cognitive Distance and possible indicators, factors that support its exchange



Source: 29/05/2012, own elaboration, archive.

These knowledge creation variables are innovation inputs that are then correlated to innovation outputs in European Union members states. Data relates to the year 2008. Innovation outputs have been segregated into outputs from exploitation activities, and outputs from exploration activities (GILSING & NOOTEBOOM, 2006). Exploitation indicators include those related to actual achieved results in business and those related to innovation in products and services. Exploration results relate to radically new knowledge and their indicators are patents and publications, as well as market for complementary services of these radically new ideas.

Bathelt (BATHELT, et al., 2004) and the absorptive capacity literature is the major reference when selecting indicators regarding collaboration with external knowledge. Cross referencing with external authors provides an indication on the degree of collaboration with external entities (STEINMUELLER, 2000). Others are available resources to access external knowledge, for instance foreign language knowledge of most commonly used languages in the world. Thirdly, a large number of authors in the external knowledge and international business literature field have used a number of variables that could be summarized under international operations. Foreign subsidiaries or outward FDI are considered vehicles that transport codified knowledge from the RIS to other RIS.

Indicators that could provide us with an indication for tacit knowledge flow include population density and distribution of the population into urban and non-urban areas, indicating non-systematic knowledge exchange. Cities are vehicles that enable frequent face-to-face contact and transfer of tacit knowledge bases (BATHELT et al, et al., 2004; LUNDVALL & JOHNSON, 2002). Arundel (ARUNDEL & GEUNA, 2001) and Carlino (CARLINO, 2001) have also shown that an important link between economic growth and concentration of people exist, since the high concentration of people and firms in cities creates an environment in which ideas move quickly from person to person and from firm to firm. Parrilli (PARRILLI, 2011a) also notes on the activation of tacit knowledge that frequency and intensity of interactions are important factors.

Vocational training is an indicator that provides us information on the degree of systematization of the transfer of tacit knowledge in the RIS. As Lundvall notes, the DUI-mode (Doing, Using, Interacting) of innovation, which refers to experience based mode of learning, assigns a major role in mobilizing tacit knowledge for problem solving and learning through informal communication and communities of practice (JENSEN, et al., 2007). The DUI-mode is knowledge that is rooted in experience and refers to the know-how and know-who type of knowledge, that will typically be learnt in apprenticeship-relations where the apprentice follows the master, studies the master's body language as well as the master's spoken language and relies upon his authority (M. POLANYI, 1958). Other possible indicators that could provide hints on the availability, flow and creation of tacit knowledge are mobility of personnel and internal migration, and tolerance among other indicators. Frequent change of jobs is an excellent indicator for a rich tacit knowledge base, since employees take their knowledge from firm to firm, and from sector to sector (P. MASKELL, BATHELT, & MALMBERG, 2006).

Table 1. Knowledge and Innovation Indicators and Variables

#	*Organized as Inputs and Outputs in the Innovation Process*						**Control Variables**
	Tacit knowledge		**Codified knowledge**		**Innovation output**		
	Indicators (Variables) Value and Exchange	Indicators (Variables) of Tacit know. increasing cognitive distance - **Openness**	Indicators (Variables) of Cod. Know. reducing cognitive distance	Indicators (Variables) Value and Exchange - **Internationalization**	Exploit type indicators (Variables)	Explore type indicators (Variables)	
1	**Systemat. knowl. exchange** (Initial Vocational Training in companies; Any Vocational Training in companies;)	**External background** (2nd generation persons with foreign background in %, 2nd generation persons with mixed background in %; 1st generation stock of persons with foreign background; Avg annual immigration 2000-2010 in % of total population; % of persons with non-native background; % of Foreign born population; Bilinguals)	**R&D** (Expenditure in % of GDP; Total R&D Expenditure in % of GDP, only Business Sector; Average (10 years) R&D expenditure (GERD), all sectors in % of GDP, GERD, all sectors in € p.c., 2008; GERD, Source Business sector in % of GDP, 2008; Business enterprise R&D expenditure (BERD), Source Business sector in % of GDP, 2008; Government sector R&D in % of GDP, Source all, 2008; Higher Education sector R&D in % of GDP, Source all, 2008)	**Internationalization Business** (FDI (outward), Firms with foreign cooperation in innovation)	**Business results** (Real labor productivity per hour worked; - % of employment in High-Tech sectors, 2008 (Eurostat); Exports of high technology products as a share of total exports; Imports of high technology products as a share of total imports; Trade Deficit / Surplus of high technology products in %; Employment in knowledge intensive activities in %)	**Patents & Public.** (Total Patents Applications; High Tech Patents Applications; Patent Applications submitted by Business sector in %; Patent Applications submitted by Goverment sector in %; Patent Applications submitted by Higher Education sector in %; Patent Applications submitted by Private Non Profit sector in %; Patent Applications submitted by Individuals in %; Nanotech Patent Applications submitted in %; Biotech Patent Applications submitted in %; ICT Patent Applications submitted in %;Publications)	% of GDP of industry activity

