INNOVATION, NETWORKING AND GLOBALISATION:

The Role of Regional Innovation Systems in the Global Innovation Processes

by

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THESIS SUMMARY

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In the global economy, innovation is one of the most important competitive assets for companies willing to compete in international markets. As competition moves from standardised products to customised ones, depending on each specific market needs, economies of scale are not anymore the only winning strategy. Innovation requires firms to establish processes to acquire and absorb new knowledge, leading to the recent theory of Open Innovation. Knowledge sharing and acquisition happens when firms are embedded in networks with other firms, university, institutions and many other economic actors. Several typologies of innovation and firm networks have been identified, with various geographical spans. One of the first being modelled was the Industrial Cluster (or in Italian *Distretto Industriale*) which was for long considered the benchmark for innovation and economic development. Other kind of networks have been modelled since the late 1970s; Regional Innovation Systems represent one of the latest and more diffuse model of innovation networks, specifically introduced to combine local networks and the global economy. This model was qualitatively exploited since its introduction, but, together with National Innovation Systems, is among the most inspiring for policy makers and is often cited by them, not always properly.

The aim of this research is to setup an econometric model describing Regional Innovation Systems, becoming one the first attempts to test and enhance this theory with a quantitative approach. A dataset of 104 secondary and primary data from European regions was built in order to run a multiple linear regression, testing if Regional Innovation Systems are really correlated to regional innovation and regional innovation in cooperation with foreign partners. Furthermore, an exploratory multiple linear regression was performed to verify which variables, among those describing a Regional Innovation Systems, are the most significant for innovating, alone or with foreign partners. Furthermore, the effectiveness of present innovation policies has been tested based on the findings of the econometric model.

The developed model confirmed the role of Regional Innovation Systems for creating innovation even in cooperation with international partners: this represents one of the firsts quantitative confirmation of a theory previously based on qualitative models only. Furthermore the results of this model confirmed a minor influence of National Innovation Systems: comparing the analysis of existing innovation policies, both at regional and national level, to our findings, emerged the need for potential a pivotal change in the direction currently followed by policy makers. Last, while confirming the role of the presence a learning environment in a region and the catalyst role of regional administration, this research offers a potential new perspective for the whole private sector in creating a Regional Innovation System.

KEYWORDS: Innovation, Globalisation, Networks, Regional Innovation Systems, Innovation Policies, Regional Economy, Venture Capital.

DEDICATION

To those, whose patience was hardly proven by this work.

And to Willingness.

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LIST OF ABBREVIATIONS

Abbreviation	Full Definition
AMT	Advanced Manufacturing Technologies
CAD	Computer Aided Design
CAM	Computer Aided Manufacturing
CIM	Computer Integrated Manufacturing
DTI	UK Department of Trade and Industry
EU	European Unione
FDI	Foreign Direct Investment
MNC	Multinational Company (ies)
NAFTA	North American Free Trade Agreement
NIS	National Innovation System
NUTS	Nomenclature of Units for Territorial Statistics
OECD	Organisation of Economic Cooperation and Development
R&D	Research and Development
RIS	Regional Innovation System (s)
SIS	Spatial Innovation System (s)
SME	Small and Medium Enterprise (s)
TL	Territorial Levels
US(A)	United States (of America)

CHAPTER 1: INTRODUCTION

Introduction

This chapter introduces the rationale, the objectives and the structure of this research. It shows that innovation, networking and globalisation are relevant fields of study that have not been previously analysed jointly in a systematic way. After an overview of background knowledge, research objectives, leveraging on the regional innovation system (RIS) theory, are introduced: this study will provide a contribution to knowledge as it is among the first econometric models built around this theory. It will also offer a contribution to policy makers working on regional development and innovation processes. Last the structure of this research is described.

1.1 Research background

Innovation is today considered a fundamental asset for companies to compete in the global markets; it is as important as the ability to export and to properly market products, processes and knowledge. While in the late 1980s multinational companies (MNCs) were supposed to lead international competition, thanks to their ability to leverage on economies of scale and scope supporting the increasing amount of investments required, it is now understood that smaller firms, better organised and more efficient, can threaten their leadership (Cooke, 1997). Innovation is a wide concept which goes beyond research and development; the UK Department of Industry and Trade (DTI) defines it as the "successful exploitation of new ideas", a definition that can be further expanded as the DTI study referred implicitly to both the generation and the exploitation of new products, processes, services and business practices (DTI, 2003).

The role of innovation has been widely recognised by policy makers too: the Organisation of Economic Cooperation and Development (OECD) collects a wide set of statistics related to innovation and showed in a recent report how its member countries have designed and applied several policies aimed at supporting innovation (OECD, 2011a). The European Union studies innovation in member countries through annual reports performed at regional and national level, called "Innovation Union Scoreboard" (formerly known as "European Innovation Scoreboard"): these reports provide a comparative assessment of research and innovation performances of member states, through the definition of a synthetic index generated through the combination of various variables, at regional and national levels. The latest release of the national level report was published on March the 27 (European Commission, 2013a) preceded by a few days, February the 2^{nd}, by the regional level report (European Commission, 2013b).

Several policies and metrics about innovation rely on the fact that this process is a networked one. Cooke (1997) highlighted how innovation, besides being a crucial competitive asset, happens thanks to the ability of firms to i) access new knowledge and skills through a multiple set of sources and ii) absorb it. Pittaway, Robertson, Munir, Denyer and Neely (2004) made a systematic review on the intersection between innovation and networking; they found how these two processes related to each other in various ways and levels: for example innovation networks are diverse in terms of i) their spatial span (local, global), ii) the actors involved (institutional, customers/suppliers, scientific, financial) and iii) their lifecycle and organizational characteristics (formation, management, governance, behaviours, configuration). This study also highlighted the importance of networking for firms engaged in innovation processes and the objectives they look for. The relevance of networking can be seen from two perspectives. First, networking allows innovation to become a virtuous cycle: companies who joined formal or informal networks are shown to have better expanded their knowledge and skill base, while they have increased their ability to establish relationships with external players. Second, networked companies have increased both their innovation performances and their productivity. There are also several objectives firms are looking for while joining innovation networks, and access to knowledge is just one of them. Firms enter into formal and informal partnerships also for reducing risks, accessing new markets and technologies, leveraging on complementary skills and better protecting their intellectual property.

Innovation and networking are two interlocked knowledge areas both aimed at supporting firms in their competition on the global markets. The concept of global markets and globalisation was first introduced in the early 1980s and has radically evolved since then. Theodore Levitt first introduced the word “globalisation” (1983): he thought about international markets where competition leveraged on prices only. Under this perspective, truly global companies were those pursuing a product mass standardisation strategy, while standard MNCs would have tried to serve specific local market needs. In the early 1990s, this approach to globalisation changed. The drivers of global firms became the economies of variety and of localities and the competitiveness of top market leaders was based on technological advantages and product based learning. A new strategy was made possible through the ability of firms to embed in local networks, called “technology clusters” (Storper, 1992). Localisation of subsidiaries has therefore become a fundamental decision for an MNC willing to compete globally, in order to access specific knowledge and to be able to develop or adapt new products to specific local market needs (Angel & Engstrom, 1995; Cantwell, 1995; Kuemmerle, 1997; A. M. Rugman & Verbeke, 2004).

The global dimension therefore emerged when it comes to innovation and networking. Competition got global, and knowledge acquisition, both technical/scientific and market, has now a global reach too. In the meantime, the role of localism increases too, as it is through the satisfaction of local needs and the acquisition of local knowledge that firms compete globally. This research is focused on this intersection between innovation, networking and globalisation, a knowledge area which still misses a systematic research framework.

1.2 Innovation, networking and globalisation

When talking about the global economy, MNCs are often perceived as the key actors. When globalisation was first introduced as a concept in 1983, these players represented half of world's trade and were accountable for 90% of foreign direct investments (Hamel & Prahalad, 1985). MNCs have a distributed structure made of central headquarters and local subsidiaries and they act as global networks on their own. As all networks they have to rely on internal social capital in order to establish a climate of trust and cooperation which is fundamental to share resources and enhance the performances of their product innovation processes; social capital in MNC was also found to be a driver in their ability to establish external partnerships and embed in networks (Tsai & Ghoshal, 1998). Global manufacturing networks are maybe the most visible kind of network established by MNCs: they are setup in particular by those industries, like the personal computer one, where product components have a high degree of standardisation and assembly is usually the only manufacturing phase performed by the leading firm. But as standardisation lead to the entrance of low cost players in the market, leaders raised their innovation pace and R&D efforts: they established local R&D centres, close to components manufacturers, in order to keep innovating and preserve their market share (Angel & Engstrom, 1995). R&D localisation becomes a key decision for MNCs and they usually follow two main streams: i) acquisition of new knowledge, locating in the premises of competitors and leading research institutions in the key markets and ii) support manufacturing improvement and accelerate time to market in crucial markets, locating R&D centres close to top manufacturing locations (Kuemmerle, 1997). As a consequence of their localisation strategies, MNCs move from a centralised R&D organisation to a networked one: the most common strategy is to have an integrated network, highly decentralised yet collaborative, as this model proved to be the most efficient in terms of organisational costs (Gassmann & von Zedtwitz, 1999). Considering MNCs as a whole, four categories of intra-firm networks have been identified, from an organisational perspective: i) home centred, where all competencies are kept in headquarters and limited autonomy is given to subsidiaries, ii) internationally duplicated, the same knowledge is available to all facilities and quickly transferred all over the network, iii) internationally diversified, when each subsidiary set up its own specific knowledge to adapt to local market needs and iv) dispersed, in case subsidiaries develop their own specific knowledge that is eventually leveraged at global level all over the intra-firm network (I. Zander, 1999). Managing networks like the intra-firm ones in MNCs requires complex organisational processes, with a different balance of autonomy and control depending on the network structure and on the life cycle of the subsidiary (Asakawa, 2001). Such organisational processes and policies have an ultimate relevant impact on knowledge sharing in the firm: hierarchical relations barely allow the spontaneous sharing of knowledge; on the other side, informal relations are not effective when resources are scares and there is an internal competition between units to manage them (Tsai, 2002). Another important variable effecting knowledge sharing in MNCs networks is path length from knowledge sources: the higher is the number of intermediaries between the source and the recipient, the lower is the knowledge transmitted. This is also one of the key reasons for MNCs to locate their R&D subsidiaries in the premises of knowledge spillovers (Hansen, 2002); such subsidiaries become both the adopters and diffusors of acquired knowledge inside the MNC network (Andersson, Forsgren, & Holm, 2002).

The presence of a MNC subsidiary in a local cluster is beneficial for the MNC and for the whole cluster too (Singh, 2007). Clusters are considered a "paradox of location in a global economy" (Porter, 1998), standing in the intersection of innovation, networking and globalisation. They are usually defined as limited territories with very specific industrial focus, since the concept of industrial cluster ("*distretto industriale*" in Italian) was first introduced by Becattini (1979). Clusters have been and are considered as a strategic model for economic development policies; several laws, based on geographical statistics, have been approved in various countries to identify them and to promote specific incentives (Giovanetti, Scanagatta, Boccella, Signorini, & Mion, 2006). The "*distretti industriali*" model was perceived as an international benchmark till the mid-1990s (Bellitti, Miller, & Papini, 1995) when the need for establishing global connections became mandatory for firms to keep on being innovative (Enright, 1995). In fact, due to their structure and social connections, clusters proved to be quite a rigid network, unable to react to global competitive pressures and leading to a sort of "lock in effect" (Varaldo & Ferrucci, 1996). A new networked model, even at local level, was therefore needed for firms to be innovative in this scenario (Rosenfeld, 1995) and the concept of Regional Innovation System, RIS, was introduced (Cooke, Gomez Uranga, & Etxebarria, 1997). The main difference between a cluster and a network is that in clusters, industrial and territorial proximity define one firm's membership, while in networks all members (firms, institutions, finance etc) chose each other based on common objectives.

Under this new perspective, regions represent the intersection between the global arena and local networks and they emerged as a crucial element of the global economy (Cooke, 1997). Cooke combined the evolutionary approach of the innovation theory, stating that all economic actors (economic, academic, institutional, social and financial) have a common evolution in a system (Nelson, 1995), with the network approach going beyond the cluster one. He defined a RIS as a network "capable of supporting numerous clustered and non-clustered industries" (Cooke, 2005) and able to catalyse innovations across industry or cluster borders (Cooke, 2010): a set of qualitative variables, both at infrastructural and superstructural levels, were introduced by Cooke to describe the potential of RIS available in a specific region (Cooke, 2001). RIS are described as today's pivotal players in our research area, the intersection between innovation, networking and globalisation, in particular if we refer to the Open Innovation theory. Open Innovation was introduced in the early 2000s and states that effective and efficient innovation processes in firms do not work anymore inside firm's boundaries, but leverage on global external opportunities (Chesbrough, 2003). RIS contribute to Open Innovation processes as they enable companies to establish connection with knowledge spillovers through the creation of controlled, yet autonomous, research institutions, as in the case of the biotech industry in the Boston area (Cooke, 2005).

RIS seems to be the most appropriate model for managing innovation in the global scenario and they are more effective than National Innovation Systems (NIS). Pittaway (2004) considers NIS as important players at institutional level as they promote the diffusion of innovations; furthermore they also contribute to countries' innovation performances setting up research priorities and providing long term funding for basic research and universities (Cooke, Boekholt, & Todtling, 2000). NIS have been defined as "institutions which are more directly concerned with scientific and technical activities" (Freeman, 1992), and have been studied more using a linear and operational perspective rather than a relational and evolutionary one which is more suitable for innovation processes (Edquist, 1997). Some limitations of NIS emerged recently when considering the global reach of innovation: a study performed on German MNCs showed that those willing to enhance radical innovation needed to relocate some of their R&D centres as the German NIS proved to be more appropriate for incremental innovation due to its limited international exposure (Lane, 2000).

1.3 Objectives and relevance of our research

Innovation, networking and globalisation are three themes much debated and investigated on their own. Networking and innovation were also jointly analysed through a systematic literature review (Pittaway et al., 2004) but no systematic joint analysis of innovation, networking and globalisation has been performed so far. Yet several studies investigated how firms could lead innovation processes through networking at a global level. MNCs are de facto global networks, still when it comes to innovation they need to establish local connections in order to acquire new skills and knowledge; they usually do it embedding their subsidiaries in clusters. However the cluster model seems now inadequate to answer the needs of global competition and global knowledge reach, and the RIS theory was more recently developed to deal with these new challenges. RIS emerge as the pivotal players in the intersection of innovation, networking and globalisation, showing a greater effectiveness with respect to both clusters and NIS.

The first objective of this research is therefore to provide a systematic joint review of innovation, networking and globalisation. Second, it would be relevant to focus on the model that seems to work more appropriately in this scenario, RIS. This model has been well defined and exploited through qualitative studies and there is a need to introduce a quantitative approach to it. More precisely this work would like to setup an econometric model describing the RIS potential of a region a see how it explains regional innovation performances and regional ability to setup global connections in the innovation processes of regional actors. Furthermore it would be required to see which, among all variables underpinning a RIS, are the most significant in explaining overall regional innovation performances, and those in co-operation with global partners.

Innovation performances of regions will be measured using patent production. Patent productivity indexes have been used by scholars to measure innovation output: Furman, Porter and Stern (2002) used the number of patents per inhabitants, while Bode (2004) used the number of patents per employee and Ejermo (2009) referred to patent quality. Furthermore, previous quantitative studies on RIS used patent production as a measure of innovation performances (Buesa, Heijs, Pellitero, & Baumert, 2006; Fritsch & Slavtchev, 2008).

This research's econometric model was therefore setup to test two hypotheses and answer two research questions.

Research hypotheses:

H1: *the higher the RIS potential, the higher regional innovation, expressed by patent production.*

H2: *the higher the RIS potential, the higher regional innovation exploited with global partners, expressed by patent production with foreign partners.*

Research questions:

R1: *which variables of a regional innovation system effect its overall patent production?*

R2: *which variables of a regional innovation system effect its patent production in cooperation with foreign partners?*

The outcome of this research would be relevant for scholars working in the field of innovation and regional development and it would also provide an important contribution to policy makers. As a matter of fact OECD (2011a) asked for a new paradigm in innovation as "*globalisation and agglomeration trends represent a challenge for public policy, exacerbating some of the classical tensions and trade-offs that policy makers have traditionally dealt with.*" Understanding if present innovation policies are aligned with the most influential variables of RIS would therefore be of significant interest for policy makers. This leads to the last research question of this work:

R3: *based on RIS theory, how effective are today's innovation policies?*

From the scholars' perspective, it represents the first systematic review of the intersection between innovation, networking and globalisation. Moreover it will also describe and test, through an econometric model, the RIS theory which has been so far described and exploited in a qualitative manner only. Policy makers would have new tools and indications in order to design and implement regional and national innovation and development policies: it has been seen how this topic is in the agenda of many national and international institution and new perspectives on it would have a relevant impact.

1.4 Research structure

This research begins with a systematic literature review of the knowledge intersection between innovation, networking and globalisation. A similar, structured approach of Pittaway (2004) was followed and, after the analysis of available findings, a research framework was developed, structuring present knowledge and shows potential streams of research (see Chapter 2 and Appendix B).

Chapter 3 describes the research methodologies found through our systematic literature review. It will highlight the need of further quantitative studies and the setup of i) an econometric model based on RIS theory deployed by Cooke and ii) a framework of innovation policies. Variables operationalization is described together with their sources and the survey used to collect them. Control variables are introduced and some variables transformed when required by our model. Furthermore research hypotheses and questions are introduced.

Some general statistical analysis on dataset were performed in Chapter 4. Then a multiple linear regression analysis was run, both using a confirmatory and an exploratory approach. Hypotheses H1 and H2 were tested and the econometric findings related to research questions R1, R2 and R3 discussed.

The economic implications of this research's findings are discussed in Chapter 5, both considering research hypotheses and questions.

Last, evidence was given of the contribution to knowledge and the potential impact of our research for policy makers in Chapter 6. This chapter also highlights the limitations of this study and offers a perspective on further researches emerging from this work.

CHAPTER 2: SYSTEMATIC LITERATURE REVIEW

Introduction

This chapter presents a systematic review of present knowledge about firm networks and their innovative behaviour in the global economic environment. It has been found that globalisation is far from being a mere standardisation of product and services worldwide. Furthermore, when it comes to innovation, local networks are still targeted as the places for knowledge acquisition processes: multinational companies, the most important players in the global markets, need to embed their subsidiaries in local networks in order to enhance market and technology driven innovation. Regional innovation systems are a new network model which seems to well describe those territories with superior innovation performances in the global arena. Still companies are designing and joining global networks with the purpose of enhancing their supply chains and complex products development processes and setting up new standards which represent new barriers for competitors; it has been found that mutual trust (a fundamental condition for knowledge sharing) can be established even globally in the so called spatial innovation systems. Multinational companies can also be considered as global networks of headquarters and subsidiaries and their internal organisational processes are connected to their ability of knowledge acquisition and sharing. This review also identifies some gaps in present literature which might be filled by future research: first there is a need to better clarify the tools and the organisational models that can establish mutual trust in global networks; second it might be better understood if the presence of a multinational company's subsidiary in one cluster enhances the local innovativeness; last an empirical verification would be needed, checking i) if RIS represent the condition for SMEs and clusters to access and create new knowledge globally and ii) if present innovation policies are effective in supporting RIS.

2.1 Literature search methodology

In approaching a systematic literature review on previous studies related to the intersection of innovation, networking and globalisation, it was decided to use a methodology similar to the one recently used for a published systematic review on innovation and networking (Pittaway et al., 2004). In his work, Pittaway developed a structured approach that might be summarised as follows:

1. Identify search keywords, including synonyms;
2. Identify most relevant search databases;
3. Review findings and cluster them based on inclusion and exclusion criteria;
4. Identify most relevant papers;
5. Review selected top papers.

The use of this approach was possible as the subject of investigation is relatively new and all relevant studies are available in literature databases. Pittaway found that the effects of inter and intra firm networks in innovation activities were studied quite recently, as the first were published only after 1980 (Pittaway et al., 2004). In the case of globalisation, data suggest that researches might be even closer in time: in effect, 95% of the 3484 articles selected in Web of Science and Science Direct using the keyword “globali?ation” were published after 1997. The graph below shows their distribution up to October 2012.

Figure 1:Percentage distribution of papers on globalisation up to October 2012

(Sources: Web of Science, Science Direct)

Aston University

Illustration removed for copyright restrictions

Keywords for database queries have been selected through an initial brainstorming based on personal experience. Searches have been performed on ProQuest, Web of Science and Science Direct, only on journals published after 1980. First enquiries used the simple search string “innovat* and network* and globali?ation”: 125 works were found on Web of Science, 156 on ProQuest and none on Science Direct. The search string “innovat* and network* and global*” led to 464 papers on Web of science, 1260 on ProQuest and 2 on Science Direct. Works showing relevant titles were used for further keywords identification (appendix 1). Not relevant papers were used to identify keywords related to other topics of research, like networks in information technology or in the transportation industry; next, search strings were modified in order to exclude papers referring to IT, information technology, information systems, internet, neural networks, transport geography, urban, UMTS, GSM, biotech etc.

The great difference in results obtained using global* or globali?ation suggested to further investigate this keyword. We analysed the titles of the 341 = 464-125 Web of Science’s papers included in the first query but excluded from the second, and we identified a new set of keywords related to globalisation. This new set includes combinations of the keyword global* with other words referring to globalisation processes, whilst it excludes all sentences using it outside the scope of our research. Final search strings with exclusion terms are reported in appendix 2.

ProQuest and Web of Science reported a significant difference in the number of results and we used EndNotes to check intersection within search sets, counting 3 articles from the first query and 8 from the second. This result confirmed a strong independence between the two sets.

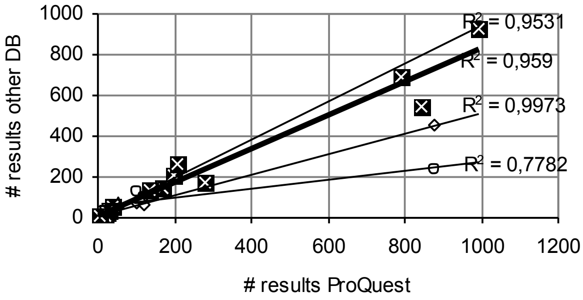
Using the final search strings, 359 papers were identified through this query on Web of Science, 9 on Science Direct. ProQuest did not provide any results. Out of the 368 we found 5 duplicates, leading to an overall list to 363.

The ProQuest result was unexpected given the high number of papers identified through the first simple query. The independence of its set compared to the one coming from Web of Science at least makes this result possible. However, given the operating limit of ProQuest's advanced research capabilities which required several steps to run the full query, we decided to have a title and abstract check on 1049 out the 1260 papers identified with the second simple query. We were not able to further check the last 211 papers as the system was not able to display them. This check confirmed that all papers were not consistent with our research scope. However we decided to pursue further cross checks between ProQuest and other databases. Due to the complexity of the whole query, we selected simpler ones related to our field of investigation and we ran them only for selected high ranked journals. We than investigated the correlation between the number of results achieved through ProQuest and those obtained through other databases. Table 2-1 reports the list of journals used and the simpler queries.

Table 2-1: Journals and Queries Used

Selected Journals	Queries Used
• International Journal of Innovation Management • International Journal of Ops and Production Management • International Journal of Production Research • International Journal of Technology Management • Journal of Engineering and Technology Management • Journal of Operations Management • Journal of Product Innovation Management • Research Policy	1. innovat* AND globali?ation AND network* 2. (innovat* OR (research AND development) OR (new product development)) 3. (network* OR (industr* AND cluster*) OR (industr* AND cluster*) OR (value AND chain) OR embedded* OR (industr* AND geographic* AND proximity)) 4. ((global* AND ((supply AND chain) OR market* OR econom* OR industry* OR competit* OR societ* OR network*)) OR internationali?ation OR (international* AND trade) OR multinational*)

Figure 2: Correlation of Proquest with other Databases



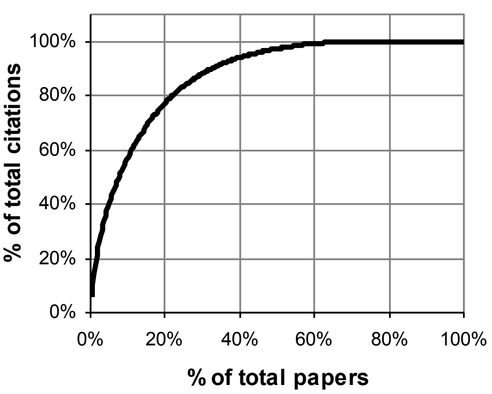
The degree of simple correlation of ProQuest with other sources recorded (see Figure 2) very high rates, with R^2 over 0.99 in the case of Emerald. Correlation with the most relevant source of our research, Web of Science, showed an R^2 equal to 0,959. The graph here attached (Figure 2) reports all correlation indexes recorded: EBSCO has the lowest correlation, while Science Direct is very close to Web of Science. These results indicate that ProQuest data and search performances are well aligned with all leading sources, at least for simple queries. For more complex queries, like the one we used eventually in our research, two options might explain the poor response rate obtained: either ProQuest search engine does not perform well with complex queries, or literature contained in its database does not really cover our scope of research. Provided that this test was performed on shared journals only, but that we experienced a high gap in results without this search constrains, we might assume that the two databases actually work on different sets of literature, thus supporting the second hypothesis. This is also confirmed by our first analysis through End Notes. However we have no evidence supporting or denying search engine performances with complex queries.

The final set of 363 articles was later reviewed using EndNotes, deleting residual articles not related to the research question. Titles were analysed and, in case of doubts, abstracts were reviewed: 301 papers were left. Five other relevant papers and studies not included in this list were later added based on personal experience and references.