#	*Organized as Inputs and Outputs in the Innovation Process*						**Control Variables**
	Tacit knowledge		**Codified knowledge**		**Innovation output**		
	Indicators (Variables) Value and Exchange	Indicators (Variables) of Tacit know. increasing cognitive distance - **Openness**	Indicators (Variables) of Cod. Know. reducing cognitive distance	Indicators (Variables) Value and Exchange - **Internationalization**	Exploit type indicators (Variables)	Explore type indicators (Variables)	
2	**Unsyst. knowl. exchange** (Population density; % of population living in urban regions)	**Tolerance** (% difference of employment rate difference of native and foreign born; % difference of unemployed between 2nd generation foreign descent and native; % difference of unemployed of foreign born and persons born in the country; % difference of over-qualification rate of foreign born and in country born; % difference of poverty rates of foreign born and in country born; % difference of tertiary education rates of 2nd generation migrants and native)	**Qualification of the population** (% of R&D personnel; % of Business R&D personnel; % of Government R&D personnel; % of Higher Education Sector R&D personnel; % of population with tertiary education; % of HST employment in the total industry; % of Scientist and Engineers employment in the total industry; Students aged 20-29 in Science, and Engineering)	**Internationalization R&D&i** (International cooperation in patenting; Innovation cooperation during 2006-2008 with Non-Nationals; Foreign Language knowledge; R&D (GERD) funded with abroad funds in % of GDP; HRST of EU 27 countries resident in an EU country other than the country of birth; Relation of international grants and its economic contribution, FP7; Participation of foreign students in tertiary education, Foreign ownership of domestic inventions in %; Domestic Ownership of inventions made abroad in %; Foreign Ownership of Domestic Inventions; Graduates from abroad)	**Business Innov.** (Enterprises with Innovation Activity in %; Turnover from innovation as the ratio of turnover from products new to the enterprise and new to the market as a % of total turnover; Enterprises with technological innovation in %; Enterprises with non-technological innovation in %; Enterprises with Novel Product Innovations; Enterprises with Novel Process Innovations; % of enterprises implementing new business practices; % of enterprises with new methods of organising work responsibilities and decision making; % of enterprises implementing new methods of organizing external relations)	**Market for complementary services** (Venture capital market)	% of large companies

#	*Organized as Inputs and Outputs in the Innovation Process*						**Control Variables**
	Tacit knowledge		**Codified knowledge**		**Innovation output**		
	Indicators (Variables) Value and Exchange	Indicators (Variables) of Tacit know. increasing cognitive distance - **Openness**	Indicators (Variables) of Cod. Know. reducing cognitive distance	Indicators (Variables) Value and Exchange - **Internationalization**	Exploit type indicators (Variables)	Explore type indicators (Variables)	
3	**Open Innovation Cooperation** (Innovation Cooperation at national scope by companies with innovation activities; All cooperation activities at national scope by companies with innovation activities; State of Cluster Development;)	**Business permeability** (FDI (inward), Number (thousands) and share (%) of foreign born HR in Science and Technology Core; Share in % of foreign born HR in Science and Technology)					% of population with more than 65 years

Source: 29/05/2012, own elaboration, archive.

Denmark´s labour market is frequently mentioned, particularly from Lundvall, as a labor market that facilitates this knowledge exchange and its specialization on the DUI mode of innovation. Internal migration or census turnover is a similar indicator (VAN DIJK, 2000). Tolerance and diversity could provide us with information on the ability of the RIS to take into account different tacit knowledge bases and incorporate them into the economic activity. Frequently, diversity exists, nevertheless society is unable to take advantage out of it since nodes of communication between various tacit knowledge bases fail. Discrimination of minorities would be an example.

Cluster strength index and vocation training are indicators that measure the degree of systematic tacit knowledge exchange in the territory. Cluster strength is the outcome of an executive opinion survey and provides information on the infrastructure available that enables its exchange and the executive's usage. Different firms congregate to collaborate in its business activities. Vocational training is an important indicator since it transfers tacit knowledge from the master to the apprentice. In countries with powerful initial vocational training schemes, for instance Germany, tacit knowledge, i.e. on the job training is complemented by education schemes in the classroom, being closer to codified knowledge. As noted before, one element regarding tacit knowledge is that innovation performance can be increased by merging two heterogeneous knowledge bases, i.e. tacit knowledge bases with a high cognitive distance (BROEKEL & BOSCHMA, 2012; NOOTEBOOM, 2007). Potential instruments that increase cognitive distance in the RIS are immigrants. They integrate different values and views and ways of acting. For instance, Hunt among others, showed how immigration boost entrepreneurship in the RIS (HUNT & GAUTHIER-LOISELLE, 2008). Immigration introduce new tacit knowledge bases (YEUNG, 2011), that may lead to new conclusions from observing phenomenon and whose exchange might be valuable to produce innovations. Bilinguism has been identified as an important resource to increase cognitive distance. As Bialystok observed based on empirical studies, individuals who actively use two languages evolve differently than monolinguals, bilinguals showing superior cognitive performance (BIALYSTOCK, 2011).

Inward FDI indicates possible spillovers of tacit knowledge at local level. Tacit knowledge that is external to the RIS and increases cognitive distance. Keller (KELLER, 2001) identified international trade and FDI as the major channels for technology diffusion across countries, since international economic activities lead to additional contacts with foreign persons who may possess advanced technological knowledge (exporter, importer, engineers, researchers), this may stimulate the diffusion of (non-codified) foreign technologies. Cohen and Levinthal indicate that these spillovers depend on the absorptive capacity of the region (W. M. COHEN & LEVINTHAL, 1990). In this analysis, we will differentiate innovation output based on Nootebooms approach (NOOTEBOOM, 2000). Output derives from exploitation or exploration activities, exploitation activities being the process where a variety of content consolidates into a dominant design. Exploration activities are experiments conducted with novel elements adopted from a novel context. The latter entails radical reconfiguration of old systems of exploitation, with tacit knowledge playing a more important role.

Variables that indicate innovation output from exploitation activities are productivity and productivity growth, new-to-the-firm products and enterprises with product and process innovations. In manufacturing industries, exploitation activities indicate a shift from product to process innovations, which would typically lead to a productivity increase. Competition shifts to efficient production and distribution, new entrants exert further pressure on price; scale division of labour and specialization emerge. Product variety decreases resulting in minor product adaptations and process improvements. These tendencies can be captured by new to the firm products and processes. Products are introduced for differentiation mainly, while new processes indicate specialization and increased competition. Variables that indicate innovation output from exploration activities are publications and patents, and a market of venture capital. According to Nooteboom, exploration activities are experimentation with new elements while existing basic design principles are increasingly being questioned. Patents and publications are signals for these activities, since every patent and most publications tend to introduce new elements to the science base. Availability of venture capital indicate that there is a market to finance new company ventures to introduce radically new products. Innovation output from exploration activities are novel combinations and entails radical reconfiguration of old systems of exploitation, that can be introduced by established companies and newly created ones. A total of 53 input variables and 28 output variables, and three control variables add up to 84x84=7056 correlations and 84 *p* variables. There are n=27 observations representing the 27 EU member states in 2008. Therefore, *n* observations of *p* variables can be displayed:

Table 2. Observations and variables

EU 27 MS	Variable 1	Variable 2	...	Variable k	...	Variable p
State 1	x [1,1]	x [1,2]	...	x[1,k]	...	x[1,p]
State 2	x [2,1]	x[2,2]	...	x[2,k]	...	x [2,p]
...	...	...	...	...	...	...
State j	x [j,1]	x [j,2]	...	x[j,k]	...	x [j,p]
...	...	...	...	...	...	...
State n	x [n,1]	X[n,2]	...	x[n,k]	...	x [n,p]

Source: 29/05/2012, own elaboration, archive.

The sample covariance and sample correlation coefficient together with its graphical illustrations will provide us with first information on the relations of the datasample. The sample covariance and sample correlation coefficient provides us with information on the relation between the input data and the output data, among all other correlations.

Formula 1. Correlation coefficient between variable *j* and variable *k* is $r_{j,k}$

$$r_{j,k} = \frac{\sum_{i=1}^{n}\left(X_{j,i} - X_{mean_i}\right)\left(X_{j,k} - X_{mean_k}\right)}{\sqrt{\sum_{j=1}^{n}\left(X_{j,i} - X_{mean_i}\right)^2}\sqrt{\sum_{j=1}^{n}\left(X_{j,k} - X_{mean_k}\right)^2}},$$

Source: 29/05/2012, own elaboration, archive.

The range of r is from -1 to 1. If the r value is close to -1 then the relationship is considered anti-correlated, or has a negative slope. If the value is close to 1 then the relationship is considered correlated, or to have a positive slope. As the r value deviates from either of these values and approaches zero, the points are considered to become less correlated and eventually are uncorrelated. To test the validity of the correlations, we can use the p-value, which is the probability of obtaining a result that confirms the null hypothesis. The lower the value, the less likely that the null hypothesis is true and the probability that we will reject it:

Table 3. Correlations

R =		Variable 1	Variable 2	...	Variable k	...	Variable p
	Variable 1	1	r[1, 2]	...	r[1, k]	...	r[1, p]
	Variable 2	r[2,1]	1	...	r [2,k]	...	r[2,p]
	...	...	...	...	...	...	...
	Variable k	r[k,1]	r[k,2]	...	1	...	r[k,p]
	...	...	...	...	...	...	...
	Variable p	r[p,1]	r[p,2]	...	r[p,k]	...	1

Source: 29/05/2012, own elaboration, archive.

To calculate the p-value, we first calculate the z-score and then look up its corresponding p-value using the standard normal table. Z-scores assume the sampling distribution of the test statistic to be normal and transform the sampling distribution into a standard normal distribution. Z is expressed in terms of the number of standard deviations from the mean value.

Formula 2. Z value

$$Z = \frac{X - \mu}{\sigma}$$

Where X being the experimental value, μ the mean and σ the standard deviation

Source: 29/05/2012, own elaboration, archive.

A result is called statistically significant if it is unlikely to have occurred by chance. Popular levels of significance are 10% (0.1), 5% (0.05), 1% (0.01), 0.5% (0.005), and 0.1% (0.001).