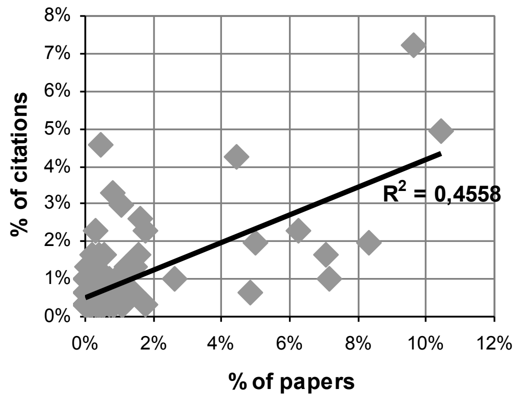
2.1.1 General findings on wide paper sample

The 306 papers found were spread in 128 different journals. Using the number of times each paper has been cited in other sources as a proxy of recognised knowledge contribution, we saw that 20% of all papers were accountable for 80% of knowledge, as reported in the graph 1.a) in Figure 3. In order to see if any journal was particularly relevant for our field of research, we also add a second dimension: the span of knowledge, using as its proxy the number of published papers. With span of knowledge we define the amplitude of coverage of a certain field of research, assuming that the higher the number of publications, the more different views of a certain topic are analysed, even if with poor recognised knowledge contribution. The study reported in the graph 1.b), indicates that the correlation between the cumulative number of citations of all papers in our set published in a specific journal and the total number of papers published by the same journal is low. It was therefore not possible to state that journals with a high number of published papers in our field of research were significantly contributing to related knowledge; vice versa, those with high number of citations, might not have been fully exhaustive in terms of span of knowledge.

Figure 3: Citation Analysis on Paper Sample



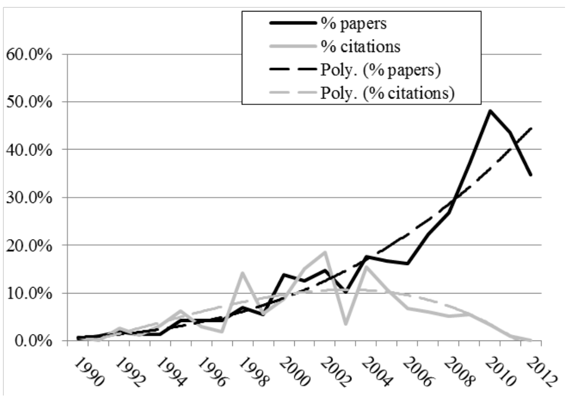
1.a) Pareto analysis of knowledge contribution of papers



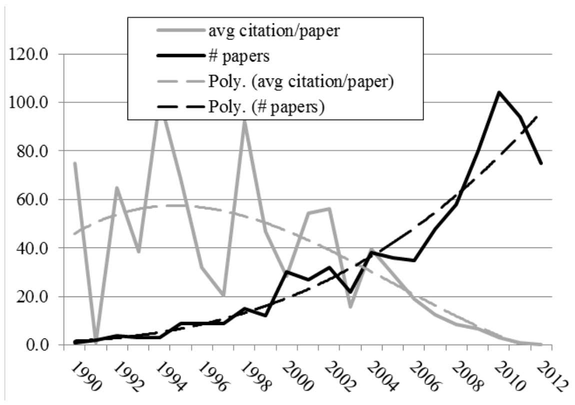
1.b) Correlation analysis between % of total papers versus % of citation of journals

A wider paper sample was also considered, to understand how knowledge in this field evolved among time. A full query on Web of Science and found 746 papers published after 1990 was run. Analysing the percentage of papers published every year with respect to all papers published and the equivalent percentage of citations, we can note an increase in time of the percentage of papers – calculated as the number of papers published each year divided by the total number of papers in all selected years – and a raising and fall of the percentage of citations – calculated as the total number of citations of papers published on a specific year divided by the total number of citations of papers published all over the selected years (graph 2.a in Figure 4). The decrease of citation index in recent years might be explained by the delay required for any paper to be read and cited. Using order 3 polynomial interpolating both trends are more clear.

Figure 4: Papers and Citations per Year of Publication



2.a) % of papers and citations per year with respect to all selected papers published and cited



2.b) papers published per year and average citation index/paper per year

Drawing the average citation index per paper and matching it with the number of papers published each year, it could be clearly seen how the first variable is steady decreasing, while the latter is increasing (graph 2.b in Figure 4). Again, the use of order 3 polynomial interpolating graphs helps identifying the two trends. Through the previous observations it was questioned if this research field has reached his maturity: an increasing number of papers is published yearly, but their average contribution to knowledge is getting smaller.

2.1.2 Process used to shortlist papers

In order to better review this research field, it was decided to further shortlist the number of papers to be reviewed. The quality criteria described in the reference previous work on Innovation and Networking (Pittaway et al., 2004) were first applied: result was not at all correlated with citation index (R^2 = 0.0154). As this evaluation contains qualitative, therefore subjective, criteria, it was decided to triangulate a sample with other researchers. Ten papers have been randomly selected and sent to another, more senior, academic for her evaluation following the same criteria: results were again not correlated and some papers have not been evaluated as abstracts did not fully allow the required understanding for such a quality assessment. Ideally several scholars should have been asked to fully review all abstracts and later averaging all evaluation: it was therefore inferred that citation index was the best proxy for paper relevance and quality evaluation as it expresses the value given by the whole research community. The perfect Pareto distribution of citation index described above was used as the shortlist criteria, and top 60 papers were chosen. In order to make a clearer review, these top papers seldom required to be integrated with knowledge delivered by papers cited in their bibliographies or written by the same authors.

It might be argued that this approach prevents the most recently published papers to be considered, as citing them might require a few years. Therefore, in order to include the most recent findings in our review, a paper alert system on Web of Science (the widest source of papers in our study) was created based on the final query. All recent papers have been analysed and 6 added to this review whenever delivering coherent, additional knowledge to the top 60 papers.

Once analysing the short listed papers it was found that only two of them were part of Pittaway's (2004) bibliography and an additional check to prove the validity of our process was required. The introduction of globalisation as a new search variable was tested to see if it was the fundamental reason for having so different results. Using one of Pittaway's search strings inside Web of Science (see Appendix 4) it was found that out of 250 papers, 11 were included in Pittaway's bibliography and 4 in our short list, with one overlapping result. Introducing the globalisation variable 51 papers emerged, of which 4 still belong to our short list and just one to Pittaway's bibliography, actually the overlapping result. These results confirmed to us that the introduction of the globalisation variable was leading to a different relevant bibliography.

2.1.3 Reviewing process and emerging model

Unlike Pittaway (2004), no NVIVO analysis was performed on paper texts in order to cluster results. A first approach was to arrange papers in clusters through their abstract review; however once starting reading the full texts, some inconsistencies have been soon discovered with respect to the previous clustering process. It was therefore decided to read papers, write the key findings and arrange clusters accordingly. Following this approach, many logical steps happened to be missing in the short list, but available in the related bibliography; thus other papers were added in the review to fill those gaps. Added papers were found while reading the short-listed ones and selecting key references explaining the missing logical steps. Some of them belong to already short listed authors while others have a very high level of citations: these were considered as good quality indicators for their inclusion in our review.

Following the three streams of globalisation, networking and innovation, it was possible to summarise reviewed knowledge in the general scheme (see Figure 5). Globalisation variable goes from local to fully global: firm levels, networks and innovation related topics vary according to the degree of globalisation. Firm level is introduced in the scheme as it represents the size of companies usually networking, locally or globally: clusters are usually local networks of small and medium enterprises (SMEs), while multinational corporations' (MNC) networks are usually global and do not include SMEs. MNC subsidiaries are in the middle as they are well localised, but still part of international networks.

Figure 5: General review framework

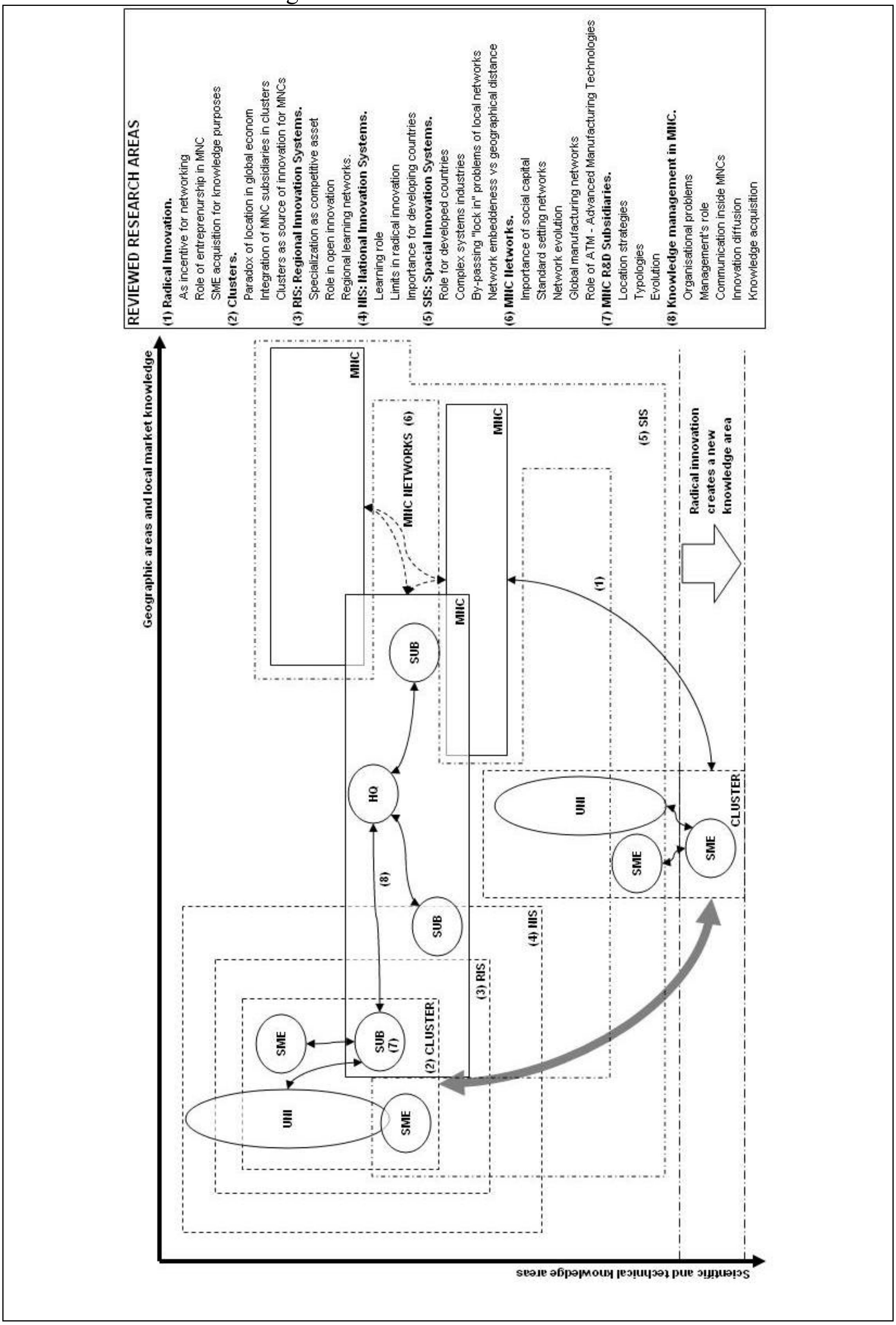
Globalisation degree	**Networks** *firm level*	*networks*	**Innovation**
Local		Cluster	
	SME		
		Regional Innovation System	MNC R&D Localization
	MNC Subsidiary	National Innovation System	MNC R&D Subsidiary
		Spatial Innovation System	Knowledge Management in MNC
	MNC		
Global		MNC Network	

Different kind of networks have been found in the review and inserted in the general scheme following their geographical span. Clusters are industrial networks well defined within limited territories. Regional and national innovation systems are networks of firms and institutions promoting innovation on increased levels of geographical coverage; spatial innovation systems are firms' networks created for managing innovation in complex systems, like aerospace, operating at global level and often lead by one major MNC. Last MNC networks have global links between international-wide companies. Our review describes each of these networks.

Innovation topics also vary depending on globalisation and networking degree. MNC R&D localisation is a major point to understand why research subsidiaries are created in specific locations and their embeddedness with local networks. Then the various typologies of R&D subsidiaries and their lifecycle are described. Last knowledge management in MNCs describes how knowledge is acquired and shared within subsidiaries and headquarters on a global level.

The general review scheme highlights the role of MNCs as a key player in our field of research, where subsidiaries are the bridge between local and global environments. To better understand all the connections between the general clusters might be referred to a second, more detailed, scheme (see Figure 6).

Figure 6: Detailed Research Scheme



The horizontal axes represents the geographic dimension and local market knowledge: firms, subsidiaries and institutions with similar x value are situated close each other on a specific local market. The vertical axe represents the technical/scientific knowledge dimension: firms, subsidiaries and institutions with similar y value work on narrow scientific or technical areas. Continuous lines shape single networking subjects (SMEs, subsidiaries – SUB, headquarters – HQ, institutions – UNI, MNCs), while dotted lines delimit networks; for graphic clearness MNC networks have been indicated by dotted arrows only. MNCs are de-facto networks linking subsidiaries to headquarters but act as single subjects on a global level too; we represented them with a wide horizontal dimension but limited vertical one as they operate on specific industries, therefore in specific scientific and technical areas, but on large geographical scale (unless they are conglomerates like General Electric, where this representation works if considering each single business as a standalone MNC). Clusters, regional innovation systems (RIS) and national innovation systems (NIS) are drafted as networks with limited but increasing geographical and scientific spread. Spatial innovation systems have strange shapes as they break the usual knowledge-spatial relation of previously mentioned networks.

Using this model, breakthrough innovation is represented by a new knowledge area which stretches previous boundaries: SME is drawn as the actor leading radical innovation as literature suggests that small firms, usually universities' or MNCs spin-offs, make breakthrough innovations. A legend on the right side of the scheme explains the various knowledge topics which emerged in our review, describing the key actors and their relations. The big, grey arrow represents one of the key questions which this review was not able to explain: how do SMEs and clusters access to radical innovation which occurs in a faraway location?

2.2 Critical examination of core texts

2.2.1 Globalization

Theodore Levitt, Harvard professor, was among the first scholars to introduce the term "globalization" in 1983, referring to products standardization worldwide, where price was seen as the main purchasing decision variable. He suggested that global companies have different approaches than usual MNC ones: the first drive worldwide standardization, while the latter still follow local preferences. Product standardization was not intended as the end of market segmentation and product customization, but indicated that consumers segments were almost the same all over the world and local preferences were a weaker selling proposition than price (Levitt, 1983).

While economies of scale are appropriate to Levitt's definition of globalization, nearly ten years later, Storper (1992) began highlighting the relevant role of economies of variety and of localities in the global economy. He discovered that export specialists, those companies driving global trade, based their competitiveness on technological advantages and product based learning; furthermore they were embedded in production networks and in precise sub-national areas called "technological clusters". This finding was very close to researches performed on US patents, showing how the concept of globalization was not linked to the production of technology which was instead seen as deeply linked to companies' host countries (Pari Patel & Pavitt, 1991).

MNCs represent 90% of FDI (Foreign Direct Investments) and count half of world's trade. Some theories define global those companies who are able to rebuff competitors in their home markets (Hamel & Prahalad, 1985). If we consider as truly global a firm with more than 20% of sales in each of the three main economic regions (NAFTA, EU, Asia) and less than 50% of them in its home one, it was discovered that just nine out of Fortune’s top 500 global companies can be considered as such (A. M. Rugman & Verbeke, 2004).

Many companies are acting globally upstream in the value chain (sourcing), but being close to local markets downstream is important too. The case of Japanese television manufacturers shows that investments in global distribution channels are more effective than just focusing on the lowest cost sources, which eventually change quite often (Hamel & Prahalad, 1985). Hamel and Prahalad also indicated that investments in distribution channels or brand franchises can be successful only if supported by a wide product portfolio and a continuous stream of new products. Being close to local units has been found to be one of the key reasons for creating local R&D subsidiaries able to adapt global products to local needs (Angel & Engstrom, 1995; Cantwell & Harding, 1998; Kuemmerle, 1997; A. M. Rugman & Verbeke, 2004). In fact localization strategies are fundamental in the Knowledge Based Economy theory as geographic proximity was demonstrated to be an important catalyst for accessing new knowledge (Harris, 2001): in effect, the genesis and assimilation of innovation and its transformation into economic growth across European regions is not only driven by the traditional linear model local R&D innovative efforts, but also by the local socio-economic conditions (Rodriguez-Pose & Crescenzi, 2008).

Globalization can also lead to hyper-competition, that is “the process of continuously generating new competitive advantages and destroying, making obsolete, or neutralizing the opponent’s competitive advantage, thereby creating disequilibrium, destroying perfect competition and disrupting the status quo of the marketplace” (D'Aveni, 1994). Companies need to react to it fostering their abilities to develop, apply and diffuse knowledge: innovation seems therefore a competitive asset in the global arena.

Moreover, innovation can also be considered as one of the drivers of business internationalization. In recent years the role of technology has become crucial in firms' theory and scholars started talking about technology-based companies. The term technology refers to "a body of knowledge, together with physical characteristics of its embodiments" (Granstrand, 1998). Some empirical findings help us describing how technological diversification allows technology-based companies to achieve strong corporate growth. In fact, when R&D expenditures rise, product and market diversification occur, following the technological one. Combining technologies to develop different products gives corporations strong economies of scale and scope, and offers new sales opportunities; however it increases R&D complexity and its coordination costs. Internationalization is often a consequence of technology diversification: new markets are open in order to achieve returns on higher R&D investments; in the same time, the need for new knowledge forces companies to acquire it through R&D internationalization (Granstrand, 1998).

Globalization and internationalization are often considered as synonyms and international management problems increasingly become part of scholars' research agenda in recent years. Twelve streams of research in international management have been identified in a systematic literature review performed on top 20 academic journals (Werner, 2002): (1) the global business environment; (2) internationalization; (3) entry mode decisions; (4) international joint ventures; (5) foreign direct investment (FDI); (6) international exchange; (7) transfer of knowledge; (8) strategic alliances and networks; (9) multinational enterprises; (10) subsidiary-headquarters relations; (11) subsidiary and multinational team management; and (12) expatriate management.

2.2.2 Industrial clusters

Clusters are geographic entities with very specific industry focus. Their conceptualization was first introduced by Italian scholars referring to the so-called "distretti industriali" (industrial districts) at the end of the 1970s (Becattini, 1979). Industrial clusters or districts are nowadays defined by law in several countries, as indicated by a recent report of the Italian Government on national and international statistic best practices on clusters (Giovanetti et al., 2006). The reason for such a legally formal definition of cluster is due to their recognition as key players in national economic development and several policies and incentive schemes were designed in various European countries to support them. Their economic model, more precisely the Italian industrial district model, have been considered for years a global benchmark for economic development (Bellitti et al., 1995).

Industrial clusters introduce the "paradox of location in a global economy" (Porter, 1998): "the enduring competitive advantages in a global economy lie increasingly in local things – knowledge, relationships, motivation – that distant rivals cannot match". Based on the analysis of different industries' clusters worldwide, Porter (1998) shows how the competitive advantages of clusters in the global economy relate to three main areas: increased productivity, innovation pace, and stimulation of new businesses. Innovation pace of firms operating in clusters has been found to be higher for several reasons: proximity and trust with suppliers offering technological improvements, opportunities for co-development, easy and low risk testing in small environments before international escalation, continuous benchmarking with peers (Porter, 1998). However no global, a-priori condition for technological and market dynamism has been found: successful clusters continuously redefine product and process best practices in their industries, but each of them reaches industrial leadership following a different path (Storper, 1993).

Provided industrial clusters' key advantages for competing in the global markets, Porter (1998) suggests companies follow a four steps process aimed at selecting, joining and operating subsidiaries in clusters; he also suggests that new public-private industrial relation policies might facilitate this process. Once established in a cluster, subsidiaries' competence creation and their business mandate are influenced by its dynamism: the more dynamic is a cluster, the higher will be the competences, the mandate and the resources available in the local subsidiary. Therefore closures, rationalizations and resource drainage are not likely to occur in subsidiaries located in dynamic clusters (Dicken & Malmberg, 2001).

But while Porter highlighted the role of collaboration, based on mutual trust, among firms located in the same cluster as a mean for cluster competitiveness, Enright (1995) gave a different perspective for innovation. He stated that to be innovative, firms will inevitably have to meet global firms (and sometimes local ones) in the competitive arena: therefore a more balanced approach between collaboration and competition with local partners would have been more appropriate.

Small companies are usually well integrated in their clusters; big MNCs with high decentralised and autonomous divisions can be integrated too in several clusters internationally spread (Nooteboom, 1999). This theoretical finding has been confirmed by empirical researches in Swedish and Canadian clusters (Birkinshaw & Hood, 2000). Local embeddedness is important for developing business relations which facilitate technical embeddedness too: despite business embeddedness is relevant for market performances of subsidiaries only, technical one effects technical knowledge in the whole MNC internal network (Andersson et al., 2002). The integration of MNCs' subsidiaries is beneficial for those clusters integrated in global value chains: they reduce the level of endogenously generated knowledge and contribute to build ties external to the cluster itself (Oliver, Garrigos, & Porta, 2008).

Industrial clusters are an important variable to consider while choosing international relocation strategies. Case studies in East Europe, like Volkswagen – Skoda, show how MNCs can leverage on local clusters capabilities, not only on their lower labour costs, transforming their abilities to deliver higher quality components (Pavlinek & Smith, 1998). This enables subsidiaries to enjoy local embeddedness and a higher degree of autonomy and innovation; in contrast subsidiaries' employees enjoy better compensations and working conditions than those working with cluster's suppliers: a condition which might lead to some possible social tensions. This investment approach, named "offensive restructuring", is opposed to the "defensive" one: subsidiaries located outside incumbent clusters are just becoming part of MNC's international sourcing network and have minor innovation capabilities.

The relevance of clustering for innovation has also been much debated with respect to the Knowledge Based Economy theory: geographic proximity is an important catalyst for the existence of knowledge spillovers (Harris, 2001). Empirical studies show that foreign companies are creating subsidiaries in various clusters in order to acquire local knowledge which is not available in their home bases; historical patent data analysis shows a change in MNCs' R&D policies, from a home centred one allowing economies of scale to a network structure, internationally dispersed, and aimed at acquiring new competencies. Global MNCs pursue innovation through several centres: even when central R&D departments are still the most relevant, they are not anymore the dominant innovation drivers (Cantwell, 1995).

It has also been noted that foreign companies in clusters are often more active than local ones in learning and that they contribute to clusters development through direct investments and knowledge exchange (Almeida, 1996). However a learning lifecycle approach, where companies follow a parallel organizational cycle of integration and disintegration, suggests that industrial clusters might be relevant mainly in the knowledge exploratory phase (Nooteboom, 1999). In effect knowledge exploration activities rely on the external links subsidiaries are able to build, while the phase of knowledge exploitation is usually performed exploiting firms' internal networks (March, 1991).

2.2.3 Regional Innovation Systems

Some case studies suggest that regions can play an important role in global innovation. A region is a territory part of a state with significant degree of local administration and cohesiveness; "a regional innovation system is not a cluster, but [a network] capable of supporting numerous clustered and non-clustered industries" (Cooke, 2005) and able to catalyse innovations across industry or cluster borders (Cooke, 2010).

Networks might be a more appropriate mean for companies to be innovative; they can be defined as group of firms with limited memberships and very specific, often contractual, relations based on business goals, designed to achieve mutual gains (Rosenfeld, 1995). Based on Rosenfeld work, Cooke (1997) elaborated a framework which compares clusters and networks.

Table 2-2: Networks and Clusters

Networks	Clusters
Give access to specialized services at low cost	Attract specialized services to a region
Have restricted membership	Have open membership
Rely on informal or formal-contractual agreements	Are based on shared norms of reciprocity
Facilitate more sophisticated business practices	Facilitate frim-acquisition of wider competencies
Have common business goals	Have shared vision

In a network, members chose each other, while in a cluster industrial and territorial proximity are the only conditions for belonging to it. Of course network links are generated inside a cluster, due to the proximity of business partners often covering a very specific step in one industry's value chain. However networks go beyond clusters' boundaries. They are driven by shared business objectives: a main difference with respect to clusters, where cooperation is implicit as all members share a same vision. When it comes to innovation, this phenomenon has to be linked "*to the cluster structure of the industry and to the regional innovation system*" (Cooke, 1997); in effect the evolutionary approach of innovation theory (Nelson, 1995) stated that all actors in a system (economic, social, institutional and technical – in other words the Regional Innovation System) evolve together through continuous interactions. In introducing the concept of "learning economy", Lundvall and Johnson (1994) highlighted that advanced economies are learning ones, where knowledge intensity and learning are the most important assets and innovation becomes fundamental for the survival of firms.

Lundvall and Johnson consider learning a key performance of firms. In effect companies are operating in a scenario of increasing R&D costs and continuous reduction of time to market and pay back times of investments: the innovation process needs to respond faster, thanks to multiskilling and networking ability. RIS are therefore fundamental players in the learning economy as the offer a systemic dimension of learning and innovation to their members (Cooke et al., 1997); vice versa clusters will not be enough flexible and quick to adapt to the global economic evolutions (Varaldo & Ferrucci, 1996). Varaldo and Ferrucci stated that such rigidity is determined "*by an absolute and omnipresent vision that determines strategic firms'* *orientations, behaviours and expectations. This produces and supports systematic economic efficiency, conditioned by local actors' convergent strategic behaviours*" which makes the district "*orderly and regular in its evolutionary processes*". The exogenous changes of the competitive landscape, like those indicated by Lundvall and Johnson, require firms located in district to establish new "*strong and long term relationships with external actors*". Under this perspective the role of RIS is crucial. Using Cooke's (1997) words "*renewed interest is the extent to which business 'clusters' cohesively forming or evolving in innovative regional settings are an appropriate means of successfully engaging in networks that facilitate globally competitive economic practices*". One of key RIS objective is to provide the opportunity to enable connections between its members and global players. In his analysis of the Massachusetts RIS case, analysing the biotechnology sector, Cooke (2001) clearly showed the role of a RIS. First he pointed out the power of regional lobbies that manage to have a regional Food and Drug Administration (FDA) office to be opened in Boston; a move that regionalized a previously national level only authority, speeding up the fundamental regulatory processes underlying this specific industry. Second he marked up the degree of global connections established by regional firms, again with an example of a biotech one: "*Then there are the global linkages between the regional cluster and innovation partners elsewhere, from California to Europe, not least in the case of Genzyme with a Dutch CEO, and two enzyme-production plants in the UK plus other European branch operations*" (Cooke, 2001). In extreme synthesis, and still using Cooke's words, "*this is the advantage of taking a regional innovation system approach. The rich picture of interactions in the cluster can be set on the canvas of wider, global innovation interactions*".

RIS are perceived as a competitive element in the global economy, also in peripheral regions (Doloreux & Dionne, 2008), due to the increased level of specialization associated with it. However specialization is important up to a certain degree: Fritsch and Slavtchev (2010) discovered that it has an inverse "U" shaped form of relationship with RIS performances. To perform properly RIS need to be really innovative, following an evolutionary path with a continuous improvement of local special competences and supported by a governance system less state-led but more associational (Cooke, 1997).

The role of regional innovation systems for innovation in the global economy is fundamental for companies using an open innovation approach. The key concept behind open innovation is that firms do not consider innovation as an internal process to be secretly developed, but open the boundaries of their innovation funnels to the external world. One of the major consequences is that new ideas previously rejected for not being part of company's core business, can now be launched into the market in the shape of spin-outs. Vice versa, the "not invented here" syndrome disappears as external R&D create significant value to firms (Chesbrough, 2003). Regional innovation systems are key players in open innovation, enabling global companies to bypass their internal knowledge asymmetries. MNCs establish strong links through controlled, but autonomous, research institutions, located in strategic regions where the most advanced knowledge required for their business is available (Cooke, 2005).

In addition to improved innovation performance, companies embedded in regional networks have shown a higher level of internationalisation than those not embedded (Gellynck, Vermeire, & Viaene, 2007).

To support RIS, regional learning networks, formed by non-directly competing firms, can be created to enhance regional response to global hyper-competition. They are especially suitable for SMEs as small companies do not usually have the internal diversity or a significant amount of professional staff able to develop new knowledge (HanssenBauer & Snow, 1996). Evidence from the Netherlands shows that universities can be important players too in supporting RIS, provided that they adopt a hybrid approach combining research and teaching excellence with the status of an economic development institution, therefore bridging knowledge-producing with knowledge-valorising activities (Benneworth & Hospers, 2007).

Technology centres are other RIS actors involved in innovation processes, especially when local economy relies mainly on SMEs. But their role goes beyond their ability to offer high value R&D services. In a networked approach towards internationalization of companies, the evidence shows that SMEs leveraging on external technology services have a higher degree of internationalization. This can be explained as technology centres are themselves pivotal points of international networks and, while offering R&D services, they also allow customer SMEs to enter these networks and extend their international span (Martinez-Gomez, Baviera-Puig, & Mas-Verdu, 2010). However a quantitative study performed on Italian regions and provinces shows that not all international knowledge flows contribute to the growth of regional economies. Italian districts based their strategies on industrial specialization, but variety seems not to be affecting regional growth: however when it comes to employment growth, extraregional flows of knowledge are an important variable when they refer to sectors related but not similar to those present in the region (Boschma & Iammarino, 2009).

2.2.4 National Innovation Systems

Industrial district and RIS represent local networks, but moving to a wider geographical scale, national innovation systems (NIS) could also be found. An historical view of innovation development shows that local systems, integrating companies and institutions at national level, are still playing a relevant role in firms' learning performances and intellectual capital creation in the global economy (Freeman, 1995). Researches on the German case, however, reported that while the national network of research (connecting companies, institutions and the financial system) well served incremental innovation, its low international exposure lead to a low degree of radical innovation (Lane, 2000). This might confirm the idea that "*innovation systems analysts have been wedded to sentiments of 'national' economies*" (Cooke, 2001), due to the long tradition of Listian-Shumpeterian development economics theory.

Those few German companies who really act globally have partially relocated some of their R&D centres in foreign countries in order to be close to leading knowledge spillovers of their diverse product units (Lane, 2000) or for pursuing the competitive advantage of product customization to host country's needs (Cantwell & Harding, 1998).

The role of national system of innovation is strategically important for developing countries willing to attract foreign R&D investments; the availability of highly trained researchers is actually a key asset MNCs are looking for, due to its scarcity in developed countries. Research performed within R&D subsidiaries in India highlighted that labour cost is not the primary reason for location choice: availability of skilled employees, good communication infrastructure and reliable intellectual property protection policies are among the most important ones. Once established, R&D subsidiaries embed themselves in the national innovation system, linking with institutions and innovative companies, and bringing a new commercial culture of market-applicable research, thus creating a virtuous cycle (Reddy, 1997).

The concept of National Innovation System is yet itself not fully clear: in some cases federal states like Belgium have central policies of innovation (Kerremans & Beyers, 1996) while other states with weaker regional autonomies showed a significant degree of decentralised innovation policies (Braczyk, Cooke, & Heidenreich, 1997). Freeman (1992) defines a NIS as a set of institutions which are more directly concerned with scientific and technical activities. However, i) on one side innovation is not just related to science and technology and it includes, on example, organizational and marketing innovation, and ii) a system is not only made by its elements but includes the relationships between them too (Lundvall, 1992). The complexity of analysis at national level led NIS researchers more focused on a linear and operational perspective rather than on the relational and evolutional one of innovation (Edquist, 1997) which is much used for RIS. Uncertainty of NIS definition does not directly imply that it is impossible to draft a picture of innovation at country or central state level. History, social habits and language, in example, represent a common ground at national level which impacts some characteristics of an innovation system like firms organization, national R&D systems etc. Moreover NIS are still maintaining an important role in setting up scientific priorities and providing long term funding for both basic research and university education (Cooke, Boekholt, & Todtling, 2000). However, under an evolutionary perspective, the hierarchical relationship between national and regional research budget allocation and fund raising policies is steadily changing and regional lobbies are acquiring more and more power in driving decisions and the role of local private foundations in financing research is increasing (Cooke, 2001).

2.2.5 Spatial Innovation Systems

National and regional innovation systems are fundamental for continuous technical improvement in developed countries and for attracting research investments in development ones. However the present increased complexity of innovation, which moves on full systems combination of different technologies, requires new, wider models. Spatial innovation systems are networks connecting different actors engaged in the development of complex systems on a global scale. Technological systems may go beyond geographical constraints, depending on the industry they refer to: lasers or aircrafts are complex systems developed through collaboration of several producers in many places. National innovation systems partially contribute to develop complex technological systems; they link and overlap with each other following the dynamic evolution of the system, creating spatial innovation systems (Oinas & Malecki, 2002). As a matter of fact some scholars are extending the concept of embeddedness outside the traditional regionally oriented cluster view. Territorial embeddedness is associated to competence sharing and innovation but might be also considered a potential source of decline due to technical lock-in phenomena. The German case supports this point highlighting the role of a decentralised MNC network for achieving radical innovation (Lane, 2000). At the same time globalisation is often considered as a de-embedding force; however studies on global manufacturing networks show that embeddedness exists also in geographically spread networks. This non local type of embeddedness does not replace the cluster-related one, but complements it. In effect, mutual trust, always at the base of intra-cluster relations and fundamental asset for knowledge exchange and innovation, can be established even on global networks (Hess, 2004). This confirms the theory on spatial innovation systems, complementary to national and regional innovation systems, where most relationships, even key ones, are not always proximate (Oinas & Malecki, 2002). Scholars supporting the regional innovation systems model, although not directly mentioning spatial innovation systems, give de-facto such a role to MNCs. In fact those MNCs operating with an open innovation approach, acquire specialist knowledge through regional innovation systems, while all systematic integration activities are performed in their internal networks (Cooke, 2005). This is also close to the role Chesbrough (2003) named as “innovation architects”.

2.2.6 MNC networks

Innovation does not follow usual economic exchange theories. It is often distinguished by missing prices (or even markets), high uncertainty and ambiguity, therefore companies aiming at becoming innovation leaders build policies to create a social context of trust and cooperation (Ghoshal & Moran, 1996). Social capital is an important asset for product innovation in MNCs’ networks. Its three dimensions, structural, cognitive and relational, are all positively correlated with resource sharing which strongly influences product innovation (Tsai & Ghoshal, 1998). Moreover, social capital, together with technical and commercial ones, is often a required condition to build partnerships inside networks: firms look at it as an important complementary asset to share within the network relation. Firms’ innovation history is often considered as a proxy of their competences and potential partners might enjoy the acquisition of such knowledge while collaborating with them. Technical breakthroughs are also attractive even without a previous consistent history of incremental innovation: having the potential to change the competitive scenario of a specific industry, companies are willing to create partnerships with the inventing firm in order to first achieve such a market advantage (Ahuja, 2000).

For specific kind of networks, like standard-setting alliances aimed to manage product standards in a specific industry, the criteria for joining are different. Product standards have strong business impact as they reduce life cycle costs to customers and might be a technological threat for companies unable to meet them; business impact increases when it comes to industries operating with global standards, like computer operating systems. Companies base their joining decisions on two main variables: the dimension of alliance (the bigger, the higher the influencing power on standards) and the absence of direct leading competitors in the alliance (Axelrod, Mitchell, Thomas, Bennett, & Bruderer, 1995).

Networks are not static and evolve: structural changes might occur in the relations between group of firms or single companies. Changes in industry regulations and breakthrough innovations are among the most important factors that can reshape the balance of power inside firms' networks. While evolving, networks can get stronger or weaker, depending on change events. Reinforcing events are those which are based upon existing competing rules; they primarily effect the strongest companies or are initiated by them (Madhavan, Koka, & Prescott, 1998).

Global manufacturing networks are maybe the most visible result of business internationalization and have a significant impact in MNCs' innovation networking strategies. Industries with a high level of standardised components and product modularity, like the personal computer one, have distributed manufacturing networks (Sturgeon, 2002); however they still enjoy clustering when it comes to innovation (Angel & Engstrom, 1995). Assembly is usually the only manufacturing phase performed by the leading firms close to key markets, while all components are developed and manufactured by suppliers in remote locations. In order to keep a competitive position versus low cost suppliers, industry leaders have increased the pace of technology development. This was achieved through an organizational change, having R&D departments being divided in several small groups, each closely operating with components' manufacturing partner in order to drive innovation more effectively and faster (Angel & Engstrom, 1995). The fast obsolescence of personal computers makes this industry close to the retail fashion one, in terms of supply chain management complexity. Here key suppliers, like Li & Fung, are not anymore just low cost manufacturers. They add value to major retailers through joint product design, supply chain management and finite product quality control: they are able to dissect the supply chain in order to separate labour intensive activities from value added ones, managing dispersed manufacturing networks. Moving into the design of products allows them and their customer to quickly react to consumers' needs changes and reduce unsold inventories: a major issue in an industry with some six or seven seasons per year, almost the double of few years ago (Magretta & Fung, 1998).

Supply chain management together with information and communication technologies now enables MNC to easily gain advantage of the various locations they subsidiaries are hosted in. This is leading local subsidiaries to specialized themselves in specific activities of the whole company value chain, from R&D to sales. Furthermore their specialization is not static and it changes based on the degree of trade and business liberalization at a level beyond the national one (Rugman, Verbeke, & Yuan, 2011).

Advanced Manufacturing Technologies (AMT) might play an important role in network organization. AMT range from computer aided design (CAD), computer aided manufacturing (CAM) up to computer integrated manufacturing (CIM) and flexible manufacturing systems. They support companies in achieving faster new product introduction and the economies of scale required to operate in different markets. Companies using these tools need to be managed with truly cross functional organisation in order to maximise their effectiveness; moreover firms working in networks need to set up common open systems and modular approaches. The combination of cross functional internal structures and cross firm interdependencies is a major managerial challenge innovative for firms operating in networks and using AMT (Lei, Hitt, & Goldhar, 1996).

2.2.7 R&D localization strategies of MNCs

MNCs R&D localisation is important for acquiring two kinds of critical knowledge: technical expertises and local consumers' needs to be included in new products. Many companies are acting globally on the sourcing side of the value chain (including R&D resources) but only few of them are really global in their relation with their markets (A. M. Rugman & Verbeke, 2004) and further research might be required for investigating the relevance of local embeddedness of MNCs subsidiaries to achieve a truly global sales leadership.

In a recent quantitative study based on 1722 R&D international projects, Demirbag & Glaister (2010) found that several firm external and internal variables are driving the choice of R&D offshoring: i) differences between domestic and external R&D wages and knowledge infrastructure, ii) science and engineering talent pool of foreign country and iii) its political stability are the most influential external drivers, while iv) previous international R&D experience is the most important internal one.

A research performed on 32 MNCs in US, Japan and Europe highlighted that location strategies of foreign R&D centres follow two paths. The first refers to research subsidiaries created for acquiring new specific competencies, usually placed in specific knowledge clusters close to competitors and leading local institutions. A second strategy is applied to subsidiaries dedicated to manufacturing improvement and local fast commercialisation of new products; in this case they grow close to leading operational facilities or to critical markets (Kuemmerle, 1997).

Market driven approaches are in effect relevant too: MNCs can decide upon location of innovation centres depending on the relevance of local market. Ideally they want to be close to customers' needs and move knowledge processes close to profit generating ones. In case of complex products the presence of best suppliers is the main decision variable (Gerybadze & Reger, 1999). More often researchers have found a general lack of clear location guidelines for managers, varying from industry to industry; consequently, R&D organization in MNCs can assume several models. Gassmann & von Zedtwitz (1999) have well represented them and their dynamics: international R&D organizations change moving on a two dimensional space determined by the degrees of cooperation and centralization. The general trend is to evolve toward an integrated R&D network, highly decentralised yet highly collaborative as this organizational model minimises total organizational costs.

Whatever is the reason for MNCs localisation, an analysis performed on patent databases shows that knowledge flow balance is usually in favour of MNCs rather than subsidiaries host countries. This should not be seen as a negative result for the latter's as a careful planned FDI (Foreign Direct Investments) attractiveness policy can give some advantages to their economies: first, global application of local knowledge is an opportunity for local SMEs to access international market; second, local firms might develop products and technologies which are complements and not competitors to existing ones; third an increased citation of local patents and scientific publications enhances local firms' reputation and attractiveness to additional investors (Singh, 2007). In effect, , the presence of an MNC subsidiary in a specific cluster has proven to be a beneficial asset for all companies belonging to the same cluster; more precisely it helps cluster's firms to build relationships going beyond the cluster boundaries and reduce the level of endogenously generated knowledge (Oliver et al., 2008). The MNC-cluster relationship seems therefore a win-win one: on one side MNC acquire new knowledge through localizing their subsidiaries; on the other, cluster firms enjoy i) the opportunity to establish connections outside the cluster itself which offer them new knowledge, not previously generated in the cluster and ii) potential foreign direct investments brought through MNC subsidiaries.

The first point confirms the analysis made by Varaldo and Ferrucci (1996) who pointed out the rigidity of clusters in reacting to the exogenous changes lead by the globalization of economy and suggested the need for "*strong and long term relationships with external actors*" (Varaldo & Ferrucci, 1996).

2.2.8 MNCs R&D subsidiaries

MNCs often represent networks of units operating in different industries and different countries. Four categories of intra-company innovation networks have been identified, based on duplication and diversification of advanced technologies (I. Zander, 1999):

Home centred. Leading competencies are kept in the country of origin. Although some local units provide duplication or specialised knowledge, innovation initiatives are only lead by the central one. Low flexibility and missed growing opportunities are two weaknesses of so organised firms;

Internationally duplicated. Home based and dispersed subsidiaries access the same technologies, thanks to knowledge transfer activities or acquisitions. Firms in this category are highly flexible in managing innovation activities in different location and have an effective knowledge sharing process between units;

Internationally diversified. Each location developed relevant and specialised knowledge and the main operating mode is through clear division of activities. Firms have usually exploited local growing opportunities building specific competencies;

Dispersed. This is the most advanced category, where all subsidiaries built relevant specific competencies with global product mandate, but also managed to successfully activate knowledge exchange processes in the network leading to substantial duplication. Usually firms in this category grew their innovation capabilities through acquisitions.

Analysis performed on Swedish MNCs' international subsidiaries revealed an increasing weight of foreign technological development, joined with a higher leading role of foreign R&D centres in individual technologies (I. Zander, 1997).

Following Porter (1990), we might refer to subsidiaries in two ways: "transplanted home bases", where radical innovation is performed through dedicated R&D and marketing departments, or "scanning units" mainly established just for using some of clusters' competitive resources. Researches in Sweden, Canada and Scotland show that transplanted home bases are usually integrated in leading industrial clusters; they also report a higher percentage of international sales and a higher degree of managerial autonomy with respect to global headquarters (Birkinshaw & Hood, 2000). Other scholars divide R&D units of MNCs into three categories: local adaptors, international adaptors and international creators; each characterised by an increasing level of geographical and technical scope (Nobel & Birkinshaw, 1998).

An evolutionary approach has been used in analysing relationships inside subsidiaries and central R&D units. Under this perspective local units are disintegrating the internal network once being fully embedded in local research environments; MNCs are using this approach when looking for new knowledge which usually occurs at the very early stage of R&D subsidiaries' life. Later, once knowledge is acquired, MNCs start integrating their subsidiaries more, requiring increasing knowledge exchange with central R&D units and more applied research to be performed. Among these phases, organizational tensions might occur in terms of autonomy-control trade off and information sharing: autonomy-control refers to the degree of autonomy given to and required by subsidiaries to create a solid knowledge base; information sharing is the quantity of information required and provided by central R&D units. During the disintegration phase both tensions are usually low, while they increase when the integration phase begins. When integration starts, subsidiaries become more controlled by central units and partially lose their degree of autonomy; at the same time the quantity of information required increases, with central units usually believing they are receiving few information, while subsidiaries claim enough quantity is sent and parent units have a low absorptive capacity (Asakawa, 2001).

When R&D subsidiaries are funded to adapt centrally developed technologies to local market needs, then their evolution follows two different paths. Either they enhance their product development expertise working with local functions to satisfy new local needs, or they leverage on research competencies available in their premises and become a knowledge centre. In both cases central unit's concerns about control and co-ordination might slow down these evolutions. However three main forces might help R&D subsidiaries in changing their role. First, development programs with local production facilities, bypassing the simple adaptation of already developed products. Second, support provided to central labs in researching new technologies. Third, distinctiveness of technological characteristics in host countries (Pearce, 1999).

The lifecycle or evolutionary approach is sometime replaced by other strategies: acquisition of technological leading edge small companies is becoming a popular way for MNCs to access new knowledge. However it usually leads to integration problems, including extra coordinating costs which should be counterbalanced by synergy effects, like a decreased time to market (Gassmann & von Zedtwitz, 1999). MNCs are looking to SMEs acquisition as innovation is often pursued by small entrepreneurial firms: in various industries new companies are far more innovative than incumbents (Hamel, 2000) and radical innovation is one of SMEs' key competitive assets (Ahuja & Lampert, 2001). Breakthrough innovative SMEs are usually spin offs of universities or big private R&D labs working in an open innovation environment. Scientists becoming entrepreneurs have a specific new mindset which can be defined as "intrapreneurial". Intrapreneurs are a new kind of professionals able to manage team work, protect intellectual property and have a business understanding of scientific discoveries (Kirschbaum, 2005). More traditionally, entrepreneurship can be defined as the identification and exploitation of previously unexploited opportunities; entrepreneurs heavily rely on networks to acquire the resources they need (including knowledge) and to drive innovation (Hitt, Ireland, Camp, & Sexton, 2001) while social capital is an important condition to establish effective relations in networks (Tsai, 2000). In the global economy the importance of networking goes across cultures and seems to be a common characteristic of entrepreneurs belonging to different countries; however cultural differences emerge when it comes to how entrepreneurs establish their networks (Zhao & Aram, 1995). Networking is also an important way of internationalizing small firms' business: a research on Japanese SMEs shows that setting up a presence abroad through direct investments in local firms and connecting to the local business environment provides more results than just increasing exports (Lu & Beamish, 2001). We might infer that MNCs acquiring SMEs do not only access new knowledge, but enter networks they might not have been included in before.

It is hereby important to highlight that R&D internationalization does not necessary mean that MNCs have a wide number of research facilities scattered around the globe; at the opposite, it has been shown that the more advanced and differentiated is the knowledge area a company wishes to operate, the fewer might be the knowledge centres qualified (Gerybadze & Reger, 1999). The dynamic organizational model previously cited confirmed this point and highlights a trend towards the rationalization of number of research sites in integrated R&D networks. The choice of such world class centres is made through market-driven and technical knowledge variables, which influence their coordination policies too.

2.2.9 Knowledge management in MNCs

In order to compete on global arenas, MNCs establish organizational processes allowing them to centrally manage a dispersed network of facilities. This does not mean to go back to a centralised, one location, structure which would prevent the exploitation of global cost and knowledge opportunities. Vice versa, MNCs react to disconnections created by fragmentation. For example, Fuji-Xerox's approach is to standardise internal processes and avoid duplication. Furthermore they decided to design products for the global market at once, avoiding later costly and time consuming re-designs (McGrath & Hoole, 1992).

Under this perspective managing knowledge sharing in MNCs is a main organizational issue. The internationalization of firms has led to stronger position of local subsidiaries in leading innovation; there is currently a significant research focus in understanding the effects of appropriate knowledge exchange practices in firms' multinational networks (I. Zander, 1999).

Knowledge flows in MNCs usually go from subsidiaries considered as capable to those that consider themselves capable and are associated with high level of communication and reciprocity. Other subsidiaries kept outside of such flows are de facto isolated and underperform with respect to the more integrated ones (Monteiro, Arvidsson, & Birkinshaw, 2008).

Like all organizational matters, leadership is critical for ensuring R&D subsidiaries' good performances and knowledge exchange within MNC's network; leading companies are therefore looking for people combining both deep technical and managerial competencies (Kuemmerle, 1997). Such leaders have to: supervise technical development, enable their teams to be strongly embedded with the local scientific community, be open to any new idea, understand and follow company's strategy and market trends. As a matter of fact technology leaders are now operating based on global internal and external networks; external links are relevant to knowledge acquisition while internal ones are important for knowledge sharing inside the organisation (Cantwell, 1995). Following this perspective, global R&D managers, those leading MNC's central research units and all subsidiaries, might be considered managers of knowledge, rather than managers of people and processes (Kuemmerle, 1997).

From a competitive perspective, internal networks are important for development and diffusion of firm's specific advantages, while external ones often rely on countries' specific advantages: the first are therefore important in knowledge exploitation activities, while the latter drive knowledge exploration (March, 1991). Knowledge exploration is considered one of the key drivers of R&D internationalisation, but subsidiaries' degree of embeddedness with host environment is proportional to several factors: subsidiary's technical scale, dimension of parent company presence in host country and historical presence of subsidiary (Frost, 2001).

In case of MNCs, subsidiaries and home headquarters are playing a multiple set of different roles in exploiting home and host units' advantages: in specific cases when firm's advantages are developed locally, sold globally but related knowledge is not easily shared, we can speak of subsidiary specific advantages (A. M. Rugman & Verbeke, 2001). However subsidiaries specific advantages are not enough to cope with global competition, dominated by a higher complexity of product and services requiring a new, technologically diversified approach. Unfortunately specific competencies are usually spread internationally as both the percentage of foreign technological development and specific technological leadership of subsidiaries have increased in the near past: MNCs should create ad-hoc organizational strategies to increase knowledge sharing between subsidiaries (I. Zander, 1997).

Analysing the internal networks, an empirical research performed in a big multiunit company, showed that formal hierarchical relations have a negative effect in knowledge sharing; informal ones can be negative too when different units are competing for internal resources, while they create positive effects between units competing on external markets only (Tsai, 2002). Path length, represented by the number of intermediaries, is another key variable. A study performed within 120 new product development projects of a large MNC revealed that the best performing teams were those with shorter paths to required knowledge sources (Hansen, 2002). Long paths implicate information distortion and make knowledge research more difficult. The same research also reported that direct relations are the best for sharing uncodified knowledge, while their level of maintenance costs can be considered too high just for sharing codified information.

The scope of activities is an important driver for developing different patterns of communication (Nobel & Birkinshaw, 1998). MNCs R&D units with a local influence and minor innovation contribution (local adopters) are embedded with the local environment (customers, suppliers, company's local functions but excluding local universities or research institutions) and have poor international connections with other subsidiaries. Units with limited innovation but wider international scope (international adopters) have stronger international ties with company's subsidiaries, but lack of links with external research institutions; actually only those units with wide international and innovation scope (international creators) developed such links.

Innovation diffusion and adoption is another challenge for global firms. In the case of small clusters of networked firms, geographical proximity is an important variable, confirmed by the fact that adoption of any innovation changes just the private or close environment of the adopter (Wejnert, 2002); this is confirmed by the fact that MNCs subsidiaries which are highly technically embedded in local clusters have the double role of knowledge adopters and diffusers inside company's network (Andersson et al., 2002). Wejnert (2002) also noted that MNCs are the main promoters of global technologies: however when it comes to their industrial partners, they adopt them just because of the relation with the leading adopter: vice versa individual actors usually base their adoptions decision on rational principles.

Knowledge acquisition, or learning, might be a strategic tool to move from a network model of relationships with suppliers to a more hierarchical one. Cases in the Japanese automotive industry show two possible scenarios. The first occurs when the leading company decides to create an internal competence centre previously delegate to partners: long term business relationships last until the gap of knowledge between supplier and customer is limited. Once this gap increases and specific knowledge becomes the core of product (i.e. electronics in cars), the supplier might start offering its services to customer's competitors, as a consequence of higher negotiation position. Creating an internal centre of competence allows balancing negotiation power and keep control of product core technologies. The second scenario relates to product standardisation combined with globalisation of supply: when products become systems built around standard parts, then knowledge gets almost explicit and previous partners are put in competition with other suppliers internationally (Ahmadjian & Lincoln, 2001).

The previous findings show that knowledge management and company organization are strongly connected. This is confirmed in the contingency theory of organizations, which in extreme synthesis states that the organizational model varies depending on several contingent variables, being knowledge one of them. Two dimensions of knowledge have been identified and used as an indicator of organizational model: observability, that is "how easy is to understand the activity by looking at and examining different aspects of the process or final product" (U. Zander, 1991), and system embeddedness, "the extent to which the knowledge in question is a function of the system or context in which it is embedded" (Birkinshaw, Nobel, & Ridderstrale, 2002). Varying these two dimensions from low to high and combining them Birkinshaw, Nobel, & Ridderstrale (2002) found four different types of R&D units: isolated, integrated, transparent and opaque. Isolated units are autonomous and less integrated having high level of both knowledge dimensions. In opposition we have integrated units, the most integrated and less autonomous in company's research network, with both low levels of knowledge dimensions. Opaque units have low level of knowledge observability which prevents competitors to copy it, and often not even inside the company, but represent an important competitive asset and are strongly embedded in company’s network. Eventually transparent units have such a high level of knowledge observability that are easily copied by competitors and are not felt as a competitive asset by the parent company.