Table 4

	O1_Product	O1_InnoAc	O1_InnTurn	O1_InnoTecl	O1_Innonoti	O1_NovProd	O1_NovProc	O1_HighEm	O1_HighExp	O1_HighIm	O1_HighTrac	O1_EmpKno	O1_NewPra	O1_NewRes	O1_NewRel	O13_Em_Hig	O2_Pat	O2_HiPat	O2_BusPat	O2_GovPat	O2_EduPat	O2_PNPPat	O2_IdvPat	O2_NanoPat	O2_BioPat	O2_ICTPat	O2_VC	O23_Publ	
OPENNESS	0,67		-0,58									0,73										0,63				0,58		I2_Frg2nd
	0,60								0,64	0,56	0,57	0,72										0,54						I2_Mixed
	-0,52											-0,52						-0,58	-0,52						-0,59			I2_For1
												0,53										0,63				0,52		I2_Immpy
	0,56																0,66	0,65	0,64				0,53	0,70	0,64		0,65	I2_Native
																												I2_Forborn
	0,77					0,52						0,70					0,74	0,56	0,72			0,54	0,51	0,67	0,62	0,76	0,67	I2_Difemp
																												I2_Intg2
	0,68											0,59					0,66	0,60	0,66			0,53		0,51	0,63	0,53	0,61	I2_Intg1
												0,52																I2_Qua
																												I2_Pove
																												I2_TerE2
																												I2_FDI_in
INTERNATIONALIZATION	0,79											0,82					0,50		0,53			0,50				0,78		I41_FDI out
														0,53														I42_Co-Pat
										-0,50																		I43_In_Col
	0,61																0,67	0,65	0,63			0,57		0,62	0,65		0,71	I4_Lang
																												I4_RDExt
	0,58											0,71										0,59				0,76		I4_ForHRST
																	-0,51											I4_FP7
									0,76	0,62	0,71	0,68																I4_ForHRSTC
																												I4_ForStu
									0,76		0,88																	I4_ForOwnIn
																												I4_DomOwn
																												I4_PatFor
																												I4_GradFor
																												I4_Stuout
																												I4_AirPa
	O1_Product	O1_InnoAc	O1_InnTurn	O1_InnoTecl	O1_Innonoti	O1_NovProd	O1_NovProc	O1_HighEm	O1_HighExp	O1_HighIm	O1_HighTrac	O1_EmpKno	O1_NewPra	O1_NewRes	O1_NewRel	O13_Em_Hig	O2_Pat	O2_HiPat	O2_BusPat	O2_GovPat	O2_EduPat	O2_PNPPat	O2_IdvPat	O2_NanoPat	O2_BioPat	O2_ICTPat	O2_VC	O23_Publ	

Source: 29/05/2012, own elaboration, archive.

If a test of significance gives a p-value lower than the significance level chosen, the null hypothesis is rejected. Choosing level of significance is a somewhat arbitrary task, but for many applications, a level of 5% is chosen, for no better reason than that it is conventional as has been done in this analysis.

A first analysis of all input variables with an external component, i.e. input variables that indicate openness –in light grey–, and variables that indicate internationalization in light blue, both in table 2, show that, after applying a filter for significant correlation and significance, **tacit knowledge components with a positive and significant correlation are more numerous than codified knowledge components**[3]. As was to be expected, highly correlated values with very low significance values have been observed between the tacit knowledge dimension *value and exchange* (systematic and unsystematic knowledge exchange, open innovation cooperation) and the outputs variables, as well as between the codified knowledge dimension with the objective of reducing cognitive distance (R&D and Qualification of the Population) and the output variables. Particular high values have been observed for *initial vocational training*, *all vocational training* activities with *productivity* (0.68, 0.66)[4]. In addition, high *clustering* and *productivity* show with 0.82 even higher values. Furthermore, *clusterisation* seem to favour *employment in knowledge intensive industries*. Moreover, exploration activities seem to benefit from clusterisation as well, showing correlation values of 0.79 and 0.70 in the case of *high technology patents*. *Publications* is also positively correlated with *clusterisation*, with a value of 0.73.

Regarding codified knowledge variable that reduce cognitive distance and innovation output variables, positive correlation can be observed for total *R&D investment* and *productivity* (0.88), *R&D and patents* (0.91) and *R&D and high technology patents* (0.80). *R&D, human resources in science and technology* as well as *percentage of scientists and engineers, scientist and technical personnel*, are all highly correlated to exploitation activities including *productivity, employment in knowledge intensive industries* as well as exploration activities including *patents, high technology patents, venture capital investment, and publications*. All control variables are insignificant. Table 3 below summarizes the most important relations with respect to the external dimension. Within the tacit knowledge sphere, the presence of *non-native inhabitants* in a territory have a positive correlation with *productivity* (0.57), *employment in knowledge intensive industries* (0.67), i.e. exploitation output, and to a lesser extend with outputs of exploration type with *patents* (0.33) and *venture capital* (0.53) showing lower values. *Foreign born human resources in science and technology* show particular high values for *venture capital investment*.

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3. Please observe only the number of available values at the grey zone and at the light blue zone, the meaning of the variables are not important at this stage.

4. Productivity measured in real labor productivity per hour worked, € per hour worked, Eurostat.

Regarding codified knowledge, selected variables include *outward FDI, co-patenting, innovation collaboration, R&D* in the country financed with external sources, participation in *EU research programs (FP7)*, and *domestic owned foreign inventions*. Here, results are less clear, with positive correlations between *outward FDI and productivity* (0.79) as well as *outward FDI* and *employment in knowledge intensive industries* (exploitation output). *Outward FDI* also show positive correlations to *patents, venture capital investment, and publications*. *Co-patenting* and *innovation collaboration with foreign entities* do not show any positive correlation with any output variable, while *R&D financed with external sources* is correlated to *productivity* per hour worked and *patenting* in particular, while *domestic owned foreign inventions* is correlated with *productivity* per hour worked as well as *high tech exports*.

Analyzing selected values in a graph, we can observe the strong correlation with a few outliers of non-native population and productivity (graph 2). Estonia and Latvia show a high percentage of non native population and low productivity per hour worked, while Denmark and Finland with a lower percentage of non-native population show higher productivity values than their non-native value would suggest[5].

Moreover, Finland's and Denmark's high productivity per hour worked is a result of the superior effort in investing in R&D, here denominated as investment to reduce cognitive distance of the codified knowledge base. It is striking, that when R&D investment and the productivity value is analyzed, these countries are among those that underperform substantially. Future analysis should investigate in what way this underperformance is related to the low value of non-native population. The same pattern can be observed when correlating foreign born human resources in science and technology with employment in knowledge intensive industries. Denmark and particularly Finland show low levels of influx of foreign born HR in Science and technology. Regarding the value and exchange of codified knowledge (Internationalization Business and Internationalization R&D&i), results are less clear. Positive correlation can only be observed for outward FDI and the innovation output variables.