2.3 Conclusions

This review of the relationships between innovation, networking and globalisation highlights several trends and open questions.

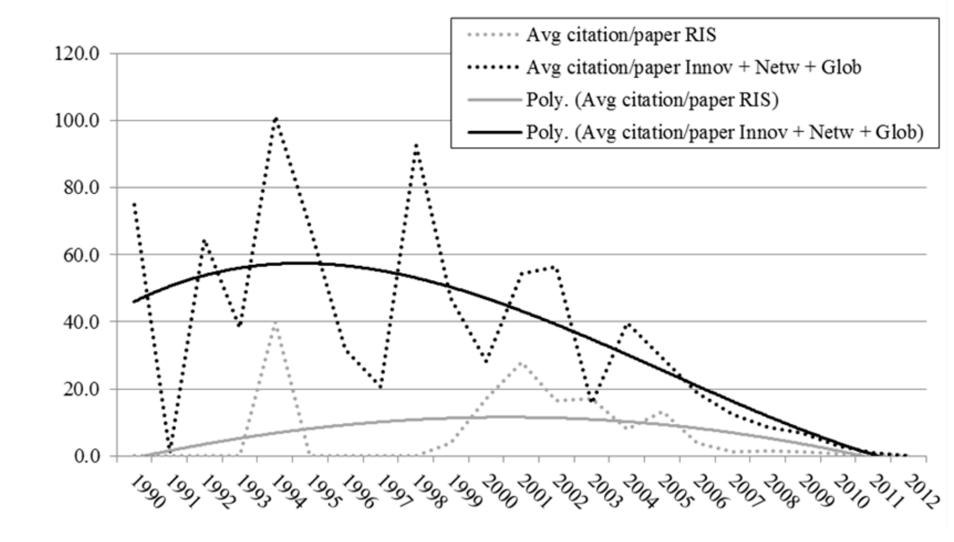
First, when it comes to innovation in the global economy, localism still plays a fundamental competitive role. Knowledge acquisition, either market and technical knowledge, relies on local network embeddedness. This does not preclude the existence of global networks, like MNC networks or spatial innovation systems; however in both cases the main objective is to enhance supply chain, complex product (system) development or to drive the definition of business standards: knowledge acquisition is not core and knowledge diffusion is guaranteed through formal relationships. Nevertheless spatial innovation systems offer new perspectives on the creation of mutual trust, the basis for knowledge exchange, even within remotely located actors: understanding the drivers for such remote mutual trust could be an interesting question for researchers. It might be inferred that in present global society new communication tools are making networking an easier process and it would be interesting to empirically show if, how and to which extent these tools are really supporting knowledge exchange and innovation globally.

The central role of MNCs highlighted in this review is another interesting point. Beside the debate on what is a real global company, MNCs represent the most active players in the global economies. Their continuous search for new knowledge is an important driver in their localisation decisions: MNCs need to innovate in order to compete, combining market and technology driven innovation, and being close to the source of knowledge is crucial for them. MNCs are therefore acquiring their knowledge thanks to their subsidiaries' embeddedness in local networks. But MNCs can be considered global networks on their own, connecting headquarters and subsidiaries: knowledge diffusion inside these networks is linked to their organisational structure, in a continuous trade off between autonomy and control, where the higher is autonomy, the more knowledge is acquired from local networks, but it might remain fully dispersed inside MNC internal network. This last consideration opens a new question on the need for formal and hierarchical relationships in order to enable knowledge transfer globally; it was previously asked about the tools for trust generation within remote actors and this question brings the organisational variable into the very same debate.

This review also highlighted a new perspective on SMEs and clusters. SMEs were discovered to be increasingly important drivers for radical innovation into the global business arena and MNCs are often accessing this new knowledge through SMEs acquisition. Furthermore MNCs are looking at clusters as an opportunity for locating their subsidiaries and acquire local knowledge. However clusters' evolutionary paths for global competitiveness vary case by case too; furthermore some clusters are suffering the effects of global competition and more generally MNC subsidiaries embedded in clusters are often more active than local companies. It might therefore be argued that SMEs and clusters keep their attractiveness until they dominate a specific knowledge niche but only those which manage to continuously improve it and create new knowledge will survive in the global environment: how clusters and SMEs innovate globally represents another interesting open research stream. The presence of MNCs subsidiaries seems to be an important asset for clusters and SMEs in order to access new global knowledge. Regional innovation systems could play a decisive role in the global innovation process too.

In effect, it was seen how the concept of regional innovation systems is gaining momentum in the global innovation debate. It is a research field which, among the wider one we started reviewing (the intersection between innovation, networking and globalization) needs to be further exploited. In Figure 7 graphs were compared, representing how much, on average, papers published each year have been cited in the wider review area and more specifically in the regional innovation systems one. Both graphs were built using Web of Science database only and search string used were, respectively, i) the full research string indicated in appendix 2 and ii) “regional innovation system”. It was noticed that order 3 polynomial curve has lower y value for regional innovation systems and its peak is closer is around year 2002, while the innovation, networking and globalization curve peak is located in year 1994: this indicates that regional innovation systems studies are more recent and might have room for additional contributions.

Figure 7: Average times cited per paper in overall research area and in RIS one



Average times cited per paper published, 1990 – 2012, in overall research area (intersection between innovation, networking and globalization) and regional innovation systems niche.

2.3.1 Gaps in literature, research hypotheses and questions

The present review highlighted that regional innovation systems are an intermediate level between clusters and national innovation systems. RIS introduce a holistic model of networks which include firms, research institutions and local governments and are expressed by specific variables determining their potential (see Table 2-3).

Table 2-3: Definition of RIS Potential (Cooke, 2001)

Worldwide renowned innovation territories, like Massachusetts, are some of their examples, and assessing if the RIS model enables global knowledge reach will be a relevant contribution to present studies. More precisely it would be important to determine if and how the presence of regional innovation systems is the condition allowing innovation through global connections, in line with what was seen for knowledge exchange as explained for the case of technological centres (Martinez-Gomez et al., 2010). The majority of RIS related studies based their findings on case based researches and we found in literature a lack of empirical, quantitative works offering a more general perspective on RIS and their role in determining regional innovation performances and collaborative innovation with global partners. Furthermore the RIS model introduced by Cooke (2001) and reported in Table 2-3 has been considered as a whole, and understanding which variables of the model contribute most to RIS potential, would provide additional knowledge to RIS theories. Innovation performances of regions is often measured by patent related variables (Buesa et al., 2006; Fritsch & Slavtchev, 2008) and the relationship between RIS potential and RIS variables with regional patent output would be an appropriate area of investigation.

This research will therefore be focused in two mainstreams: i) the development of a quantitative model testing the hypotheses that RIS potential determined both the total regional patent production and the regional patent production with global partners, and ii) the development of a quantitative model investigating which RIS variables determines both the total regional patent production and the regional patent production with global partners. More precisely, the gaps identified by this systematic literature review lead to a set of two research hypotheses and two research questions.

Research Hypotheses:

H1: *the higher is RIS potential, the higher will be regional innovation expressed by patent production.*

H2: *the higher is RIS potential, the higher will be regional innovation exploited with global partners, expressed by patent production with foreign partners.*

Research questions:

R1: *which are the variables of a regional innovation system effecting its overall patent production?*

R2: *which are the variables of a regional innovation system effecting its patent production in cooperation with foreign partners?*

Last, the systematic literature review highlighted a significant policy making impact of RIS theories. Using Cooke's words (2001): "*it is clearly desirable that some account is taken [..] in redesigning innovation policy in Europe to begin to close the gaps that have once again opened up between the innovation performances of the two [USA vs EU] competitor economies.*" This research would also provide a qualitative indication on the effectiveness of today innovation policies, leading to a third research question:

R3: *based on RIS theory, how effective are today's innovation policies?*

CHAPTER 3: MODEL SET UP

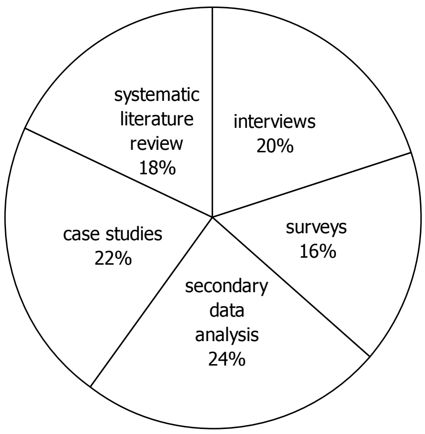
Abstract

In this chapter research methodologies found in our literature review were analysed and, more specifically, those related to RIS studies. It was noticed how RIS papers are mainly based on qualitative studies and few quantitative ones have published, thus leading to the need for additional quantitative ones. Population of interest and level of analysis are introduced, choosing NUTS 2 (Nomenclature of Units for Territorial Statistics) level as it fits with the theoretical definition of region and offers a good set of secondary data. The use of a multiple linear regression model is introduced, with its opportunity to be used both as a confirmatory and exploratory tool. Model variables have been selected: independent, dependent and control ones, based on RIS theory and available literature; dummy variables accounting for potential country level effects were introduced too. A framework of 22 regression models was than setup, through a preliminary work of variables operationalization required to enable further model analysis. Furthermore, innovation policies have been rationalised in a parallel descriptive framework. Eventually final research hypotheses and questions were introduced in order to be verified and answered through models analysis.

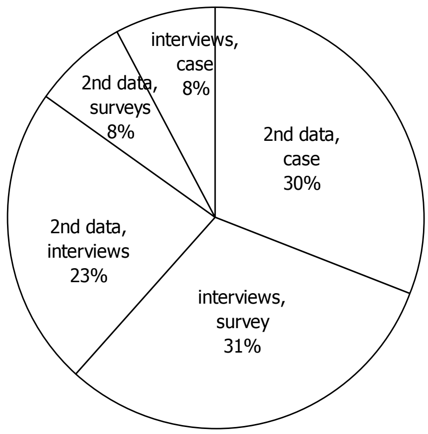
3.1 Methodologies found in systematic literature review

In assessing paradigms and methodologies, it was referred to the framework developed by Guba & Lincoln (1994) which was well summarised by Healy & Perry (2000). Realism is the leading paradigm within the analysed papers: actually 88.4% of them are using it. Positivism is used by 9.3% of authors while only 2.3% might be linked to constructivism. It was noted that all positivist papers were based on statistical analyses of US patents database and 75% of them focused on knowledge management in MNCs. Furthermore another 75% of positivist studies were longitudinal, compared with 26% of the whole literature reviewed. As a matter of fact patent databases are among the few data sources which are permanently fed; others, like surveys, might allow longitudinal studies too, but at the price of very long research durations. Beside the low percentage of positivist papers, the majority of scholars used quantitative approaches (51%); 35% of them preferred qualitative and 14% adopted mixed ones. Several methodologies have been used, and their distribution can be seen in graph 1 (Figure 8). A significant percentage of authors, above 40%, opted for more than one methodology: the distribution of their combinations is reported in graph 2 (Figure 8).

Figure 8: Research Methods Used in Reviewed Literature



1. Methods



2. Combinations of Methods

3.2 Research methods used on regional innovation systems studies

The previous chapter highlighted a direction for this research. More specifically a framework was set up, describing the various dimensions operating at the intersection of innovation, networking and globalization. More precisely, this framework highlighted how RIS are potential key players in enabling the access to global knowledge and represent a novel research stream among our overall research framework. In order to better setup our model and research hypotheses, first the methodologies used in RIS studies were analysed and the most appropriate research approach for this study was defined.

Among the top 60 papers identified in the previous systematic literature review, 11% of those referred to RIS were empirical studies combined with multiple case studies, while 89% were case based only. The dominance of case based studies is confirmed in the additional references cited in our literature review and in other paper generally referred to RIS.

RIS have been studied deeply since the early 1990s by Prof. Phil Cooke (1992) mainly with a case based approach (Cooke, 2001; Cooke, 2002, 2004b, 2005, 2007, 2010; Cooke et al., 1997; Cooke & Morgan, 1994; Cooke, Roper, & Wylie, 2003; Cooke, Uranga, & Etxebarria, 1998). Other authors used this methodology too with the aim of theory building (Heidenreich, 1997) or theory confirmation (Asheim & Coenen, 2005; Gerstlberger, 2004; Iammarino, 2005; Niosi & Bas, 2003).

A minority of studies use primary or secondary data to support the description of major RIS characteristics (Cooke, Boekholt, & Tödtling, 2000; Doloreux & Dionne, 2008; Koschatzky & Sternberg, 2000) in the perspective of supporting policy makers.

Muller and Zenker (2001) collected primary data from a survey deployed to 1903 manufacturing small and medium enterprises (SMEs) and 1144 knowledge intensive business services (KIBS) and performed a descriptive analysis of the results showing that SMEs and KIBS interacting each other are more oriented towards innovation.

Fritsch is one of the few scholars to have used more advanced quantitative models in analysing RIS. First (2001) he used a hurdle count data model to analyse the differences in co-operative relationships between regions as well as between smaller and larger firms. In (2002) he used a production function to assess RIS quality. Together with Leydesdorff (2006) he suggested an uncertainty reduction model to test triple helix dynamics in German regions. The triple helix theory was developed by Gibbons et al. (1994) and states that the relevant environment for research and development is constantly and increasingly changed by networks of research, technology and development linking university, industry and government.

Later Fritsch & Slavtchev (2008) introduced an econometric model to assess RIS efficiency. RIS efficiency was defined based on the concept of technical efficiency described by Farrell (1957) and indicates how much a region is technically efficient in transforming innovative inputs in innovative outputs. Fritsch and Slavtchev used a model based on data from German regions; disclosed patents applications were used as innovative output while innovative inputs were measured using the number of employees in private corporations dedicated to research and development. Dummy variables have been introduced too for taking into consideration any regional effect.

Eventually the same authors (2010) proposed an OLS (Ordinary Least Square) cross-section regression technique to identify the impact of several determinants of RIS efficiency. OLS was also used by Agrawal and Cockburn (2003) to verify the concentration of R&D activities in the United States around local, R&D intensive firms.

Italian scholars (Evangelista, Iammarino, Mastrostefano, & Silvani, 2002) made an empirical research using secondary data from Eurostat CIS (Community Innovation Survey). Using a factor analysis they identified three clusters of variables: i) the systemic interactions in innovation processes, ii) non-R&D related innovations and iii) regional technological and R&D strengths. Then through a cluster analysis they described regional patterns of innovation, divided into four categories: 1) no innovation systems, 2) weak innovation systems, 3) science-based systems and 4) informal learning systems.

Factor analysis was also used in a Spanish study (Buesa et al., 2006) who identified four factors too: 1) regional and productive environment of innovation, 2) universities, 3) Civil Service (the Spanish public administration) and 4) knowledge creation in innovative firms. Like in the previously mentioned Italian research, factors have been used for a cluster analysis aimed at identifying the various typologies of Spanish RIS.

Last, Rodriguez-Pose and Crescenzi (2008) performed a multiple regression analysis on secondary data to "uncover the importance not only of the traditional linear model local R&D innovative efforts, but also of the local socio-economic conditions for the genesis and assimilation of innovation and its transformation into economic growth across European regions". They also highlighted the role of proximity for the transmission of economically viable knowledge.

As far as knowledge flows within and outside regions are concerned, Boschma and Iammarino (2009) used linear multiple regression studies based on secondary data of Italian regions and provinces. They estimated the impact of regional variety and trade linkages on regional economic growth, discovering that regions endowed with complementary sectors perform better than others, while knowledge exchanges through regional boundaries perform better when there is affinity, but not overlapping, of knowledge sectors.

3.3 The need of further quantitative models

The previous section highlighted how studies on RIS have been predominantly qualitative and case based, whenever it came to theory development and early testing. Much of empirical researches have been used for further RIS characteristics description, even some of those few based on statistical analysis (Buesa et al., 2006; Evangelista et al., 2002). With the notable exception of Fritsch studies (Fritsch, 2001, 2002; Fritsch & Slavtchev, 2008, 2010) and other recent contributions (Rodriguez-

Pose & Crescenzi, 2008), we found a potential need for further quantitative models testing RIS theories and describing their role as innovation enablers.

More specifically present core research question is to check the role of RIS in supporting innovation in general and understand if RIS enables the access to innovation on a global scale by local firms. It would therefore be needed to build a relationship model based on theoretical hypotheses to be tested statistically: a positivist approach seemed therefore appropriate (Babbie, 1998) as it leverages on experiments and quantitative methodologies aimed at testing hypotheses. In effect this approach is based on the methods used in natural science describing the reality which exists outside of the observer values and offer the opportunity to study it objectively (Delantly, 2002). It leverages on hypotheses to be formulated in terms of relations and level of association among various variables; its results can be further used to test new hypotheses or to generalize results (Babbie, 1998; Miller, 2002). Furthermore the positivism approach enables the creation of rigorous models to validate the relationships among variables (Guba & Lincoln, 1994).

3.3.1 Population of interest and level of analysis

In this research, variables were selected based on Cooke's theoretical model (Cooke, 2001), which states that regions might have a low or high potential for becoming RIS, either on infrastructural or superstructural levels. The variables described by Cooke and leading to low or high RIS potential were represented in Table 2-3. In measuring innovation performances of companies linked to RIS characteristics it was first argued if variables should have been selected at firm or regional level. Sternberg and Arndt (2001) discovered that firm specific innovation determinants are more relevant that regional ones while Boschma and Frenken (2006) showed how a combination of firm and regional level characteristics would have been appropriate; indeed firms' sectoral differences could affect innovation performances (Davies, Maguire, Rimmerfeldt, & Pezzini, 2007). However this study wants to compare regional performances more than firm level ones, fitting the conditions under which the use of regional level data is appropriate (Brenner & Broekel, 2011).

There are several institutions measuring data aggregated at regional level, among which OECD (Organization for Economic Cooperation and Development) and Eurostat (the European Union statistics bureau) offer the most updated and homogeneous databases. Still the concept of "region" needed to be clarified in order to better represent Cooke's theoretical model and have coherence of aggregation among data. The European Union (2003) has developed a Nomenclature of Units for Territorial Statistics (NUTS) which divides each member state into a three level hierarchy based on their existing national administrative division: each unit is identified through a specific five digit code where the first two digits are letters representing the country, the latter three are numbers from 0 to 9 where 0 represents the upper level; in case a unit has more than 9 division, alphabetic letters starting from A are used. To make an example for Germany:

Table 3-1: Example of NUTS codification and administrative hierarchy

Level	Unit	Code	Description
0	Country	DE	Germany
1	Federal State (Bundesland)	DE7	Hessen
2	Region (Regierungsbezirk)	DE71	Darmstadt
3	District (Kreis)	DE71E	Wetteraukreis

In addition to the three level hierarchy, a two level one was developed for non-European countries, like EFTA countries (Norway, Switzerland, Iceland, Lichtenstein), Canada, USA and Turkey.

OECD has also developed a hierarchy for the identification of territorial units among its member states (OECD, 2010). Countries are divided into two Territorial Levels

(TL) consisting of macro-regions (TL2) and micro-regions (TL3), where TL1 is country or state level unit. A comparative between European Union and OECD hierarchies analysis showed that NUTS2 and TL2 are, when both applicable, overlapping.

When it comes to regional innovations studies, statistics are mainly made using NUTS 2 level aggregated data, with some notable exceptions (European Commission, 2010). OECD data are also available at TL2 level. Hierarchical level 2 seemed the most appropriate one for our analysis based on data availability. From a theoretical point of view, the concept of region was summarised by Cook (1997) as follows: "*Region is the name given to a territory which is less than the state in which it exists but has a significant degree of supralocal administrative, cultural, political or economic cohesiveness that differentiates it both from its state and its neighbouring regions*". Entities represented by NUTS2 or TL2 hierarchical levels are all territories with specific administrative power and, in some cases, very different historical and cultural specificities (for example the Basque Countries or Catalunia in Spain, or Alto Adige/Sůd Tyrol in Italy); it was therefore inferred that following aggregated data as done for the European Regional Innovation Scoreboard (European Commission, 2010) for our research was appropriate to represent our theoretical background.

3.3.2 The use of multiple regression

Multiple linear regression is a mean for hypotheses validation (Hair, Anderson, Tatham, & Black, 1998) and can be used for model selection purposes too (Agresti & Finlay, 1997) or in other words applies to both explanatory and exploratory research. In this research both approaches were used:

- **Explanatory:** the significance and strength of correlation between independent and dependent variables was verified, therefore testing the hypothesis that the presence of RIS potential explains innovation and collaborative innovation with foreign partner;

- **Exploratory:** it was also verified, among all independent variables, which really contributed in explaining the variation of dependent ones, identifying any differences in independent variables explaining each dependent one. The research objective was therefore to identify, if any, the differences among RIS leading to overall innovation or to international collaborative innovation.

In both cases, multiple linear regressions need to verify some assumptions (Agresti & Finlay, 1997; Hair et al., 1998):

a) the distribution of dependent and independent variables should be close to normal;
b) absence of multicollinearity, or significant correlation between independent variables;
c) the relationship between independent and dependent variables has to be linear;
d) homogeneity of variance in errors (homoscedasticity);
e) absence of autocorrelation of errors and independence of observations;
f) normal distribution of errors;
g) absence of outliers causing distortions.

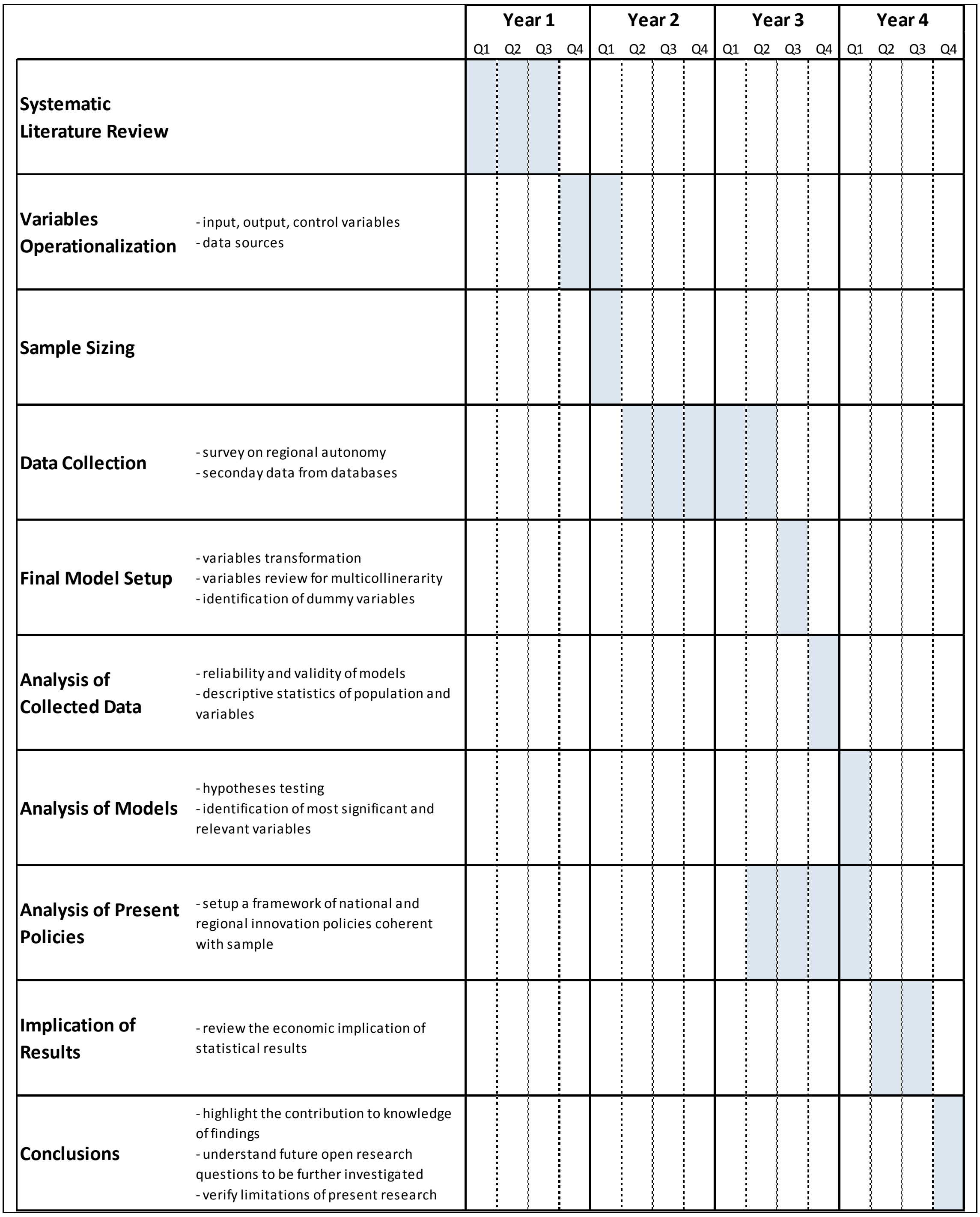
3.3.3 Research Process

Based on the previous analysis, multiple linear regression was chosen as the quantitative method for this research. Based on the statistical needs of this method, this research was divided into the following steps (see also Figure 9):

1. Systematic literature review, leading to the identification of research gaps, hypotheses and questions;

2. variables operationalization, the process enabling the identification of the quantitative input, output and control variables, and their data sources (primary or secondary);
3. sample sizing, the identification of the appropriate number of cases required for running a multiple linear regression;
4. data collection, both from primary and secondary data;
5. final model setup, the process of variables transformation, multicollinearity check and identification of potential dummy variables;
6. analysis of collected data, for a statistical description of data;
7. analysis of models, to provide statistical answers to research hypotheses and questions;
8. analysis of present policies, a specific analysis on innovation policies at national and regional level in order to support the understanding of the implications of results under a policy making perspective;
9. analysis of results implications, providing the economic implication of the econometric models developed
10. research conclusion, to highlight the contribution to knowledge and policy making, new streams of research and the limitations of this research.

Figure 9: Research Process and Timing



3.4 Variables operationalization

The process of variables operationalization was performed starting from the theoretical framework developed by Cooke as previously reported in **Error! Reference source not found.**. For each variable existing literature was searched in order to identify quantitative proxies, either available in existing databases or collectable through specific surveys. In some cases variables needed to be built through the combination of existing data. After independent and dependent variables were identified control variables were introduced for increasing overall power of our model (Seltman, 2012): control variables were determined through the models available in the literature.

3.4.1 Infrastructural level

3.4.1.1 Autonomous taxing and spending

Cooke (2001) clearly defines this variable and defines three levels: 1) decentralised spending, regions that act as mere central government budget allocators following national directives; 2) autonomous spending, when taxes are defined at national level but budget allocation is a regional decision; 3) taxation authority, regions with autonomous fiscal policy and budget allocation.

3.4.1.2 Policy influence on infrastructure

A region with a high RIS potential has a significant autonomy in planning infrastructural investments (Cooke, 2001; Cooke, 2002; Cooke et al., 1997), spacing from transportation to research infrastructures. The span of possible infrastructures' typologies is quite vast: using Cooke's words "*the range of possibilities is enormous in this respect, so we classify broadly into types of infrastructure over which regions may have more or less managerial or influence capacity*" (Cooke, 2002). Setting up a clear level structure of this variable is very difficult: as a matter of fact it is not only related to the ability of regions to directly finance infrastructural investments with their own budgets, but it includes their ability in influencing and, sometimes, managing such investments. This variable has three levels (autonomy, non-autonomy, partial autonomy) based on national and regional governance processes.

3.4.1.3 Regional university-industry strategy

This variable refers to the ability of a regional government to set up directions and supportive actions in order to facilitate university-industry relationships. In Cooke, Gomez Uranga and Etxebarria (1997) the authors refer mainly to the presence of policies and programs (table 1, page 483). In Cooke (2001) this variable is only included in the above mentioned table, but not discussed in the text, while in Cooke (2002) it is not mentioned at all. In all analysed texts, most attention is given to the ability of a regional government to invest in research infrastructures: we might infer that a good proxy for this variable is the autonomy of spending of regional governments in research and universities, again expressed in three levels linked to national and regional governance processes (autonomy, non-autonomy, partial autonomy).

3.4.1.4 Survey used for collecting data on regional autonomy

The three above mentioned variables (i. autonomous taxing and spending, ii. policy influence on infrastructure and iii. regional university-industry strategy) have been collected through a questionnaire sent to diplomatic or trade representatives in Italy of the 19 European countries represented in our dataset (Italy excluded), followed by phone interviews or reminders. Answers were triangulated with information collected on each country's government websites. All questionnaires were tailored for each country, indicating their regional entities as expressed by the European Regional Innovation Scoreboard database (European Commission, 2010). For each regional unit respondents were asked to answer three questions. Response rate was 100% for non-Italian countries. The questionnaire for Italian regions was answered reviewing the Italian constitution and regional statutes. Eventually data from 132 regions in Belgium, Cyprus, Czech Republic, Denmark, Estonia, France, Greece, Hungary, Italy, Latvia, Lithuania, Luxemburg, Malta, Norway, Poland, Romania, Slovenia, Slovak Republic, Spain and the United Kingdom (excluding North Ireland) were collected. It has to be noted that the Norwegian representative highlighted a mismatch between the regional subdivision made by the European Regional Innovation Scoreboard and the real administrative one; in order to have full alignment among secondary data and data collected through this survey, answers were adapted to EU NUTS.

Figure 10: Survey on Regional Autonomy

QUESTION 1) AUTONOMY IN TAX SPENDING

Please indicate w hich of the follow ing answ ers better describes the autonomy of tax spending in selected regions.

- [ ] **decentralised spending**, regions allocate central government budgets follow ing national directives;
- [ ] **autonomous spending**, taxe level is defined at national level but budget allocation is a regional decision
- [ ] **taxation authority**, regions w ith autonomous fiscal policy and budget allocation

QUESTION 2) AUTONOMY IN INFRASTRUCTURAL INVESTMENTS

Are selected regions autonomous in making their infrastructural investments (transportation, research centers etc)?

- [ ] **YES**
- [ ] **PARTIALLY**
- [ ] **NO**

QUESTION 3) AUTONOMY IN RESEARCH

Are selected regions autonomous in spending for research and universities?

- [ ] **YES**
- [ ] **PARTIALLY**
- [ ] **NO**

3.4.1.5 Regional private finance

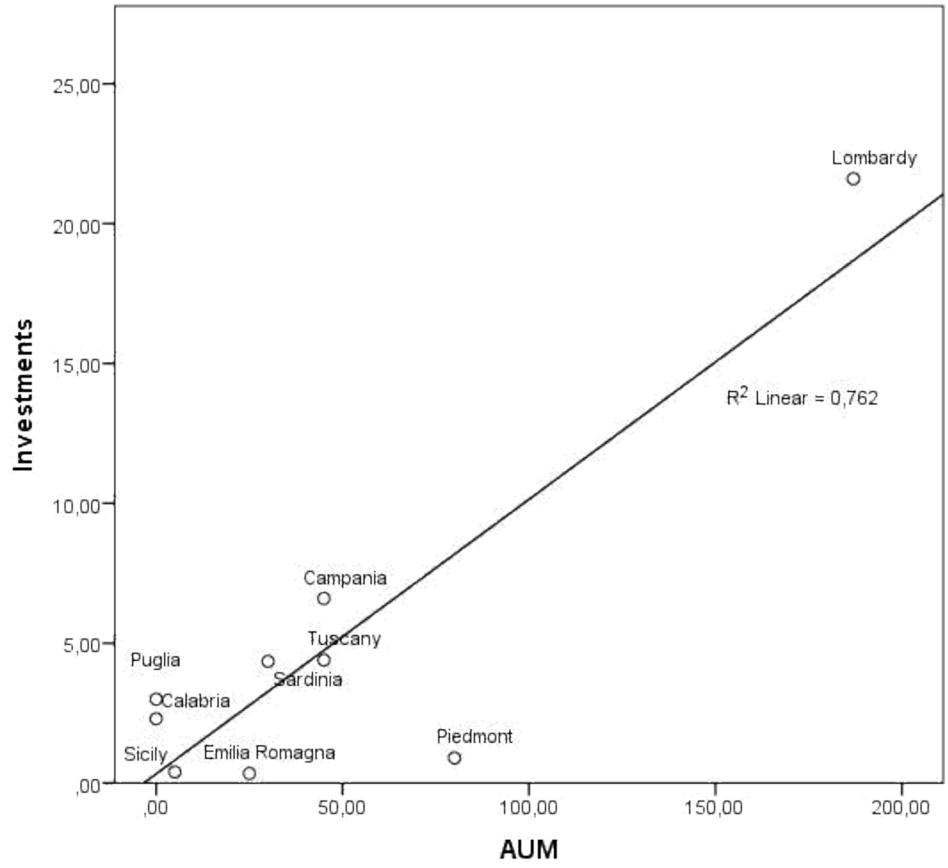
This variable should be considered in the perspective of "secured proximity capital" (Cooke, 2001) and regional administration's role is to orchestrate public/private financial opportunities for innovation. This role is confirmed in a later paper (Cooke, 2002), differentiating between those countries where private sector is less risk oriented (like Germany) – and the role of regional government is to "be involved in co-financing or provision of loan guarantees" – and other countries in which venture capital is the main financial source for innovation (USA and UK). Still, if "private" finance only has to be measured, the size of regional venture capital industry might be a good proxy. This proxy is used by the European Commission in its European Innovation Scoreboard report (European Commission, 2009), based on European Venture Capital Association (EVCA) statistics measuring the total amount of capital invested in venture funds as a percentage of national GDP. However this variable is not included in those measured by the European Regional Innovation Scoreboard (European Commission, 2010) and it was needed to build it at regional level. A database of seed and early stage (EVCA, 2010b) was setup and linked each fund to a specific European region belonging to the previously identified list. Then, for each region (R), a variable expressed by the following equation was set up:

$$VC_R = (\Sigma_i \, AUM_{iR})/GDP_R$$

Where AUM_{iR} are the total assets under management (in Euro) in seed and early stage vehicles of the "i" fund management company located in the "R" region, and GDP_R is the gross domestic product of the "R" region (in Euro) as reported by OECD (2011b). This variable does not measure the amount of venture capital investments, weighted by GDP for each region, but the amount of assets under management (the size of funds) located in each region and weighted by regional GDP. This represents a difference with respect to national level Eurostat variables, but data on venture capital investments per region are not fully available. It was therefore decided to test the correlation between these two different variables, using data collected by AIFI, the

Italian Venture Capital and Private Equity Association, and LIUC, Università Carlo Cattaneo (Donadonibus, Meli, & Marseglia, 2013). Available data from 32 venture capital operations all over Italy were crossed with data and location of existing Italian venture funds: the size in Euro of the investments and the regional location of each target company were combined with the size in Euro of Italian operating venture capital funds and their location in Italian regions. The total amount of investments in Euro and the total amount of funds' size in Euro (AUM) for each region were correlated. The two variables shown to be well correlated, with an $R^2 = 0.762$ and significance = 0.002 (see Figure 11). The results of this correlation were used to triangulate this approach with researchers from the University of Bologna whose research focus is venture capital and scientific entrepreneurship.

Figure 11: Correlation between VC investments and VC AUM in Italian regions



Investments and AUM are expressed in Milion Euro

3.4.2 Superstructural level

As previously mentioned, superstructural level variables are the most qualitative ones. Cooke (2002) defines these variables as the "*mentalities among regional actors or the culture of the region and can be divided into the institutional level, the organizational level for firms, and the organizational level for governance. Together, these help to define the degree of embeddedness of the region, its institutions, and its organizations*." They have been divided into three main areas (Cooke, 2001; Cooke, 2002): institutional, firms organizational dimensions and policy organizational dimensions. These variables seem to be a synthetic representation of "*the systemic* *dimensions of learning and innovation*" and "*productive culture: the institutional setting*" described in paragraphs 5 and 6 of a previous paper (Cooke et al., 1997); still in this paper such variables represent "*non-quantifiable*" values (Cooke et al., 1997).

It was first tried to setup a dataset regarding these variables through a specific survey to be sent to firms in the various target regions. The survey was based on Cooke's description of factors effecting superstructural level variables of RIS and it covered six sections with 59 questions. Each question was linked to a specific scalable variable and did not use a Likert scale approach. As a matter of fact a survey would have been appropriate as it is a proven method for answering questions and allowing the comparison among variables (Pinsonneault & Kraemer, 1993; Wimmer & Dominick, 1994). Before preparing a web based version of the questionnaire, it was tested it in a limited environment (Aaker, Day, & Kumar, 1998); an area in the Tuscany region, in Italy, was selected thanks to the support of a very collaborative industrial association. The results from this pilot run have been poor in terms of redemption and with some negative feedbacks: several variables introduced in our survey, based on RIS theory, touched sensible topics like industrial relations and perceptions about regional policies which entrepreneurs and institutional representative were not willing to answer even in presence of confidentiality agreements and anonymous questionnaires. With such a poor redemption rate, combined with negative feedbacks of respondents on several questions perceived as politically sensible, the survey approach was questioned. Its content was reviewed with specific respect to sensible questions. A lighter and reviewed version of the questionnaire was tested, but poor redemption rate and issues on sensibility were confirmed. A further analysis on the redesign of the questionnaire was performed in parallel with one on the availability of secondary data: as a result is was under the impression that available secondary data, combined with few, specific primary data, would have supported the setup of a database coherent with our research goal.

Based on the previous Cook's definitions of regional embeddedness, two variables as proxies of regional embeddedness were identified (co-operative culture and interactive innovation):

i. the percentage of innovative SME collaborating with others (European Commission, 2010);
ii. the percentage of PCT (Patent Cooperation Treaty) patents co-invented with regional partners, available in OECD database.

The PCT was signed in Washington on June 19, 1970 and entered into force on January 24, 1978. It provides a unified procedure for patent filing among all contracting countries, known as "international application". With respect to national applications, the international one offer the opportunity to have a unified procedure for all patents filed in contracting countries, thus delaying the significant expenses linked to the extension into all desired national and regional phases (WIPO, 2012).

The European Regional Innovation Scoreboard is also the source of a proxy variable for interactive learning or, more broadly in Cooke's words "the systemic dimensions of learning": "life-long learning", a variable which refers to the participation in learning programs by the population aged between 25 and 64.

Last, the degree of externalisation was evaluated. There are several proxy variables used for measuring externalisation or outsourcing, which have been recently compared (Horgos, 2007):

- Imported Inputs as Share of Total Imports
- Imported Inputs as Share of Total Inputs
- Imported Inputs as Share of Gross Output
- Vertical Specialization (measured by the share of imported inputs embodied in production at an industry level

- Value Added as Share of Production

The empirical analysis performed by Horgos using German data shows that the value added trends were the most accurate in representing the effects of innovation in specific sectors like services combining them with outsourcing to lower cost countries. It was therefore decided to build up a regional externalization index represented by the ratio between regional aggregated value added and regional GDP. Both variables are available in Eurostat and OECD databases. Following an analogy with the ratio between value added and sales of a single company (Woodrow Eckard, 1979), this ratio is proportional to the degree of vertical integration, therefore is inversely proportional to the degree of externalization.

3.4.3 Output variables

Many empirical studies show that the number of patents generated in a specific spatial area are often correlated with innovation inputs such as R&D investments (Buesa et al., 2006; Griliches, 1990; Parimal Patel & Pavitt, 1994) even in quantitative studies related to regional innovation system performances (Buesa et al., 2006; Fritsch & Slavtchev, 2008). while other recent researches referred to patent-related indicators, like patent quality, as a proxy of innovation output (Ejermo, 2009). More often scholars have used patent productivity indexes such as patents per inhabitants (Furman et al., 2002) or patents per employees (Bode, 2004). The use of patents as innovation output proxy has some limitations: i) patents refer to inventions not always to innovations, ii) several innovations are not patented or patentable and iii) patent appropriate localization might be questionable for patents filed by multinational corporations as sometimes ownership refers headquarters location and not to the R&D facility that drove the invention; still patent statistics are available and the trade-off might be between patents and poor data availability (Brenner & Broekel, 2011).

The European Regional Innovation Scoreboards and European Innovation Scoreboards consider patents among firm activities and not among innovation outputs; here they include i) technological innovators as % of SMEs, ii) non technological innovators as % of SMEs, iii) employment in knowledge intensive services and high tech manufacturing as % of total workforce, iv) sales of new-to-firm products in % of total turnover and v) sales of new-to-market products as % of total turnover. These variables are collected through very detailed questionnaires, covering a wide spectrum of innovation related topics; however response rates and accuracy of data are questionable (Brenner & Broekel, 2011). However not all companies have appropriate accounting processes able to track precisely R&D and new products economics; furthermore answers are pretty much subjective with respect to how much companies are innovative. On top of this not all the 132 regions identified for input variables were able to provide data on new to firm and new to market products to the European Regional Innovation Scoreboard. In particular data from the 30 regions located in Italy and United Kingdom were missing.

Based on the previous analysis on existing literature, it was decided to consider as output variables:

a) PCT patents per million inhabitants and
b) Percentage of PCT patents filed with foreign partners.

Both variables are available in OECD database. The first represents the general innovation output of one region, while the second refers to its ability of generating innovation with partners on an international scale. The two dependent variables have actually different scales, being one a ratio (PCT patents per million inhabitants) and the second a percentage (percentage of PCT patents filed with foreign partners). In order to better evaluate the two relative models, a better homogeneity among these two variables was needed and the latter was transformed into the number of PCT patents filed with foreign partners per million inhabitants. This transformation was made by multiplying the first variable with the second.

The very same transformation was required for the independent variable referring to the percentage of PCT patents filed with regional partners.

3.4.4 Notes on variables

This study is based on 2006 data for the majority of input and output variables. There are two exceptions to this rule.

First, data related to SMEs collaborating with other in R&D and referring to Italian regions were actually collected in 2004, while reported in 2006 survey with clear disclaimer on their original reference.

Second, data about private finance, referred to regional venture and seed capital presence, were collected in 2010 for all regions. It was believed this does not influence the analysis as the venture capital industry remained almost stable, with respect to asset under management, in Europe (Ernst&Young, 2010).

This model was built based on Cooke's theoretical framework on RIS, however, as previously described, it was not possible to operationalize all variables included in his model, due to their highly qualitative level. Therefore, before running any further analysis, this model was triangulated with several scholars, sending our variable operationalization analysis and following it with a phone interview. Our set of variables was considered aligned with the underlying theory of RIS.

3.4.5 Control variables

In order to have more reliable and powerful model (Seltman, 2012) a literature review was made in order to check the presence of control variables to be included in our model. The literature review was performed checking quantitative models showing correlation between each or our independent variables with other variables not included in our operationalization process.

a. Business R&D expenditures and Innovative SMEs. These two variables are more precisely i) total of business R&D expenditures over regional GDP and ii) the percentage of product and process innovative SMEs on all SMEs, both available from Eurostat (2010). We chose these variables as controls of Regional Embeddedness, measured by the percentage of SMEs collaborating with others in R&D, and previously reviewed analysing the variables affecting the willingness of companies in cooperating with each other. Thorgren, Wincent, & Ortqvist (2009) made a longitudinal study on 53 SMEs networks examining how network size and the governance structure influence the degree of collaboration. Their finding is that networking is a bottom up process, partially mediated by the administrative body, where the higher is the number of companies in a network, the higher is the degree of collaboration. In the same year another study (Gnyawali & Park, 2009) introduced a conceptual model of firm and industry level drivers of co-opetition (simultaneous strategy of competition and co-operation) among firms: the authors discovered that companies were willing to co-operate if belonging to the same industry, with significant R&D costs and low product lifecycles. High R&D costs were also indicated as a key driver for cooperation in a resource based model, based on French CIS survey data (Miotti & Sachwald, 2003). R&D cost seems therefore a variable highly correlated with the percentage of SME collaborating with others in R&D in any specific regions.

   Furthermore, business R&D expenditures represent, together with the variable used as a proxy of tertiary education level (see next point c.), a control variable for the presence of venture capital. In our study we built up the venture capital variable using the ratio of venture capital assets under management of each specific region and regional GDP. The development of the venture capital industry was studied in Europe between 1990 and 1996 (Leleux & Surlemont, 2003). Researchers discovered that public funds have an important role to seed the industry: their presence is therefore high in early stages, while lowers in countries with a more mature venture arena. The presence of public incentives for boosting innovation might be, however, a threat to promote venture capital due to the limited appropriability of new knowledge (Peneder, 2008); the same study highlighted a second threat in the imperfections of a national capital markets. Unfortunately none of the previous variables can be considered in our model, as they either refer to national level or they need longitudinal studies or both. Still several qualitative studies based on our Regional Innovation Systems theory report a link between venture capital and the presence of universities and research centres (Cooke, 2004a; Cooke, Davies, & Wilson, 2002; Cooke et al., 2003), confirming the previous Triple Helix theory which, among other indications, stresses the role of academia as a source of new, knowledge based firms financed by venture capitalists (Etzkowitz & Leydesdorff, 1997). In a recent study performed using Thomson Reuters database (Guerra, 2011) in order to understand the effects of the 2007-2010 financial crisis over venture capital operations, it has been shown that despite the previous finding on financial markets efficiency (Peneder, 2008), most venture capital exits are performed by industrial players: a finding which partially confirms the previously mentioned Triple Helix, closing the knowledge transfer process from universities to corporations. It might be inferred that venture capitalists are usually located in places with R&D oriented industrial players. Based on the previous analysis, the level of tertiary education (as a proxy of university presence) and private R&D spending over GDP can be considered as good control variables for the presence of venture capital funds in one region; these variables are available in the Regional Innovation System database.

b. Product and process innovators: Eurostat measures the percentage of SMEs introducing product or process innovations as a percentage of all SMEs; this data is available at regional and national level (European Commission, 2010). Product and process innovators were considered as a control variable for externalization. The determinants of externalization have been studied since the 1990s. Murray, Kotabe and Wildt (1995) investigated sourcing factors using a contingency model of global sourcing strategy: they discovered that product and process innovation together with asset specificity are negatively linked to external sourcing. A study partially confirmed by Tomiura (2007) who highlighted the correlation of capital intensity and externalization in a firm level study performed in Japan, aimed at analysing how productivity changes based on globalization strategies.

c. Population with tertiary education: measured at regional level by the number of people with tertiary education degrees per 100 population aged between 25 and 64; this variable is collected by Eurostat (European Commission, 2010). In the previous point b. it was found that this variable is a control for the presence of venture capital. Moreover, a study performed in the UK made a longitudinal analysis to determine the key factors that underpin one person's choice to undertake life-long education (Jenkins, Vignoles, Wolf, & Galindo-Rueda, 2003). The evidence shows that people with O-level or above qualifications are more likely to attend episodes of life-long learning, which also creates a virtual cycle where the frequency of attendance increases with the number of episodes. It was therefore inferred that population with tertiary education can be used as a control variable for Life-long learning, measured by participation in life-long education per 100 population aged between 25 and 64.

Table 3-2: Model Variables

	Variable	Proxy of	Definition	Source(s)
Control Variables	PP_Inno		SMEs introducing product or process innovations In % of all SMEs	European Regional Innovation Scoreboard
	Terz		Population with tertiary education per 100 population aged 25-64	European Regional Innovation Scoreboard
	Biz_RD		Business R&D expenditures as a percentage of GDP	European Regional Innovation Scoreboard
Independent Variables	**SUPERSTRUCTURAL LEVEL**			
	SME_Coll	Regional embeddedness	% SME collaborating with others in R&D	European Regional Innovation Scoreboard
	PCT_reg	Innovation with regional partners	Number of PCT patents per million inhabitants filed with regional partners	OECD
	Life_Long	Systemic dimension of learning	Participation in learning programs by the population aged between 25 and 64	European Regional Innovation Scoreboard
	Ext	Externalization	Ratio between consolidated regional value added and GDP	Eurostat, OECD
	INFRASTRUCTURAL LEVEL			
	VC	Regional private finance	(Σi AUMiR)/GDPR	EVCA, OECD
	Tax_Sp	Spending and taxation authority	1 to 3 integer value (1 lower autonomy – 3 highest)	Survey, government web sites
	Aut_Res	Autonomy in research investments	1 to 3 integer value (1 lower autonomy – 3 highest)	Survey, government web sites
	Aut_Infr	Autonomy in infrastructure investments	1 to 3 integer value (1 lower autonomy – 3 highest)	Survey, government web sites
Dependent Variables	PCT	Innovation	Number of PCT patents per million inhabitants	OECD
	PCT_for	Innovation with global partners	Number of PCT patents per million inhabitants filed with foreign partners	OECD

Control variables for other independent ones were not identified: spending and taxation authority, autonomy in infrastructure investments and autonomy in R&D and related policies investments. These variables are related to the political strategy of each region and each country each region is located in: the historical path that lead each country and each region to the present governance system is different and sometime relies to very old political heritages. No control variables have been adopted for these variables.

3.5 Final model set up

Based on the previous variable operationalization process the following linear multiple regression models was set up, one for each of our dependent variables:

1) $PCT = \alpha + \sum_i \beta_i IV_i + \sum_j \beta_j CV_j + \varepsilon$
2) $PCT\_for = \alpha_{for} + \sum_i \beta_{for\,i} IV_i + \sum_j \beta_{for\,j} CV_j + \varepsilon_{for}$

Here the subscripts refer to (i) independent variables and (j) control variables. IV are independent variables and CV are control variables; ε is the error term. Subscript (for) refers to the constant term α and slope terms β used for predicting innovation with global partners variable (PCT_for); α and βs not showing this subscript are referred to innovation variable (PCT). Table 3-2 describes the variables included in the model on a first step.

3.5.1 Sample Size

The size of the sample to be collected, both via primary and secondary data, is a function of the number of independent variables in the models (therefore including control variables too, as they act as independent ones in the multiple regression models). Agresti and Finlay (1997) use the ratio between observations and independent variables to check samples size; the minimum size should meet the 5:1 ratio (five observations per each independent variable), while the optimal one should meet the 20:1 ration. Howitt and Cramer (2011) use the same ratio, but indicate its optimal value as 10:1 (10 observations per each independent variable. Other scholars claim that the minimum number of observations should be equal to 50 + 8 times the number of independent variables (Tabachnick & Fidell, 2007). Based on these assumptions, and considering a total of 11 independent variables in the previously introduced model (see Table 3-2), data collection process in our research should lead to a sample size of at least 55 observations (see Table 3-3 for a summary of sample size requirements).

Table 3-3: Sample Size Requirements

Reference	Obs./Ind. Var.	Sample size limit
(Agresti & Finlay, 1997)	Minimum 5:1	55
	Optimal 20:1	220
(Howitt & Cramer, 2011)	10:1	110
(Tabachnick & Fidell, 2007)	50 + 8:1	138

3.5.2 Variables transformation

One of the assumptions required for running a linear multiple regression is that independent and dependent variables should have a distribution as much as possible close to the normal one. Skewness and kurtosis of all our variables were analysed and their distributions visually checked (Agresti & Finlay, 1997; Hair et al., 1998; Seltman, 2012). Figure 12, Figure 13 and Figure 14 show the distribution graphs of our variables, while Table 3-4 reproduces the values of skewness and kurtosis for each variable. Several variables show a distribution far from normality and we decided to transform them in order to set up a model fitting with the required assumption of normality:

a) Terzialization: has a positive (right), yet moderate, skewness while kurtosis is moderately negative. We transformed this variable into its natural logarithm;
b) Externalization: shows a significant left skewness and high positive kurtosis. However looking to the graph it seems that this is due to some outliers which, if not considered, are making the distribution close to normal. We discovered that all outliers belong to Norway: as a matter of fact in all countries but

Norway the value of externalization is very close to country average; we might infer that the presence of such outliers is a consequence of national statistic approaches. The value of skewness and kurtosis without outliers go from -9.09 to 2.75 and from 89.50 to 11.58. Looking to the distribution graphs and provided the significant concentration of data into few classes we decided not to transform this variable;

c) Venture capital: this variable has a significant right skewness and very high kurtosis. This distribution reflects the concentration of venture capital funds in few regions, which does not implies that investments are not performed elsewhere. Still it was decided to transform this variable into its square root in order to lower its skewness and kurtosis. The natural logarithm transformation was not used as it was leading to less normal distributions;

d) PCT patents, and all variables related to this parameter (PCT, PCT_reg, PCT_for): their distributions are all positively skewed and with positive kurtosis too. All these variables were transformed into their natural logarithm.