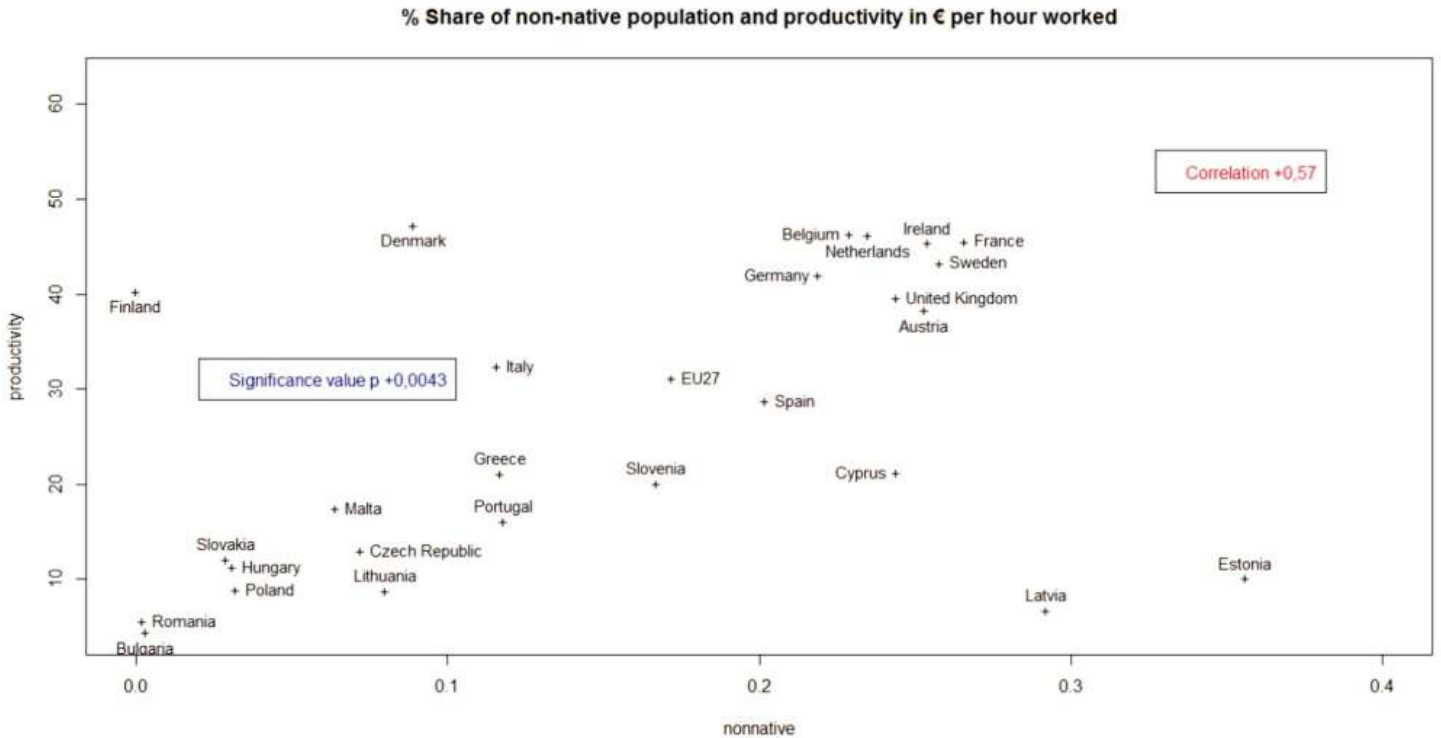
5. Estonia and Latvia have a very high percentage of Russian descendent population that are not naturalized as a result of the break-up of the Soviet Union. The Scandinavian countries are outliers at the other end. Finland and Denmark might compensate the lower value of non-native population and share of foreign HR in science and technology respectively (Finland) with other variables that increase cognitive distance of the tacit knowledge base, for instance Denmarks high labor mobility or Finlands inclusive education system. Labor mobility increases cognitive distance as tacit knowledge bases from other companies and industries are shared. Similar would do an inclusive educational system. Inclusiveness assure heterogeneous classrooms that increase coordination costs but increase cognitive distance.

Table 5: Correlation of input variables with an external dimensión and output. In red values that show a significance, p<5%

O1_Productivity	O1_High Tech Exports	O1_Employ know. ind.	O2_Patenting	O2_Hightech Patenting	O2_Venture Capital	O23_Publications	
0,57	0,32	0,67	0,33	0,11	0,53	0,07	I2_Non-Native
0,58	0,43	0,71	0,32	0,08	0,76	0,19	I2_Foreign HRST
0,79	0,39	0,82	0,50	0,36	0,78	0,44	I4_FDI outward
0,01	-0,01	-0,02	-0,13	-0,19	0,18	0,04	I4_Co-Patenting
-0,25	-0,06	-0,24	-0,25	-0,13	-0,33	-0,24	I4_Innovation Collaboration
0,61	0,11	0,48	0,67	0,65	0,35	0,71	I4_R&D financed abroad
0,29	0,08	0,26	0,36	0,48	0,12	0,40	I4_FP7 participation
0,50	0,76	0,68	0,25	0,19	0,43	0,14	I4_Dom. owned foreign inventions
O1_Productivity	O1_High Tech Exports	O1_Employ know. ind.	O2_Patenting	O2_Hightech Patenting	O2_Venture Capital	O23_Publications	