Figure 12: Distributions of Control Variables

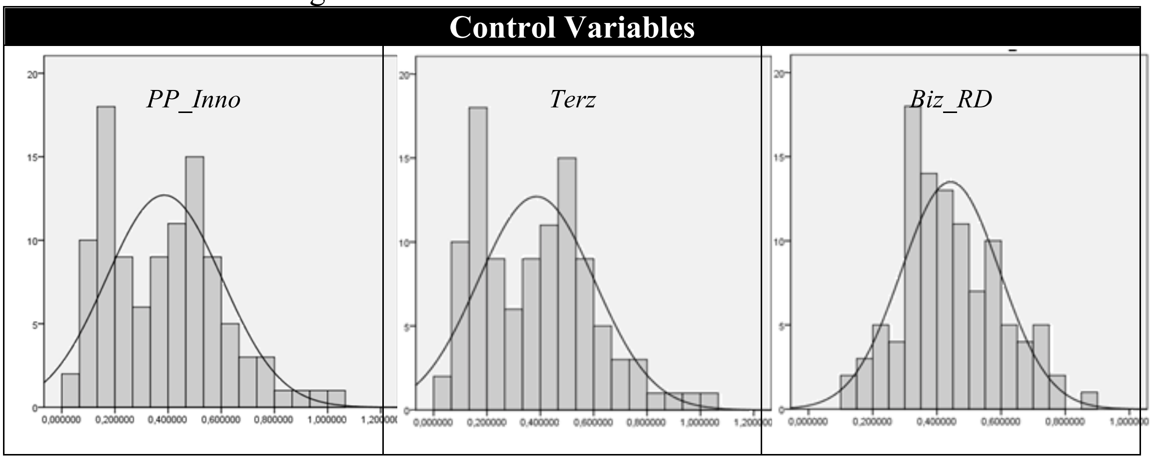


Figure 13: Distributions of Dependent Variables

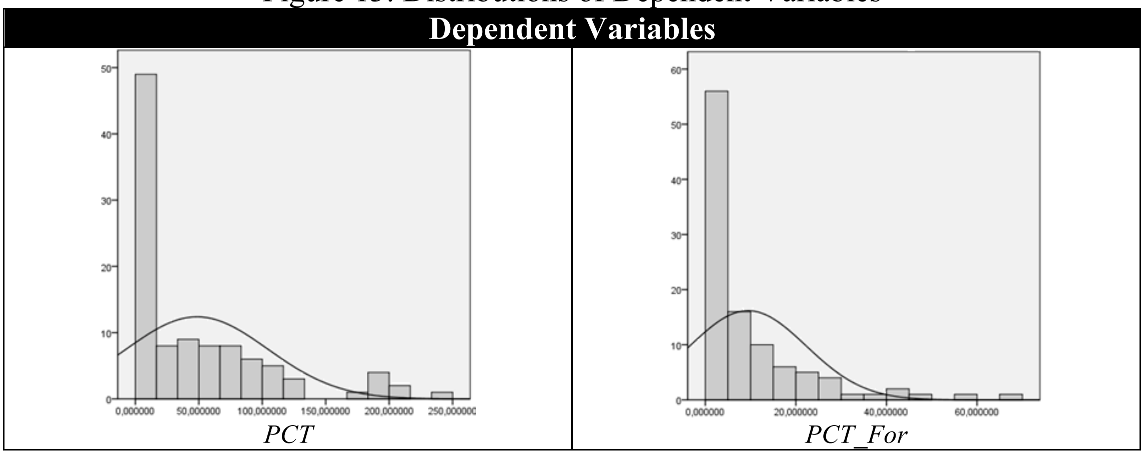


Figure 14: Distributions of Independent Variables

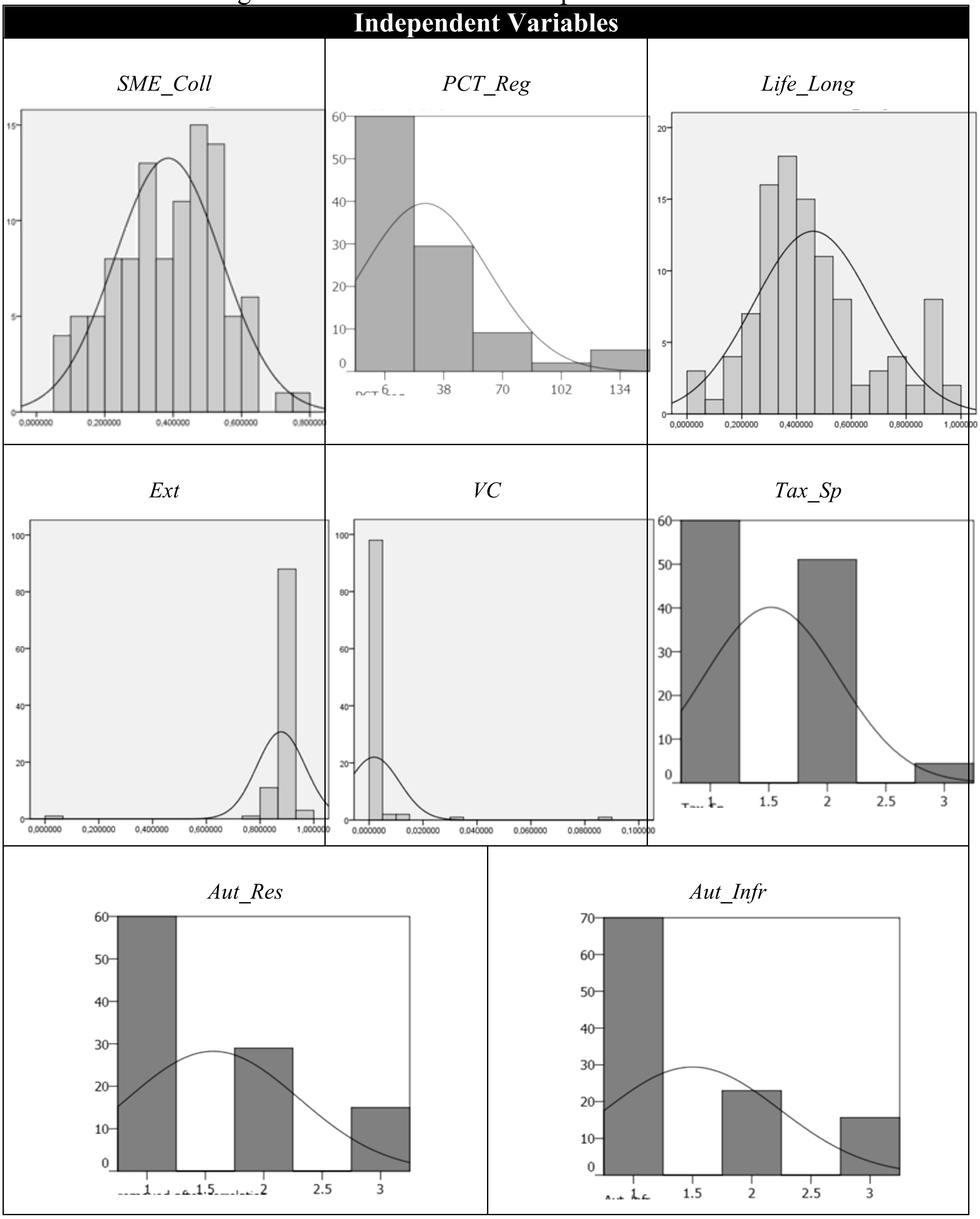


Table 3-4: Skewness and Kurtosis of Variables

		N	Skewness		Kurtosis	
		Statistic	Statistic	Std. Error	Statistic	Std. Error
Control Variables	PP_Inno	104	.305	.237	-.715	.469
	Terz	104	.534	.237	-.198	.469
	Biz_RD	104	.342	.237	-.240	.469
Independent Variables	SME_Coll	104	-.226	.237	-.587	.469
	PCT_reg	104	1.740	.237	2.740	.469
	Life_Long	104	.704	.237	-.071	.469
	Ext	104	-9.092	.237	89.506	.469
	VC	104	8.145	.237	72.321	.469
	Tax_Sp	104	.551	.237	-.665	.469
	Aut_res	104	.890	.237	-.600	.469
	Aut_infr	104	1.111	.237	-.252	.469
Dependent Variables	PCT	104	1.555	.237	1.909	.469
	PCT_for	104	2.144	.237	4.933	.469

3.5.3 Avoiding multicollinearity

Following Hair et al. (2003) correlation among independent transformed variables were analysed and it was checked if any was exceeding a Pearson's value above 0.7. Two variables were found above this limit and it was decided to remove them from the model: Aut_res and PCT_reg, respectively correlated with Aut_infr (with correlation value of 0.744) and with Biz_RD (with correlation value of 0.728). Table 3-5 shows the outcome of our analysis: highlighted in grey the variables which needed to be removed and their Pearson's values.

Table 3-5: Analysis of Correlation

		PP_Inno	Log_Terz	Biz_RD	SME_Coll	Log_PCT_reg	Life_Long	Ext	Sqr_VC	Tax_Sp	Aut_infr	Aut_res
PP_Inno	Pearson	1	.023	,352**	,372**	,406**	,199*	-.037	,207*	.132	.147	.068
	Sig. (2-tailed)		.820	.000	.000	.000	.043	.710	.035	.183	.138	.494
	N	104	104	104	104	104	104	104	104	104	104	104
Log_Terz	Pearson	.023	1	,368**	,222*	,506**	,583**	-.129	,310**	,692**	,329**	.153
	Sig. (2-tailed)	.820		.000	.023	.000	.000	.192	.001	.000	.001	.120
	N	104	104	104	104	104	104	104	104	104	104	104
Biz_RD	Pearson	,352**	,368**	1	,397**	,728**	,516**	-.021	,263**	,513**	,343**	.159
	Sig. (2-tailed)	.000	.000		.000	.000	.000	.833	.007	.000	.000	.106
	N	104	104	104	104	104	104	104	104	104	104	104
SME_Coll	Pearson	,372**	,222*	,397**	1	.134	.180	-.057	.169	,204*	,365**	,262**
	Sig. (2-tailed)	.000	.023	.000		.175	.068	.566	.087	.037	.000	.007
	N	104	104	104	104	104	104	104	104	104	104	104
Log_PCT_reg	Pearson	,406**	,506**	,728**	.134	1	,676**	-.029	,328**	,587**	,414**	.041
	Sig. (2-tailed)	.000	.000	.000	.175		.000	.773	.001	.000	.000	.681
	N	104	104	104	104	104	104	104	104	104	104	104
Life_Long	Pearson	,199*	,583**	,516**	.180	,676**	1	-.007	,334**	,656**	.136	-.063
	Sig. (2-tailed)	.043	.000	.000	.068	.000		.946	.001	.000	.170	.527
	N	104	104	104	104	104	104	104	104	104	104	104
Ext	Pearson	-.037	-.129	-.021	-.057	-.029	-.007	1	-.031	.036	-.041	.072
	Sig. (2-tailed)	.710	.192	.833	.566	.773	.946		.752	.718	.681	.466
	N	104	104	104	104	104	104	104	104	104	104	104
Sqr_VC	Pearson	,207*	,310**	,263**	.169	,328**	,334**	-.031	1	,248*	.157	.124
	Sig. (2-tailed)	.035	.001	.007	.087	.001	.001	.752		.011	.112	.208
	N	104	104	104	104	104	104	104	104	104	104	104
Tax_Sp	Pearson	.132	,692**	,513**	,204*	,587**	,656**	.036	,248*	1	,504**	,262**
	Sig. (2-tailed)	.183	.000	.000	.037	.000	.000	.718	.011		.000	.007
	N	104	104	104	104	104	104	104	104	104	104	104
Aut_infr	Pearson	.147	,329**	,343**	,365**	,414**	.136	-.041	.157	,504**	1	,744**
	Sig. (2-tailed)	.138	.001	.000	.000	.000	.170	.681	.112	.000		.000
	N	104	104	104	104	104	104	104	104	104	104	104
Aut_res	Pearson	.068	.153	.159	,262**	.041	-.063	.072	.124	,262**	,744**	1
	Sig. (2-tailed)	.494	.120	.106	.007	.681	.527	.466	.208	.007	.000	
	N	104	104	104	104	104	104	104	104	104	104	104

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

3.5.4 Dummy variables

Dummy variables, or indicators (Seltman, 2012), are categorical independent variables that can only take the values 0 or 1. The present model is based on regional level data and is aimed at analysing RIS performances, however several variables might be influenced by national level ones. For example the regional degree of autonomy in taxation, infrastructural or research investments is influenced and determined by country level policies. In case of venture capital policies are even moving up to European level (EVCA, 2010a). Furthermore, literature shows that National Innovation Systems still play a relevant role in pursuing innovation performances (Cantwell, 1995; Lane, 2000) as well as for attracting foreign investments in R&D (Reddy, 1997). Belonging to a specific country might therefore influence the performances of a RIS and it was decided to add to the model dummy variables linked to each country represented in our database. United Kingdom was considered as the baseline country and 13 dummy variables were added, each referring to one of the other represented countries (Belgium, Czech Republic, Denmark, France, Greece, Hungary, Italy, Luxemburg, Norway, Poland, Portugal, Slovak Republic and Spain); each variable takes i) the 1 value whenever a region belongs to the specific country represented by the variable itself and ii) the 0 value elsewhere.

3.5.5 Final model

Based on the previous preliminary analysis and performing required variable transformation and elimination final variables were shaped, as represented in Table 3-6.

3.5.6 Proposed models

The following equations have been used to assess the role of regional innovation system variables on i) innovation in general and ii) innovation with global partners:

3) $Log\_PCT = \alpha + \sum_i \beta_i IV_i + \sum_j \beta_j CV_j + \sum_k \beta_k + \varepsilon$

4) $Log\_PCT\_for = \alpha_{for} + \sum_i \beta_{for\,i} IV_i + \sum_j \beta_{for\,j} CV_j + \sum_k \beta_k + \varepsilon_{for}$

Here the subscripts refer to (i) independent variables, (j) control variables and (k) dummy variables. IV are independent variables and CV are control variables; ε is the error term. Subscript (for) refers to the constant term α and slope terms β used for predicting innovation with global partners variable (Log_PCT_for); α and βs not showing this subscript are referred to innovation variable (Log_PCT). β_k are dummy variables with value = 1 in case data were referring to one specific country and value = 0 for all other countries; subscript K goes from 1 to 12, being 13 the total countries represented in our analysis and having chosen one country (UK) as the reference one.

Table 3-6: Description of Final Variables with Respect to Cooke's RIS Model

	Variable	Proxy of	Definition	Source(s)
Control Variables	PP_Inno		SMEs introducing product or process innovations In % of all SMEs	European Regional Innovation Scoreboard
	Terz		Population with tertiary education per 100 population aged 25-64	European Regional Innovation Scoreboard
	Biz_RD		Business R&D expenditures as a percentage of GDP	European Regional Innovation Scoreboard
Independent Variables	**SUPERSTRUCTURAL LEVEL**			
	SME_Coll	Regional embeddedness	% SME collaborating with others in R&D	European Regional Innovation Scoreboard
	Life_Long	Systemic dimension of learning	Participation in learning programs by the population aged between 25 and 64	European Regional Innovation Scoreboard
	Ext	Externalization	Ratio between consolidated regional value added and GDP	Eurostat, OECD
	INFRASTRUCTURAL LEVEL			
	VC	Regional private finance	(Σi AUMiR)/GDPR	EVCA, OECD
	Tax_Sp	Spending and taxation authority	1 to 3 integer value (1 lower autonomy – 3 highest)	Survey, government web sites
	Aut_Infr	Autonomy in infrastructure investments	1 to 3 integer value (1 lower autonomy – 3 highest)	Survey, government web sites
Dependent Variables	PCT	Innovation	Number of PCT patents per million inhabitants	OECD
	PCT_for	Innovation with global partners	Number of PCT patents per million inhabitants filed with foreign partners	OECD

For each dependent variable a total of 11 models were set up with different means:

- Models 1 to 7 are built using control variables and one (or none) independent variables. This approach is used i) to check control variables and their ability to act as blocking factors (Seltman, 2012) and ii) to see how each independent variable, stand alone, impacts the dependent one (Fini, Grimaldi, Santoni, &

Sobrero, 2010). No dummy variables were considered. These models were analysed using a multiple regression;

- Models 8 and 9 are built with the whole set of control and independent variables in order to assess the full model. More precisely model 8 does not include country-related dummy variables, while model 9 includes all dummy variables. Multiple regression was used for analysing models 8 and 9.
- Models 10 and 11 are exploratory ones and where analysed using a stepwise multiple regression. This method is used for variable selection based on their contribution to the explanatory power of the model. Hair et al. (1998) indicated that independent variables are selected when their partial correlation coefficients are significant while they are dropped if their predictive power drops to a non-significant level when another independent variable is added to the model. Model 10 did not include dummy variables, while model 11 included dummies. In stepwise multiple regressions we used as limits an F probability to enter lower equal to 0.05 and an F probability to remove or 0.1.

Table 3-7: Variables Used in Running Models Explaining General Innovation (Log_PCT)

Dependent variable:	enter	enter	enter	enter	enter	enter	enter	enter	enter	stepwise	stepwise
Log_PCT	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	1.10	1.11
Prod_proc_inno	X	X	X	X	X	X	X	X	X	X	X
Log_Terz	X	X	X	X	X	X	X	X	X	X	X
Biz_rd	X	X	X	X	X	X	X	X	X	X	X
SME_coll		X						X	X	X	X
Life_long			X					X	X	X	X
Extern				X				X	X	X	X
Sqr_Venture					X			X	X	X	X
Tax_aut						X		X	X	X	X
Invest_infr							X	X	X	X	X
Dummies	N	N	N	N	N	N	N	N	Y	N	Y

The variables used in the above mentioned 22 models are represented in Table 3-7 and Table 3-8, where models 1.1 to 1.11 refer to Log_PCT as dependent variable and models 2.1 to 2.11 refer to Log_PCT_for.

Table 3-8: Variables Used in Running Models Explaining Foreign Collaborative Innovation (Log_PCT_for)

Dependent variable: Log_PCT_for	enter 2.1	enter 2.2	enter 2.3	enter 2.4	enter 2.5	enter 2.6	enter 2.7	enter 2.8	enter 2.9	stepwise 2.10	stepwise 2.11
Prod_proc_inno	X	X	X	X	X	X	X	X	X	X	X
Log_Terz	X	X	X	X	X	X	X	X	X	X	X
Biz_rd	X	X	X	X	X	X	X	X	X	X	X
SME_coll		X						X	X	X	X
Life_long			X					X	X	X	X
Extern				X				X	X	X	X
Sqr_Venture					X			X	X	X	X
Tax_aut						X		X	X	X	X
Invest_infr							X	X	X	X	X
Dummies	N	N	N	N	N	N	N	N	Y	N	Y

3.5.7 Research questions

In the previous chapter a framework of research related to the intersection between innovation, networking and globalization was developed. Through this framework a research gap emerged in understanding how setting up global innovation alliances is possible for firms located in specific areas. More precisely it was seen that RIS might represent an opportunity for global knowledge reach and related research is still in development. Analysing research methodologies about RIS, the need for additional quantitative studies were highlighted and it was decided to setup a multiple linear regression framework. This framework is made of 22 different models, 11 related to a general innovation dependent variable and 11 related to a specific dependent variable related to collaborative innovation with foreign countries.

As previously explained in this chapter, there is limited quantitative modelling of RIS. The first step in analysing our framework is to ensure that we properly modelled RIS, that is to say we expect strong positive correlation between RIS potential and regional innovation. In other words the first hypothesis to be tested is:

H1: *the higher is RIS potential, the higher will be regional innovation expressed by patent production.*

Once hypothesis H1 will be tested and, in case, confirmed, our main research question, related to understand if RIS are an opportunity for local firms to exploit innovation with global partners, will be verified. The second hypothesis is therefore:

H2: *the higher is RIS potential, the higher will be regional innovation exploited with global partners, expressed by patent production with foreign partners.*

As previously mentioned, a multiple linear regression models can be used for exploratory purposes too (Agresti & Finlay, 1997). This offers the opportunity to go beyond the test of hypothesis H1 and H2 and understand which are the key variables related to RIS model influencing innovation as a whole and collaborative innovation with global partners. The present quantitative framework will therefore be used to answer two additional research questions:

R1: *which are the variables of a regional innovation system effecting its overall patent production?*

And

R2: *which are the variables of a regional innovation system effecting its patent production in cooperation with foreign partners?*

3.6 Framework of Present Innovation Policies

A wide set of policies is nowadays in place in various countries: some of them are applied at national level and/or at regional one. OECD (2011a) made a comparative study on various innovation policies in some of its member states and listed those applied at national and regional level. In order to analyse them, OECD findings related to 14 European countries have been extracted (see Appendix D). OECD marked with "X" policies fully applied and with "S" policies with partial application; policies not applied are those not marked. To better analyse OECD data "X" were substituted with "10", "S" with "5" and not applied policies with "0"; this modification will enable to perform some simple quantitative analyses aimed at understanding which policies are applied most at national level, regional level and which are most applied at regional level compared with national level. The quantitative framework of innovation policies can be seen in Table 3-9 and in Table 3-10. This quantitative framework would be used to understand how today's innovation policies are aligned with RIS theory and understand their effectiveness with respect to the variables that would emerge from research questions R1 and R2. In other words, this framework would give an answer to the third research question introduced:

R3: *based on RIS theory, how effective are today's innovation policies?*

Table 3-9: Framework of Innovation Policies – (OECD, 2011a)

Aston University

Illustration removed for copyright restrictions

Legend: “N” – application at national level; “R” – application at regional level

Table 3-10: Framework of Innovation Policies – cont. (OECD, 2011a)

Aston University

Illustration removed for copyright restrictions

Legend: "N" – application at national level; "R" – application at regional level

3.7 Conclusions

The analysis of methodologies found in the systematic literature review highlighted that few quantitative studies have been performed on RIS: one of the objectives of this research is to fill this gap. Therefore the most suitable quantitative method and process were investigated in this chapter.

Regions emerged as the most appropriate level of analysis, and the target population was chosen among level 2 of the Nomenclature of Units for Territorial Statistics, as defined by the European Union (2003).

Provided both the confirmatory and exploratory nature of this research, the multiple linear regression method emerged as an appropriate one. While this method would be suitable for testing research hypotheses (H1 and H2) and investigating research questions related to RIS variables (R1 and R2), the analysis of today's innovation policies (R3) required the development of a specific framework to assess their effectiveness under the RIS theory perspective.

The research process and timing was developed according to these specific methods, leading to a ten steps project (see Figure 9). Once the research method was identified and planned, variables have been operationalized and 22 quantitative models have been setup: 11 aimed at analysing overall RIS innovation performances expressed by regional patent production, and 11 verifying RIS global collaborative innovation performances expressed by regional patent production in cooperation with foreign partners. Last, a quantitative framework based on OECD (2011a) works was setup in order to check the effectiveness of today's innovation policies with respect to RIS theories.

CHAPTER 4: ANALYSIS OF COLLECTED DATA

Abstract

The models set up in the previous chapter have been analysed in this one. The whole research framework was first tested in terms of reliability and validity, the latter in terms of external, internal and constructs validity. Collected data have been then analysed, reviewing their distributions with respect to the normal one, and performing some descriptive statistics on them. It was also performed a qualitative analysis on top and bottom 10% performers, to understand the presence of trends among dependent and independent variables. Eventually a quantitative analysis was made, using multiple linear regression models. 22 different models have been deployed, all with good significance and power. A review of standard coefficients across models confirmed the role of control variables as such. The analysis then concentrated on six models: four related to the full RIS model, in order to verify hypotheses H1 and H2; the latter two were stepwise models aimed at understanding the single variables with highest correlation on our dependent ones and, therefore, allowing the set up of two econometric models with the best prediction of the variances of the dependent variables. All models were tested for their significance, power and multicollinearity. H1 and H2 were confirmed. The latter two predicting models have been also tested through their residuals and re-run after removing a few outliers: final predicting models passed all required test and represent good answers to our research questions R1 and R2. Last, the framework related to innovation policies was exploited and the degree of policy application at regional and national levels tested.

4.1 Research method

The present research has two main objectives: i) hypotheses testing, aimed at confirming the role of RIS as innovation enablers even with global partners, and ii) exploratory, thus understanding which variables expressing RIS potential are mostly correlated with innovation in the global arena and if present policies are aligned with these findings. Multiple linear regression has been chosen as the statistic method of analysis in the previous Chapter 3, due to its ability to be performed both under confirmatory and exploratory approaches.

Regions have been selected as the population of interest (see paragraph 3.3.1), more precisely those referring to NUTS 2 level ones, as defined by the European Union. Variables operationalization, based on existing literature, lead to the definition of a set of 11 variables, of which nr.3 control variables, nr.8 independent variables and nr.2 dependent variables (see Table 3-2). Data collection was performed using both primary and secondary data, targeting a number of observations aligned with the statistic requirements of the model (see paragraph 3.5.1). Primary data were collected through a short survey: a process required for those variables not already included with available secondary sources.

Following Agresti & Finlay (1997) and Hair (1998) final models have been setup through a process of i) variables' transformation, in order to meet the needs of normal distributions, and ii) variables deletion for those leading to multicollinearity problems. 22 models have been identified out of this process and their final set of variables is made by nr.3 control variables, nr.6 independent variables and nr.2 dependent variables (see Table 3-6). After preliminary descriptive statistics, these 22 models will be analysed in this chapter first in terms of reliability and validity, second reviewing their significance and power and third looking to errors and outliers.

Last, an innovation policy framework was introduced in Chapter 3 in order to answer our third research question (R3): descriptive statistics will be presented in this chapter.

4.2 Reliability and validity

Seltman (2012) states that "*the qualities that make a* [variable a] *good measure of a scientific concept are high reliability, absence of bias, low cost, practicality, objectivity, high acceptance, and high concept validity*" where reliability "*refers to the reproducibility of repeated measurements*" and "*construct validity is the link from* *practical measurements to meaningful concepts*". When it comes to a full experiment we should also consider internal validity and external validity, also known as generalizability.

4.2.1 Reliability

Churchill (1979) suggests to perform a reliability check before going to the validity one. Reliability is both internal and external. Internal reliability expresses the consistency of data collection, analysis and interpretation and indicates the extent to which an independent researcher, reanalysing the same data, would come to the same conclusions. External reliability tells the ability for an independent researcher to reproduce the study and come to the same conclusions.