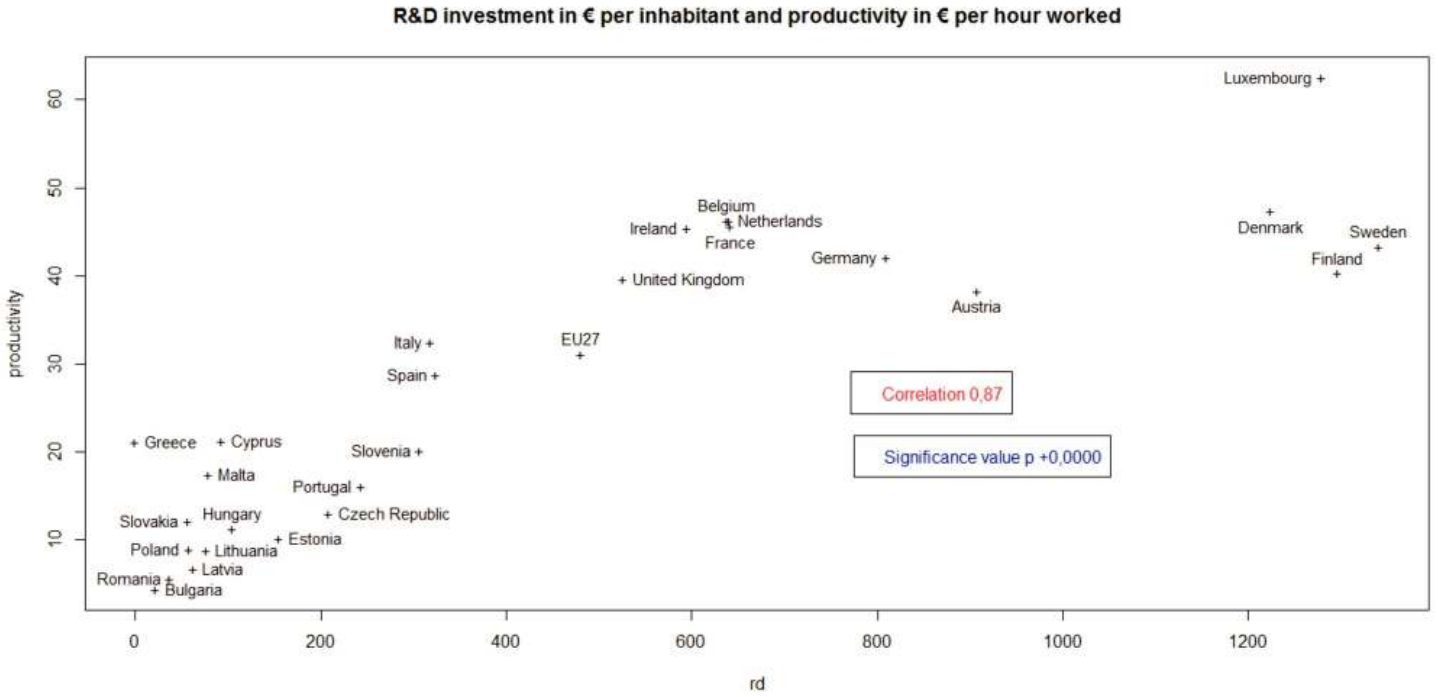
Source: 29/05/2012, own elaboration, archive.

Graph 2: Positive correlation with Finland, Denmark, Latvia and Estonia as Outliers



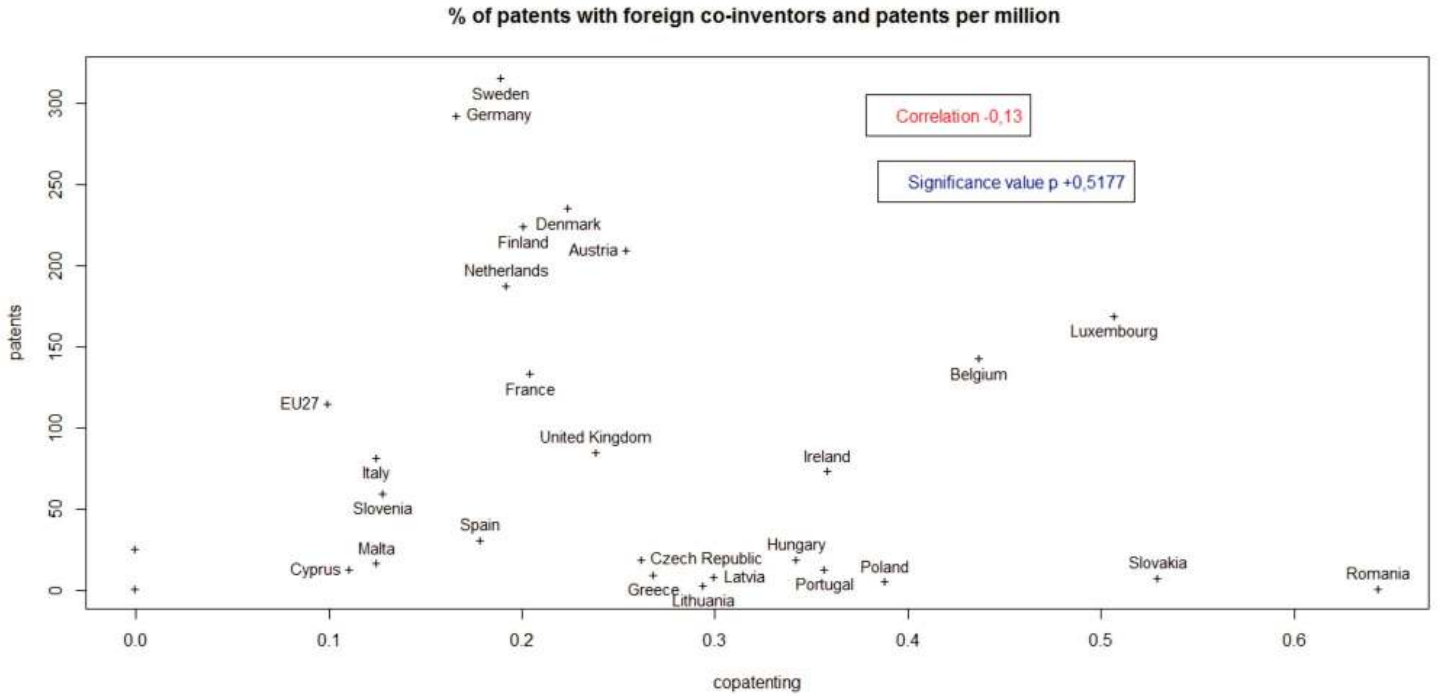
Source: 29/05/2012, own elaboration, archive.