Internal reliability of the whole model was tested following Chirchill (1979), determining Crombach's Alpha of our full set of variables: a value of 0.84 was found, above the limit of 0.7, confirming internal reliability.

External reliability is usually checked using test-retest method. However, in this research, secondary data were used. Furthermore, primary data, those determining the variables Tax_Sp and Aut_infr were built based on a survey with no space for discretional answers: in effect the values 1, 2 and 3 of possible answers were based on factual evidences based on laws of each region and nation; furthermore answers were, in some cases, double checked with direct review of laws (see paragraph 3.4). Test-retest method would therefore not be the most appropriate in this case and it might be inferred that our model is intrinsically externally reliable (Seltman, 2012).

4.2.2 Validity

Internal validity indicates if the variations of dependent variables in an experiment are really caused by variations of independent ones. Experiment based researches can solve the problem of internal validity through a process of randomization (Seltman, 2012). However the present research is actually an observatory one, therefore randomization cannot be used as “explanatory variables” are not “under the control of experimenter”(Seltman, 2012). Observational experiment can improve their internal validity using controls (Carlson & Morrison, 2009), a process that was actually followed in setting up our model.

External validity, or generalizability, “*relates to the breadth of the population we have sampled and how well we can justify extending our results to an even broader population*” (Seltman, 2012). In the present case 104 regions from 13 European countries were sampled. This sample represents 57% of European regions and 30% of global regions tracked by OECD regional economic statistics. Based on OECD databases, this sample represents 17% of total patents and 25% of total GDP (expressed in USD) of a wider sample of 31 countries, mainly related to Western economies, excluding emerging BRICS economies (Brazil, Russia, India, China, South Africa). If we refer to OECD represented European economies only, our sample represents 23% of patents and 66.9% of GDP. A recent analysis of survey response rates shown that the average value of responses in social studies by institution is 36% (Baruch & Brooks, 2008): based on this level of representation it was inferred that the selected sample is a good representation of total population and external validity is reasonable.

Last construct validity was verified. Seltman (2012) says that construct validity “*describes how well the measurement can stand in for the scientific concepts or constructs that are the real targets of scientific learning and inference*.” Cronbach and Meehl (1955) deeply investigated construct validity in social sciences tests and proposed the use of a “gold standard” for checking it. Gold standard refers to a well-established measure of the phenomenon we want to measure: testing construct validity would mean to verify that there is significant correlation between the gold standard and our variable, provided they have to measure the same phenomenon. Furthermore operational definition of variables (Cronbach & Meehl, 1955) and reliability of measures (Seltman, 2012) are other mandatory conditions for construct validity. As discussed in Chapter 3, present variables have been all selected through dedicate literature review. Patents related variables are the gold standard for the measurement of innovation (Buesa et al., 2006; Fritsch & Slavtchev, 2008; Griliches, 1990; Parimal Patel & Pavitt, 1994), thus giving sound construct validity to our dependent variables Log_PCT and Log_PCT_for. Independent variables do not have a gold standard available, as there are no previous quantitative studies on RIS using these variables: however a clear operational definition has been given for them and the measure is reliable (see previous paragraph). Control variables have been set up based on gold standard; they have been operationally defined and are based on secondary data, therefore reliably measured. In the light of these considerations, it can be assumed that our model has a good construct validity.

4.3 Analysis of collected data

Data were collected from 104 European regions belonging to the following countries: Belgium, Czech Republic, Denmark, France, Greece, Hungary, Italy, Luxemburg, Norway, Poland, Slovak Republic, Spain and the United Kingdom. Descriptive statistics of selected variables are reported in Table 4-1. This table shows that some variables still have non-normal distributions, even after the transformation performed in setting up present model as described in the previous chapter. Normality is checked observing Skewness and Kurtosis of each variable. Seltman (2012) indicates that "*population skewness is a measure of asymmetry* [..] *and the population kurtosis is a measure of peakedness or flatness compared to Gaussian distribution*".

Table 4-1: Descriptive Statistics of Selected Variables

	Variable	# obs	Min	Max	Mean	Median	Std Dev	Skew.	Kurt.
Cont. Var.	PP_Inno	104	0.0477	0.8560	0.4248	0.3990	0.1988	0.28	-0.73
	Log_Terz	104	-1.4821	0.0000	-0.4989	-0.4256	0.2959	-0.76	0.27
	Biz_RD	104	0.1278	0.8612	0.4422	0.4220	0.1536	0.31	-0.30
Indep. Var.	SME_Coll	104	0.0504	0.7508	0.3854	0.4166	0.1565	-0.27	-0.51
	Life_Long	104	0.0446	0.9678	0.4604	0.4197	0.2168	0.68	-0.15
	Ext	104	0.0000	0.9927	0.8781	0.8902	0.0902	-8.96	86.92
	Sqr_VC	104	0.0000	0.2977	0.0148	0.0000	0.0404	4.48	24.99
Dep. Var.	Log_PCT	104	0.1304	2.3753	1.3803	0.6549	0.5765	0.31	-0.97
	Log_PCT_for	104	0.0000	1.8223	0.7432	1.3531	0.4905	-0.22	-0.94

De Carlo (1997) clarifies that kurtosis should also be referred to as a measure of tailedness too and its use, together with skewness, to verify normality should be performed in conjunction with a visual analysis of graphical checks. Table 4-2, Table 4-3 and Table 4-4 show the distribution of control, independent and dependent variables respectively. Graphical checks, together with skewness and kurtosis analysis tell us that Ext and Sqr_VC are far from a normal distribution. Even Tax_sp and Aut_infr have poor fit with a normal distribution.

Distributions are only in a few cases centred. Skewness values are often out of the -0.5, +0.5 interval which represents the limit for a centred distribution: PP_Inno, Biz_RD, SME_Coll, Log_PCT and Log_PCT_for are those fitting this limits. Four out of eleven variables have negative skewness: their distributions are skewed on the left, therefore majority of data is located on the right with respect to the average one.

With the notable exceptions of Ext and Sqr_VC, kurtosis values are negative or close to zero. Kurtosis values below 3 indicate distributions with peaks lower and broader with respect to normal distributions.

Table 4-2: Distribution Graphs of Control Variables

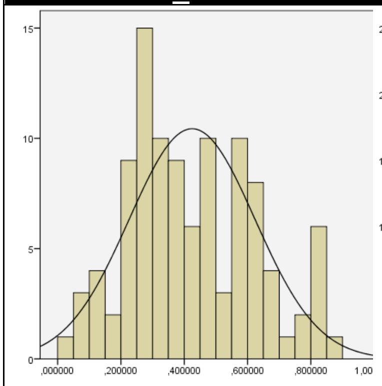
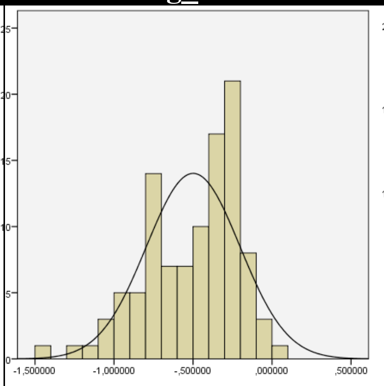
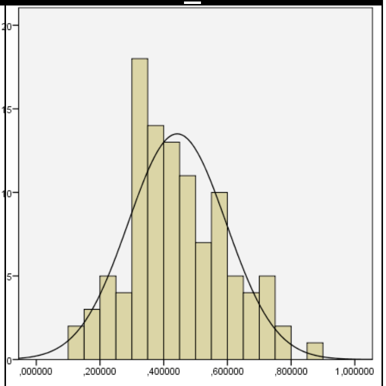
PP_Inno	Log_Terz	Biz_RD
		

Table 4-3: Distribution Graphs of Independent Variables

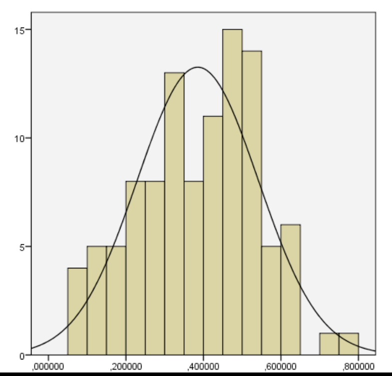
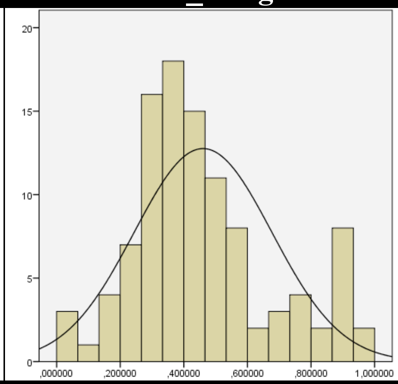
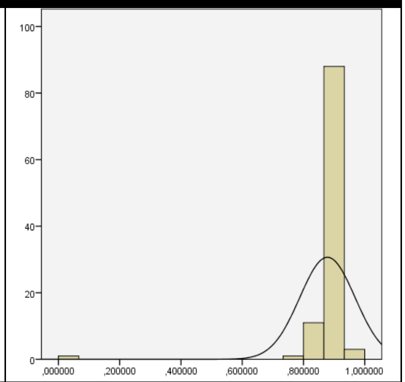
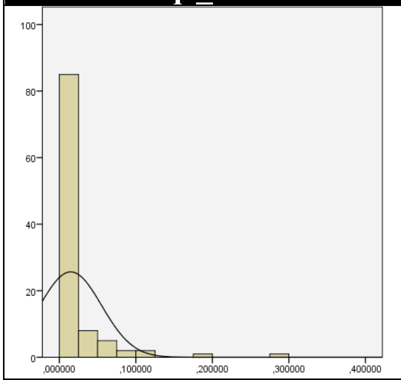
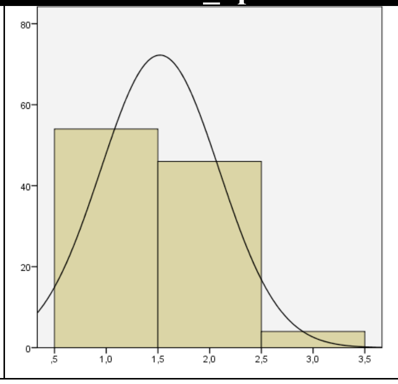
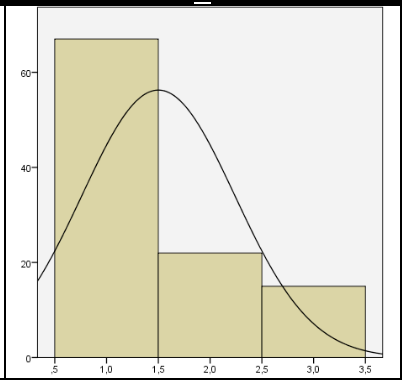
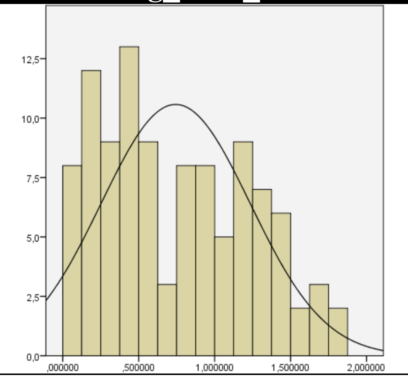
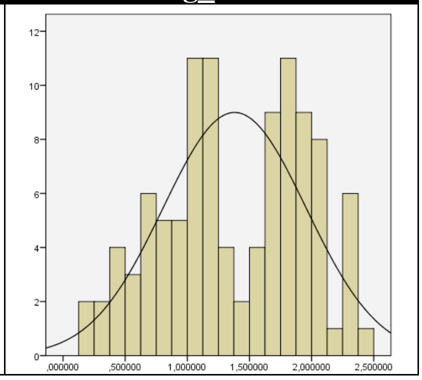
SME_Coll	Life_Long	Ext
		
Sqr_VC	**Tax_Sp**	**Aut_infr**
		

Table 4-4: Distribution Graphs of Dependent Variables

Log_PCT_for	Log_PCT
	

4.3.1 Qualitative analysis of top a low performers

Before running a quantitative analysis of the identified models, a qualitative one on top and low performers was performed. The goal of this analysis is to have a first insight on the behaviour of independent and control variables in top 10% and low 10% performers. Table 4-5 indicates top 10% performing regions in terms of PCT patents per million inhabitants. Values in white with dark gray background represent top 10% value, while those with light gray background refer to bottom 10%. The regions are ordered by their PCT value, from biggest to smallest. For a mean of better comprehension, and provided the qualitative approach followed, all values in the following top and bottom analysis refer to un-transformed variable.

It was first noticed that half of these regions are also top 10% performers with respect to the second dependent variable (PCT with foreign partners per million inhabitants) and one independent variable (Biz_RD, business expenditures for R&D). Three regions are among bottom 10% for the Ext independent variable (therefore with high externalization value: the Ext variable is proportional to the degree of internalization, therefore the highest is the Ext value, the lowest is the degree of externalization). The top three regions are also in top 10% as far as tertiary education level (Terz) and venture capital is concerned (VC). Regarding venture capital half of these regions do not have a local venture capital fund: this is not surprising as the great majority of European funds are located in the premises of each country's economic capital and operate at national or continental level. Last, it has to be noted that four out of these ten regions belong to Norway.

Table 4-5: Top 10% Innovative Regions – PCT per million inhabitants

Region	PCT	PCT_for	PP_Inno	Biz_RD	Terz	SME_Coll	Life_Long	Ext	VC
Oslo og Akershus	236.32	65.42	0.45	0.59	0.95	0.49	0.78	0.90	0.0123
Denmark	205.04	21.20	0.59	0.70	0.67	0.62	0.93	0.85	0.0339
Île de France	204.62	29.53	0.29	0.76	0.78	0.40	0.46	0.89	0.0093
La Rioja	196.93	26.69	0.49	0.45	0.55	0.35	0.50	0.89	0.0000
East of England	196.53	43.19	0.68	0.86	0.50	0.52	0.86	0.87	0.0005
Agder og Rogaland	186.64	34.34	0.27	0.53	0.57	0.50	0.70	0.90	0.0000
South East (UK)	186.51	48.42	0.58	0.71	0.63	0.49	0.93	0.87	0.0002
Trøndelag	176.16	22.73	0.25	0.72	0.61	0.52	0.77	0.84	0.0000
Centre-Est (FR)	126.49	20.88	0.27	0.71	0.46	0.43	0.47	0.89	0.0000
Sør-Østlandet	121.31	22.72	0.38	0.55	0.51	0.49	0.72	0.86	0.0000

Dark gray: top 10% values; Light gray: bottom 10% values

Table 4-6: Top 10% Globally Innovative Regions – PCT with foreign partners per million inhabitants

Region	PCT	PCT_for	PP_Inno	Biz_RD	Terz	SME_Coll	Life_Long	Ext	VC
Oslo og Akershus	236.32	65.42	0.45	0.59	0.95	0.49	0.78	0.90	0.0123
Luxembrurg	109.45	55.38	0.80	0.66	0.46	0.63	0.47	0.90	0.0033
South East (UK)	186.51	48.42	0.58	0.71	0.63	0.49	0.93	0.87	0.0002
East of England	196.53	43.19	0.68	0.86	0.50	0.52	0.86	0.87	0.0005
Vlaams Gewest	116.97	42.81	0.83	0.67	0.67	0.72	0.48	0.89	0.0110
Bruxelles-Capitale	104.18	36.79	0.75	0.48	1.00	0.61	0.54	0.89	0.0008
Agder og Rogaland	186.64	34.34	0.27	0.53	0.57	0.50	0.70	0.90	0.0000
Est (FR)	80.28	29.59	0.39	0.57	0.42	0.49	0.46	0.89	0.0000
Île de France	204.62	29.53	0.29	0.76	0.78	0.40	0.46	0.89	0.0093

Dark gray: top 10% values; Light gray: bottom 10% values

A similar analysis was performed on top 10% regions in terms of global collaborative innovation, expressed by the number of PCT patents with foreign partners per million inhabitants (PCT_for). Here regions are ordered by this variable, from largest to smallest value (see Table 4-6).

As in the previous case, regions belonging to top 10% performers have, in nearly half cases, high business R&D expenditures (Bix_RD) and tertiary education (Terz) levels. Venture capital values are higher than for top 10% performers in PCT patents only.

Norway is represented by two regions only, while Belgium, not at all represented in previous table, now has two regions in these rankings.

A parallel analysis was performed for bottom 10% performing regions. Table 4-7 refers to bottom performing regions in terms of PCT per million inhabitants. With the exception of Severozápad, a region belonging to the Czech Republic, all other regions belong to Poland. Six out of ten are also among the worst performers in terms of global innovative performances (PCT_for). None of them has local venture capital funds.

Table 4-7: Bottom 10% Innovative Regions – PCT per million inhabitants

Region	PCT	PCT_for	PP_Inno	Biz_RD	Terz	SME_Coll	Life_Long	Ext	Sqr_VC
Wielkopolskie	2.63	0.66	0.15	0.29	0.30	0.33	0.27	0.88	0.0000
Dolnoslaskie	2.58	0.60	0.31	0.33	0.38	0.48	0.35	0.88	0.0000
Pomorskie	2.04	0.74	0.34	0.36	0.35	0.49	0.35	0.88	0.0000
Severozápad	1.94	0.11	0.36	0.36	0.03	0.48	0.31	0.90	0.0000
Slaskie	1.81	0.31	0.29	0.30	0.35	0.52	0.34	0.88	0.0000
Podlaskie	1.67	0.00	0.29	0.20	0.36	0.51	0.29	0.88	0.0000
Kujawsko-Pomorsk.	1.08	0.00	0.11	0.32	0.20	0.35	0.29	0.88	0.0000
Podkarpackie	0.91	0.39	0.32	0.36	0.24	0.53	0.23	0.88	0.0000
Lubelskie	0.46	0.00	0.32	0.32	0.27	0.45	0.35	0.88	0.0000
Warminsko-Mazurs.	0.35	0.00	0.23	0.16	0.29	0.30	0.29	0.88	0.0000

Dark gray: top 10% values; Light gray: bottom 10% values

Eventually, in Table 4-8, bottom 10% performers were analysed in terms of global collaborative innovation (PCT_for). The number of Polish regions is reduced, from 9 to 6, while two belong to the Czech Republic (Strední Morava and Severozápad) plus one from Hungary (Dél-Dunántúl) and one from Spain (Alentejo). As for the previous case, none of these regions has local venture capital funds.

Similar analysis was performed using countries' average values. Results are reported in Table 4-9, where dark gray values are top 20% and light gray ones are bottom 20%. The use of regional averages supports our analysis to qualitatively see if there is a country level effect: in other words it gives us an indication if country level policies have a significant effect at regional level too.

Table 4-8: Bottom 10% Globally Innovative Regions – PCT with foreign partners per million inhabitants

Region	PCT	PCT_for	PP_Inno	Biz_RD	Terz	SME_Coll	Life_Long	Ext	Sqr_VC
Lódzkie	4.03	0.37	0.13	0.28	0.34	0.26	0.31	0.88	0.0000
Dél-Dunántúl	7.29	0.35	0.09	0.23	0.23	0.31	0.26	0.86	0.0000
Slaskie	1.81	0.31	0.29	0.30	0.35	0.52	0.34	0.88	0.0000
Strední Morava	12.82	0.20	0.56	0.57	0.14	0.60	0.40	0.90	0.0000
Severozápad	1.94	0.11	0.36	0.36	0.03	0.48	0.31	0.90	0.0000
Alentejo	5.23	0.00	0.60	0.34	0.05	0.38	0.26	0.88	0.0000
Podlaskie	1.67	0.00	0.29	0.20	0.36	0.51	0.29	0.88	0.0000
Kujawsko-Pomorskie	1.08	0.00	0.11	0.32	0.20	0.35	0.29	0.88	0.0000
Lubelskie	0.46	0.00	0.32	0.32	0.27	0.45	0.35	0.88	0.0000
Warminsko-Mazurskie	0.35	0.00	0.23	0.16	0.29	0.30	0.29	0.88	0.0000

Dark gray: top 10% values; Light gray: bottom 10% values

In case average values would show similar relations among variables with respect to regional level analysis, then we would have a qualitative indicator of a country level effect. Top and bottom 20% were used and not top and bottom 10% provided the limited number of countries represented and the willingness to have at least two countries represented as top or bottom performers. The finding was that there can be a significant difference between using average regional values and aggregate regional values: the high positioning of Poland for venture capital activities is the most notable example of a counterintuitive result. However, overall analysis shows that top and bottom performing countries coincide to those represented in our regional level analysis, with the previously mentioned exception of Poland for venture capital. Top five countries are the same for both dependent variables; furthermore all top two countries for each variable are included in the top five group. Notable exception to this rule are the venture capital variable, as previously mentioned, and externalization, which shows another counterintuitive result with Greece as the first country for average regional externalization value, preceding Denmark. These findings qualitatively indicate that there might be a country level effect in regional performances.

Infrastructure level data, collected via our questionnaire, have been then analysed. It can be shown that nearly half of analysed regions are autonomous in spending centrally collected taxes but only an additional 5% has a full taxation authority (see Figure 15). However when it comes to regional autonomy in investing in infrastructure or in R&D policies, only one third and, respectively, 40% of regions have either partial or full autonomy (see Figure 16 and Figure 17). Evidence shows that there is definitely an important role in taxation, spending and public investments policies played by central governments.

Table 4-9: Top and Bottom 20% - Countries averages values from related regions

Country	PCT	PCT_for	SME_Coll	Life_Long	Ext	PP_Inno	Biz_RD	Terz	VC
Denmark	205.041	21.203	0.621	0.935	0.845	0.593	0.701	0.675	0.004
Norway	126.004	25.003	0.486	0.744	0.857	0.304	0.521	0.600	0.001
Luxemburg	109.448	55.383	0.628	0.468	0.895	0.803	0.657	0.457	0.034
Belgium	99.914	36.260	0.622	0.454	0.890	0.802	0.603	0.775	0.000
United Kingdom	98.659	21.391	0.500	0.893	0.871	0.562	0.571	0.574	0.000
France	87.089	14.725	0.413	0.448	0.892	0.302	0.602	0.477	0.001
Italy	46.935	5.327	0.199	0.397	0.891	0.494	0.391	0.172	0.003
Spain	40.473	6.485	0.250	0.535	0.890	0.421	0.439	0.581	0.000
Hungary	15.057	2.225	0.319	0.246	0.863	0.130	0.344	0.259	0.000
Czech Republic	14.628	2.238	0.539	0.358	0.902	0.484	0.546	0.158	0.001
Slovak Republic	10.885	4.641	0.359	0.317	0.903	0.271	0.360	0.258	0.001
Portugal	8.536	2.456	0.353	0.284	0.891	0.673	0.337	0.147	0.002
Greece	7.713	1.995	0.597	0.087	0.739	0.644	0.255	0.355	0.000
Poland	2.201	0.489	0.422	0.315	0.878	0.240	0.302	0.336	0.008

Dark gray: top 10% values; Light gray: bottom 10% values

Figure 15: Autonomous Tax and Spending

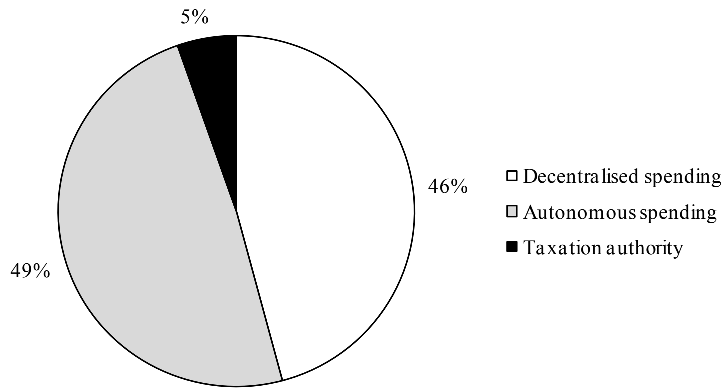


Figure 16: Autonomy in Infrastructure Investments

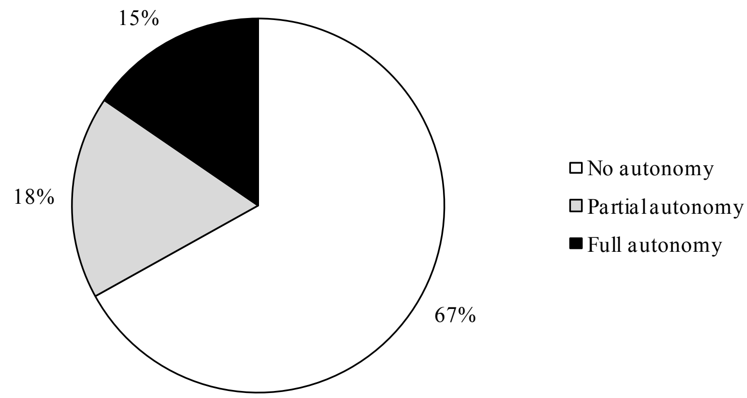
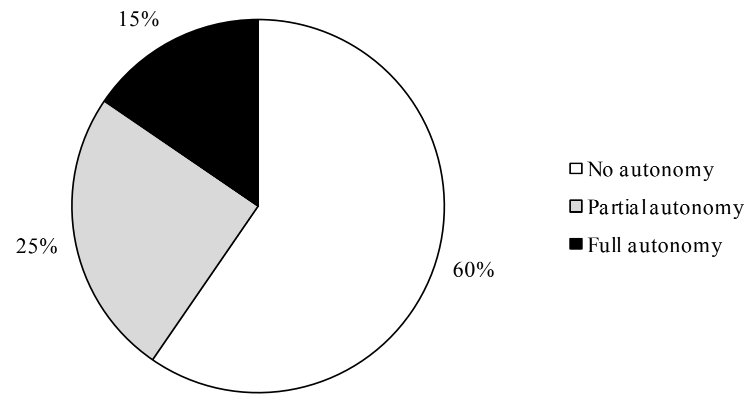


Figure 17: Autonomy in R&D Investments and Policies



4.4 Analysis of models

4.4.1 Research hypotheses and questions

The goal of the present analysis is to determine i) if the quantitative model representing RIS is able to explain the variation of our dependent variables (overall regional innovation performances expressed by the number of PCT patents per million inhabitants and regional innovation performances with foreign partners, expressed by the number of PCT patents in collaboration with foreign partners per million inhabitants) and ii) what are the models which better explain our dependent variables. In other words it was decided to: first, check how well the presence of a RIS explains overall innovation performances and those related to collaboration with foreign partners; second, verify which variables among those representing RIS effect most the variation of the above mentioned innovation performances. The hypotheses and research questions, introduced in the previous chapter, are:

H1: *the higher is RIS potential, the higher will be regional innovation expressed by patent production.*

H2: *the higher is RIS potential, the higher will be regional innovation exploited with global partners, expressed by patent production with foreign partners.*

R1: *which are the variables of a regional innovation system effecting its overall patent production?*

R2: *which are the variables of a regional innovation system effecting its patent production in cooperation with foreign partners?*

22 models have been set up, 11 for each dependent variable, based on the following linear multiple regression equations:

5) $Log\_PCT = \alpha + \sum_i \beta_i IV_i + \sum_j \beta_j CV_j + \sum_k \beta_k + \varepsilon$

6) $Log\_PCT\_for = \alpha_{for} + \sum_i \beta_{for\,i} IV_i + \sum_j \beta_{for\,j} CV_j + \sum_k \beta_k + \varepsilon_{for}$

where the subscripts refer to (i) independent variables, (j) control variables and (k) dummy variables. IV are independent variables and CV are control variables; ε is the error term. Subscript (for) refers to the constant term α and slope terms β used for predicting innovation with global partners variable (Log_PCT_for); α and βs not showing this subscript are referred to innovation variable (Log_PCT). β_k are dummy variables with value = 1 in case data were referring to one specific country and value = 0 for all other countries; subscript K goes from 1 to 12, being 13 the total countries represented in our analysis and having chosen one country (UK) as the reference one.