Graph 3: Denmark, Sweden, Finland, underperforming



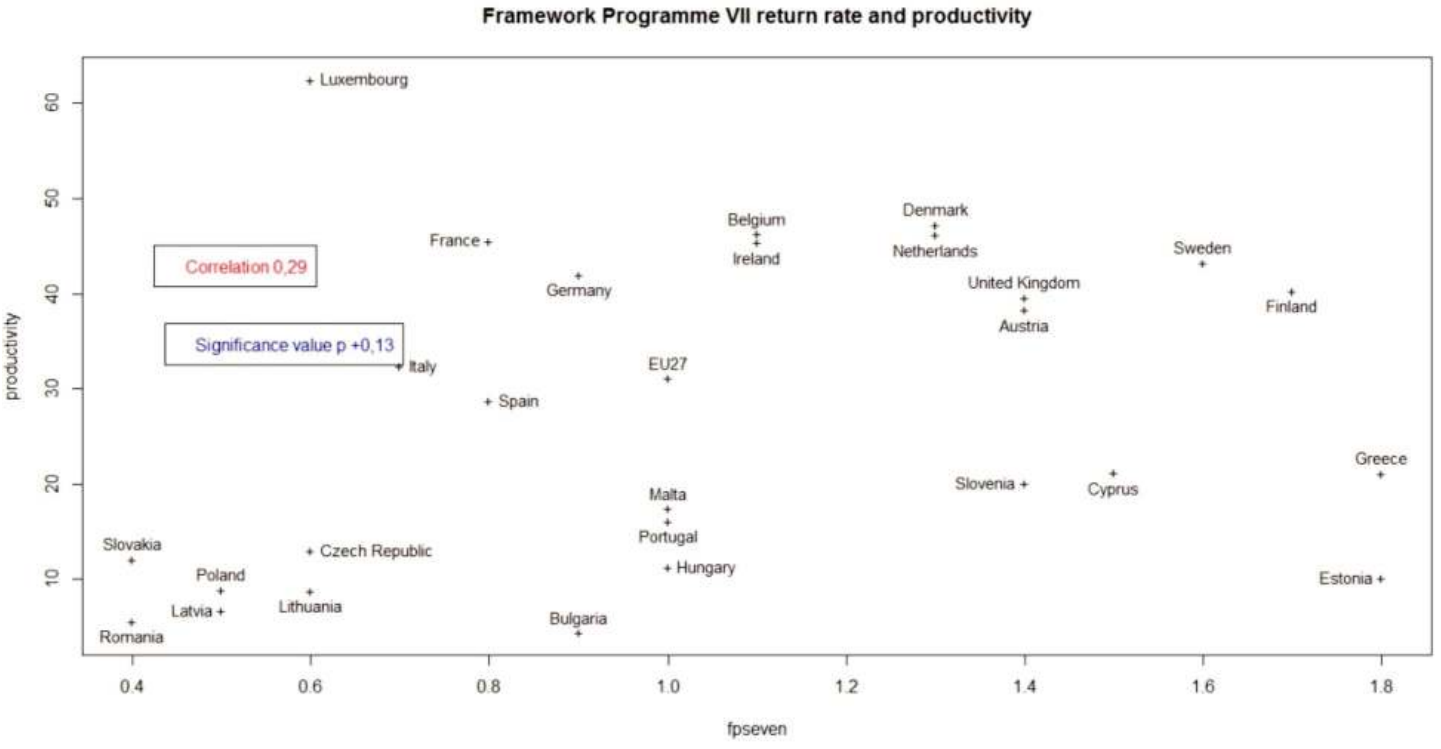
Source: 30/05/2012, own elaboration, archive.

Graph 4: No correlation can be observed for exploration activities; Groups of countries



Source: 29/05/2012, own elaboration, archive.

Graph 5: No correlation can be observed with government financed funds



Source: 29/05/2012, own elaboration, archive.

Analyzing codified knowledge exchange of a country with its exterior, i.e. internationalization indicators including *co-patenting*, i.e. percentage of *patents with a foreign co-inventor*, *patents* registered overall (as output variable), it is of particular interest that no such correlation exist. What can be observed are groups of countries that cluster around similar values. Sweden and Germany show high patent values and moderate co-patenting values. Netherland, Denmark, Finland and Austria show values that are balanced at a high level, France and the UK at a balanced lower level, while there is a group of countries with high co-patenting values and low patent values including Portugal, Poland, Czech Republic, Latvia, Greece, Lithuania. This observation suggests that sufficient absorptive capacity is needed to take advantage of foreign cooperation and that action on codified or tacit knowledge development depend on their development stage. A similar observation can be made with the return rate of European Commission *Framework Programme VII* funds and *productivity* rates in term of € per hour worked. Also here there seems to be no relation between the two variables. A high participation rate in FP7, which refers to the return rate in relation to the contribution to the fund, does not guarantee higher productivity per hour worked values. On the other hand, there is a positive correlation of R&D activities financed with *foreign capital sources* and *patent* application per million inhabitants. Positive correlations also exist with *domestic owned foreign inventions* and output variables.

6. CONCLUSION

This analysis is a first approach to examine the external role in Regional Innovation Systems. For that purpose, national data in the EU 27 member states have been analyzed and grouped into its tacit and codified components. The external role has been analyzed under the assumption, that it represents an essential input to increase the cognitive distance of the tacit knowledge base (openness) and a vital role to value and exchange the codified knowledge base of the local level (internationalization).

Based on the observations made, it can be concluded that a relation exists between the external role and innovation output variables. Moreover, this work has elaborated a theory to explain direction of causality. Openness variables seem to show more convincing results in general, whereas internationalization figures show strong correlations particularly in those fields, where private business seem to dominate. *Outward FDI*, *R&D financed with external sources* and *domestic owned foreign ownership* all point towards a strong role of firms in these variables. On the other hand, public funds earmarked for R&D&i collaboration including the *Framework Programme VII, foreign collaboration in patenting* as well as *collaboration activities in innovation with foreign sources*, do not show clear results. High performance countries group themselves together around an optimal value to exchange codified knowledge (internationalization), whereas low performers do not seem to benefit from external codified knowledge flows.

Reduced cognitive distance between the emitter and the receiver might enable the flow of codified knowledge, for instance through the same company

in a similar corporate culture or industry sector, and is reflected in the positive correlation with innovation output variables. This suggests that RIS need to have sufficient absorptive capacity in form of investments in the codified knowledge base, i.e. reducing the cognitive distance to the external world through expenditure in R&D and education. However, public funds that provide incentives for transnational collaboration between different companies, –including FP VII funds, where we may assume a strong role of public finance, show no correlation. Countries group themselves around an optimal value depending on their economic development stage. No conclusion can be made for low performing countries. The same can be said for innovation outputs of the exploration type. On the other hand, exploitation type variables, which are closer to the market, seem to benefit more from internationalization.

High potential exist in activating and cultivating tacit knowledge bases that increase cognitive distance at the local level. For instance, there are strong roles of *non-native personnel* and *foreign-born human resources in science and technology* and a number of indicators for innovation output results, be it of the exploitation or exploration type. This calls for a successful integration and cultivation of external sourced tacit knowledge bases in the country. Countries that show a low percentage of non-native population are underperformers in the relationship between codified knowledge input and innovation output, suggesting that higher output could be achieved through higher openness.

The policy implications are twofold. Common internationalization policies that deal with the external role need to be properly distinguished between openness and internationalization activities. Internationalization policies are effective if emitter and receiver have a similar codified knowledge base in form of a reduced cognitive distance. High performers should have an internationalization policy in place and search for an optimal value. Low performers should tackle the building up of absorptive capacity to increase the codified knowledge base and thus reduce cognitive distance to high-performers outside the RIS. All countries should activate and cultivate external tacit knowledge bases at local level to increase innovation performance. This could be achieved through inclusive institutions allowing pluralism, integration and collaboration activities of communities with distant cognitive knowledge bases, while value the importance of constant immigration for the innovation system in general. To find the optimal value in internationalization, public policies should provide incentives to the private sector to manage the internationalization network themselves or limit internationalization policies to those (internal) R&D groups, where their worldwide excellence is unquestionable.

This study has worked with national data and it is assumed that the observed relationships are even stronger at the regional level. Nevertheless, this needs to be confirmed in future research. Moreover, this research is applicable only to advanced economies with stable institutions and a Regional Innovation System in place and disregards extreme cases. For instance, it is likely that also negative effects exist by increasing the cognitive distance of the tacit knowledge bases at the local level. Transaction costs as a result of misunderstandings and conflicts increase, and there might be an extreme where these

costs outweigh the potential innovative outcome from merging two distant tacit knowledge bases. The same can be said for the codified knowledge base. A certain cognitive distance might always be needed to justify any collaboration. This study departed from the typical European case; limited migration and high level of R&D and Education standards in comparison to other economically developed parts of the world. Therefore, future research lines need to take into account in detail the conditions and the context of each RIS and limit the scope of the analysis. This research has laid an important base to continue with the work, formulating selective hypothesis, selecting appropriate variables and formulate concrete production functions for the future. For instance, an investigation could tackle how the variable *migration* and the variable *innovation input* might predict *innovation output* variables, which could then be compared to the real value. In this way, we would be able to check with a formula the interplay of both dependent variables. Similarly, the researcher can formulate numerous hypotheses on a range of relationships in different research areas, which would all be important steps to determine the importance and validity of the concept.

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