The 11 models set up for each dependent variables followed different approaches:

- models 1 to 7 used control variables and none or one different independent variable for each model. No dummy variables have been introduced and the models were analysed entering all variables. The scope of these models is to test control variables as such and to check the explanatory power of each independent variable alone;
- models 8 and 9 were built entering all control and independent variables. Model 9 included dummy variables too. These models were used to test the complete RIS model, therefore verifying hypotheses H1 and H2;
- models 10 and 11 were used for exploratory purposes with a stepwise regression. All control and independent variables were considered in both models, while model 11 included dummy variables too. The scope of these

models was to identify which variables should be taken into account for explaining the variations of our dependent ones, therefore answering to research questions R1 and R2.

4.4.2 Overall analysis approach

First it was analysed all models verifying (Hair et al., 1998; Seltman, 2012):

- appropriateness of the sample size;
- the hypothesis, through F-value testing, that β values in equations 3) and 4) are not null, therefore variations of independent variables effect the variations of dependent ones;
- power of models, analysing the percentage of variance of the dependent variables explained by each model, expressed by Adjusted R^2 values;
- significance of each single variable through a p-value test.

After having analysed all models based on the previous analysis, we selected the one with the highest power and we further analysed it following the assumptions indicated by Hair et al. (1998):

- Linearity of the relationship between independent and dependent variables;
- Homoscedasticity: equality of variance of the errors;
- No autocorrelation of the errors and independence of observations;
- Normality of the residuals or errors;
- No multicollinearity
- No outlier distortion

4.4.3 Sample size

The guidelines used to define the target number of observations have been introduced in the previous chapter (see paragraph 3.5.1), based on three main references. Data collection was performed before the final model was set up, through a process of variables transformation and deletions to meet the need of normality and avoiding multicollinearity. As a matter of fact, the final set of variables is made by nr.3 control variables and nr.6 independent variables. Based on this, the targets for our sample size indicated in Table 3-3 can be recalculated as by Table 4-10.

Table 4-10: Revisited Sample Size Requirements

Reference	Obs./Ind. Var.	Sample size limit
(Agresti & Finlay, 1997)	Minimum 5:1	45
	Optimal 20:1	180
(Howitt & Cramer, 2011)	10:1	90
(Tabachnick & Fidell, 2007)	50 + 8:1	122

The final available sample size was of 104 observations and was considered as acceptable. As a matter of fact Table 4-10 shows how this value is well above the minimal requirements introduced by Agresti & Finlay and by Howitt & Cramer and close to the one by Tabachnick & Fidell.

4.4.4 Control variables

Before moving forward into further analysis the variables assumed as control ones have been checked. Control variables "*affect the outcome but are not of primary interest, and for any specific value of the control variable, the variability in outcome associated with each value of the main experimental explanatory variable is reduced*"(Seltman, 2012). In all models represented in Table 4-11 and Table 4-12 β values of each control variable did not vary significantly model by model related to one specific dependent variable, thus confirming their role as control ones.

4.4.5 Testing the null hypothesis of correlation

For each model the null hypothesis of correlation between independent variables and dependent ones (β=0) was tested. Given two or more groups of variables the F statistics is the ratio between mean squares between groups and mean squares within groups (Seltman, 2012). This ratio is 1 when the null hypothesis is true, greater than 1 when the alternative one is true. Table 4-11 and Table 4-12 report the F values for each of our 22 models: they all have values much greater than 1 and the null hypothesis is rejected in all models. This means that in all models the variations of dependent variables can be predicted by variations of independent ones.

4.4.6 Power of models

The power of our models was analyzed through their Adjusted R^2 (indicated in following tables are "Rsquare Adj") values. Adjusted R^2 is the multiple correlation coefficient and can be interpreted as the of the total variation in dependent variables that is accounted for by regressing the outcome on the independent ones (Seltman, 2012), adjusted by taking into account the number of variables included in a model too. Looking to Table 4-11 and Table 4-12 we first notice that this ratio is significant in all models, from 0.617 for model 1.1 up to 0.915 for model 1.9. For both dependent variables it was also noticed that adding one single independent variable to control ones increased the power of our models (see models 1.1 to 1.7 and 2.1 to 2.7).

4.4.7 Significance of variables

After analyzing the overall power of the models, it was required to ensure the significance of each independent and control variable (Hair et al., 1998). Significance level (p-value) means that if our model is correct and the null hypothesis happened to be true, than we have a p-value percentage of obtaining our result. In other words "*p-value is the probability that any given experiment will produce a value of the chosen statistic equal to the observed value in our actual experiment or something more extreme, when the null hypothesis is true and the model assumptions are correct*" (Seltman, 2012). In present models variables have been divided into those with acceptable significance ($p < 0.1$), good significance ($p<0.05$) and very high significance ($p<0.01$). Any p-value above 0.1 was not considered as significant. Following these assumptions it was inferred from Table 4-11 and Table 4-12 that models 1.1, 1.2, 1.7, 1.11, 2.10 and 2.11 have all variables and the constant term α – as we named it in equations 5) and 6) – significant; all the other models have at least one term α and/or β not significant.

Model 2.12 was tested as, looking to the variables not selected in model 2.10, it was discovered that SME_Coll was not entered in the last model due to an F value of 0.055, very close to our limit of 0.05: it was therefore decided to run an enter model including this variable too in order to see if it was leading to a significant increase in model power with respect to model 2.10. Adjusted R^2 of model 2.12 is 0.764, slightly higher of the one of model 2.10 (Adjusted R^2= 0.757), yet lower than model 2.11 (Adjusted R^2=0.824). Furthermore it was noted that stepwise models have less power than the full ones, using dummy variables and enter approaches: model 1.11 has an Adjusted R^2 lower than model 1.9 and model 2.11 has an Adjusted R^2 lower than model 2.9.

Table 4-11: General Innovation: Dependent Variable: Log_PCT

	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	1.10	1.11
	enter									stepwise (1)	
Constant	0.423*	0.626***	0.051	0.219	0.415***	0.096	0.274*	0.014	-0.044	-0.099	0.571***
	(0.154)	(0.153)	(0.162)	(0.375)	(0.154)	(0.209)	(0.163)	(0.294)	(0.548)	(0.098)	(0.161)
PP_inno	0.218***	0.291***	0.191***	0.22***	0.202***	0.214***	0.208***	0.249***	0.406***	0.249***	
	(0.193)	(0.188)	(0.177)	(0.194)	(0.195)	(0.189)	(0.189)	(0.153)	(0.244)	(0.149)	
Log_Terz	0.25***	0.282***	0.086	0.256***	0.225***	0.130	0.212***	0.085	0.112		0.21***
	(0.269)	(0.123)	(0.137)	(0.132)	(0.134)	(0.165)	(0.131)	(0.137)	(0.168)		(0.125)
Biz_rd	0.562***	0.628***	0.449***	0.56***	0.551***	0.501***	0.525***	0.463***	0.315***	0.447***	0.438***
	(0.269)	(0.259)	(0.261)	(0.27)	(0.269)	(0.282)	(0.269)	(0.231)	(0.223)	(0.228)	(0.194)
SME_coll		-0.262***						-0.314***	-0.175*	-0.294***	
		(0.243)						(0.19)	(0.344)	(0.201)	
Life_long			0.354***					0.427***	0.29*	0.405***	0.327***
			(0.202)					(0.19)	(0.405)	(0.144)	(0.156)
Extern				0.038				0.020	0.031		
				(0.401)				(0.304)	(0.234)		
Sqr_Venture					0.095			0.046	0.08*		
					(0.95)			(0.723)	(0.608)		
Tax_aut						0.206**		-0.147*	0.053		-0.168**
						(0.091)		(0.085)	(0.171)		(0.077)
Invest_infr							0.158**	0.339***	0.035	0.3***	0.164***
							(0.052)	(0.047)	(0.063)	(0.04)	(0.037)
dummies	N	N	N	N	N	N	N	N	Y	N	Y
R	0.786	0.818	0.828	0.786	0.791	0.798	0.799	0.894	0.957	0.888	0.933
Rsquare	0.617	0.670	0.686	0.619	0.625	0.636	0.638	0.799	0.915	0.789	0.871
Rsquare Adj	0.606	0.657	0.673	0.603	0.610	0.621	0.623	0.780	0.892	0.779	0.860
F	53.731	50.233	54.080	40.129	41.231	43.254	43.587	41.539	39.683	73.432	80.404
nr of observations	104	104	104	104	104	104	104	104	104	104	104

Notes: Dependent variable is Log_PCT. Standard errors are in parenthesis. * p<0.10, ** p<0.05, ***p<0.01
(1) F probability to enter = 0.05 - F probability to remove = 0.1

Table 4-12: Global Collaborative Innovation: Dependent Variable: PCT_coll

	2.1	2.2	2.3	2.4	2.5	2.6	2.7	2.8	2.9	2.10	2.11	2.12
	enter									*stepwise (1)*		*enter*
Constant	0.104	0.153	-0.145	-0.191	0.095	-0.132	0.052	-0.465*	-0.607	-0.402***	-0.72***	-0.341**
	(0.121)	(0.128)	(0.13)	(0.292)	(0.119)	(0.164)	(0.125)	(0.256)	(0.559)	(0.131)	(0.084)	(0.133)
PP_inno	0.286***	0.307***	0.265***	0.29***	0.267***	0.284***	0.275***	0.268***	0.417***	0.246***	0.301***	0.276***
	(0.151)	(0.157)	(0.142)	(0.151)	(0.151)	(0.149)	(0.145)	(0.133)	(0.248)	(0.13)	(0.123)	(0.134)
Log_Terz	0.384***	0.393***	0.256***	0.394***	0.353***	0.282***	0.337***	0.22**	0.159	0.166**		0.178***
	(0.102)	(0.103)	(0.111)	(0.103)	(0.104)	(0.129)	(0.1)	(0.119)	(0.171)	(0.106)		(0.105)
Biz_rd	0.465***	0.484***	0.377***	0.462***	0.452***	0.414***	0.42***	0.336***	0.302***	0.298***	0.364***	0.324***
	(0.21)	(0.216)	(0.21)	(0.21)	(0.208)	(0.221)	(0.206)	(0.201)	(0.227)	(0.199)	(0.186)	(0.201)
SME_coll		-0.740						-0.125**	-0.139			-0.11*
		(0.203)						(0.177)	(0.351)			(0.177)
Life_long			0.278***					0.358***	0.437**	0.34***	0.339***	0.331***
			(0.163)					(0.166)	(0.413)	(0.151)	(0.133)	(0.15)
Extern				0.064				0.053	0.073*			
				(0.312)				(0.265)	(0.239)			
Sqr_Venture					0.119*			0.077	0.097*		0.159***	
					(0.736)			(0.629)	(0.62)		(0.584)	
Tax_aut						0.175**		-0.129	-0.143			
						(0.072)		(0.074)	(0.174)			
Invest_infr							0.194***	0.314***	0.042	0.25***	0.248***	0.275***
							(0.04)	(0.041)	(0.064)	(0.036)	(0.033)	(0.037)
dummies	N	N	N	N	N	N	N	N	Y	N	Y	N
R	0.822	0.825	0.848	0.825	0.830	0.831	0.841	0.889	0.937	0.877	0.916	0.882
Rsquare	0.677	0.681	0.719	0.680	0.689	0.690	0.708	0.790	0.878	0.769	0.839	0.778
Rsquare Adj	0.667	0.668	0.708	0.668	0.676	0.678	0.696	0.770	0.845	0.757	0.824	0.764
F	69.707	52.755	63.288	52.707	54.747	55.107	59.961	39.291	26.251	65.183	54.593	56.507
nr of observations	104	104	104	104	104	104	104	104	104	104	104	104

Notes: Dependent variable is Log_PCT_for. Standard errors are in parenthesis. * p<0.10, ** p<0.05, ***p<0.01
(1) F probability to enter = 0.05 - F probability to remove = 0.1

4.4.8 Analyzing Models 1.8, 1.9, 2.8 and 2.9

Following the previous analyses multicollinearity in models 1.8 and 2.8 was checked. Hair, Babin, Money and Samouel (2003) suggest that Condition Indexes (CI) should be below 30 and Variance Inflation Factors (VIF) should not exceed 10. Table 4-13 shows that for both models VIF values are well inside the limits. However for both models CI value is above 30, actually 40.9. This would have indicated the presence of multicollinearity, but some researchers considers VIF superior in examining bivariate correlations (Williams, 2012). Indeed CI warns about potential multicollinearity in our models.

Table 4-13: Variance Inflation Factors, Model 1.8 and Model 2.8

Model 1.8		
Variable	Tolerance	VIF
Control Variables		
PP_Inno	0.585	1.709
Log_Terz	0.298	3.361
Biz_RD	0.832	1.203
Dependent Variables		
SME_Coll	0.944	1.059
Life_Long	0.417	2.396
Ext	0.697	1.434
Sqr_VC	0.562	1.778
Tax_Sp	0.435	2.299
Aut_infr	0.763	1.31

Model 2.8		
Variable	Tolerance	VIF
Control Variables		
PP_Inno	0.585	1.709
Log_Terz	0.298	3.361
Biz_RD	0.832	1.203
Dependent Variables		
SME_Coll	0.944	1.059
Life_Long	0.417	2.396
Ext	0.697	1.434
Sqr_VC	0.562	1.778
Tax_Sp	0.435	2.299
Aut_infr	0.763	1.31

Models 1.9 and 2.9 shown definitely greater problems of multicollinearity: Condition Indexes and Variance Inflation Factors of their variables are above the limits of 30 and 10 respectively (Hair et al., 2003). Both models have a Condition Index of 100.503, while Variance Inflation Factors are indicated in Table 4-14.

Multicollinearity generates greater standard errors and might lead to overestimation and lower estimation of slope coefficients. However it does not violate ordinary least square assumptions (Williams, 2012). It might therefore be inferred that the null hypothesis of correlation (β=0) is validly rejected in all models hereby analysed (1.8, 1.9, 2.8 and 2.9).

As previously mentioned, these four models represent:

Model 1.8 – RIS potential (without country level effect represented by the absence of dummy variables) with respect to overall regional innovation performances;

Model 1.9 – RIS potential (considering country level effect represented by the presence of dummy variables) with respect to overall regional innovation performances;

Model 2.8 – RIS potential (without country level effect represented by the absence of dummy variables) with respect to overall regional innovation performances in collaboration with foreign partners;

Model 2.9 – RIS potential (considering country level effect represented by the presence of dummy variables) with respect to overall regional innovation performances in collaboration with foreign partners.

Models 1.8 and 1.9 refer to hypothesis H1while models 2.8 and 2.9 refer to hypothesis H2. In all cases the null hypothesis of correlation is rejected and the power of models is significant, with Adjusted R2 well above 0.75 (for models without dummies, 1.8 and 2.8) and above 0.8 (for those with dummies, 1.9 and 2.9).

Hypotheses H1 and H2 could therefore be considered as confirmed.

Table 4-14: Variance Inflation Factors, Model 1.9 and Model 2.9

Model 1.9		
Variable	Tolerance	VIF
Control Variables		
PP_Inno	0.047	21.166
Log_Terz	0.34	2.94
Biz_RD	0.172	5.809
Dependent Variables		
SME_Coll	0.098	10.186
Life_Long	0.041	24.345
Ext	0.067	14.973
Sqr_VC	0.369	2.708
Tax_Sp	0.107	9.361
Aut_infr	0.093	10.728
Dummies		
be	0.06	16.618
cz	0.503	1.988
dk	0.075	13.36
gr	0.192	5.196
es	0.163	6.13
fr	0.036	27.61
lu	0.577	1.734
hu	0.78	1.281
pl	0.045	22.176
pt	0.12	8.316
sk	0.297	3.371
no	0.141	7.113
it	0.149	6.727

Model 2.9		
Variable	Tolerance	VIF
Control Variables		
PP_Inno	0.047	21.166
Log_Terz	0.34	2.94
Biz_RD	0.172	5.809
Dependent Variables		
SME_Coll	0.098	10.186
Life_Long	0.041	24.345
Ext	0.067	14.973
Sqr_VC	0.369	2.708
Tax_Sp	0.107	9.361
Aut_infr	0.093	10.728
Dummies		
be	0.06	16.618
cz	0.503	1.988
dk	0.075	13.36
gr	0.192	5.196
es	0.163	6.13
fr	0.036	27.61
lu	0.577	1.734
hu	0.78	1.281
pl	0.045	22.176
pt	0.12	8.316
sk	0.297	3.371
no	0.141	7.113
it	0.149	6.727

4.4.9 Analyzing Models 1.11 and 2.11

The analysis of models 1.8, 1.9, 2.8 and 2.9 confirmed hypotheses H1 and H2. However some variables included in these models showed limited significance. Research questions R1 and R2 aimed at understanding which variables, among those defining a RIS, are determining the innovation performances and foreign collaborative innovation performances of a region. The final goal of this research questions is to set up the two models which best describe our phenomena (regional innovation and international collaborative regional innovation).

An additional analyses was therefore made on those models with highest power and with all variables showing a good significance: models 1.11 and 2.11. These models are both using a stepwise approach, including dummy variables too.

Following Hair et al (1998) and Berry & Feldman (1985) it was first checked the linearity of the relationship between independent and dependent variables: residual plots were used to check the presence of curvilinear patterns. In effect, the presence of a curvilinear pattern would indicate the need for a corrective action in order to increase the predictive accuracy of the model and the validity of its coefficients. Figure 18 and Figure 19 show the residual plots of Models 1.11 and 2.11, showing that no significant curvilinear pattern emerges. Residual plots are also useful to review the assumptions of homoscedasticity: in this case model 1.11 shows a little heteroscedasticity presenting a shape slightly asymmetric on the right. The presence of some heteroscedasticity (as well as some non-linearity) might lead to a weaker model, but will not invalidate it (Tabachnick & Fidell, 1996).

Autocorrelation of errors and independence of observations was verified using a Durbin Watson test. Values close to 2 indicate independence and the rule states that an acceptable range is between 1.5 and 2.5 (Christensen, 1997). Model 1.499 has a Durbin Watson test value of 1.5 while it is equal to 2.181 for Model 2.11. Model 1.11 is therefore at the borderline of acceptance, while model 2.11 fully complies with the test.

Figure 18: Model 1.11 residual plot

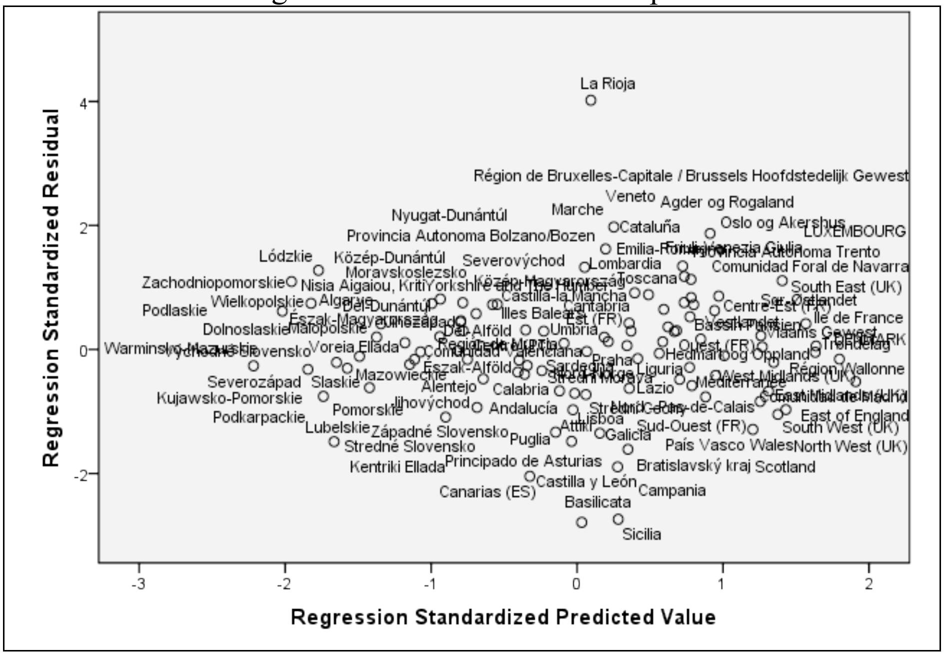
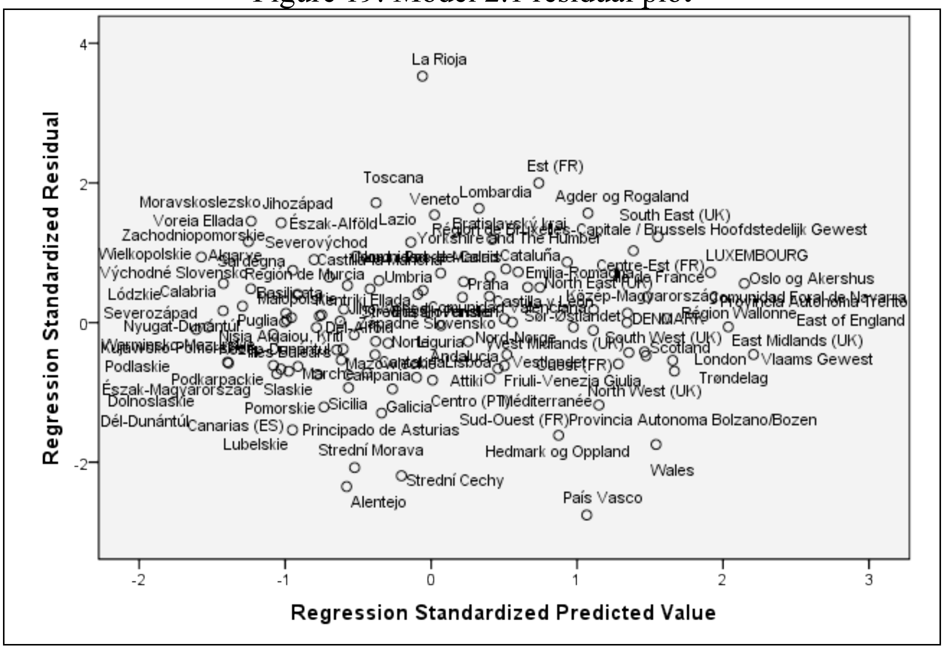


Figure 19: Model 2.1 residual plot



Normality of residuals was tested based on three graphs (Hair et al., 2003):

- Histogram of residuals: we wanted to ensure how much they fit a normal distribution;
- Probability plot of residuals: we checked if the distribution of residuals is close to the diagonal;
- Standardized predicted values versus standardized residuals: we looked for values out of ranges, where the rule says that 95% of standardized residuals should be between -2 and +2.

Figure 20, Figure 21, Figure 22 and Figure 23 show histograms and probability plots of residuals, while standardized predicted values and standardized residuals are in Figure 18 and Figure 19. Both models 1.11 and 2.11 have a good fitness to a normal distribution and more than 95% of standardized predicted values is inside the -2 / +2 interval. However histograms and probability plots clearly show the presence of some outliers.

Figure 20: Histogram of residuals – Model 1.11

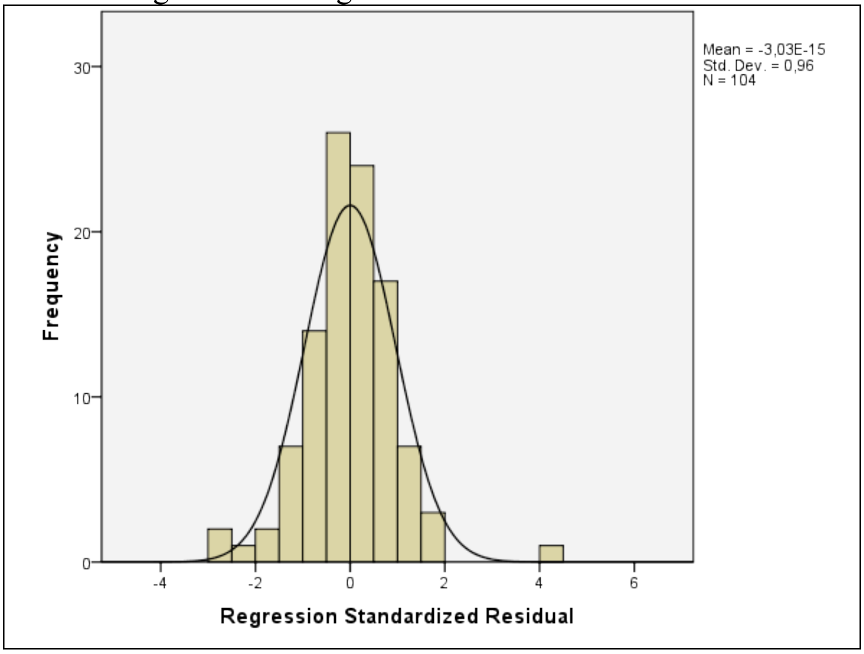


Figure 21: Probability Q-Q Plot – Model 1.11

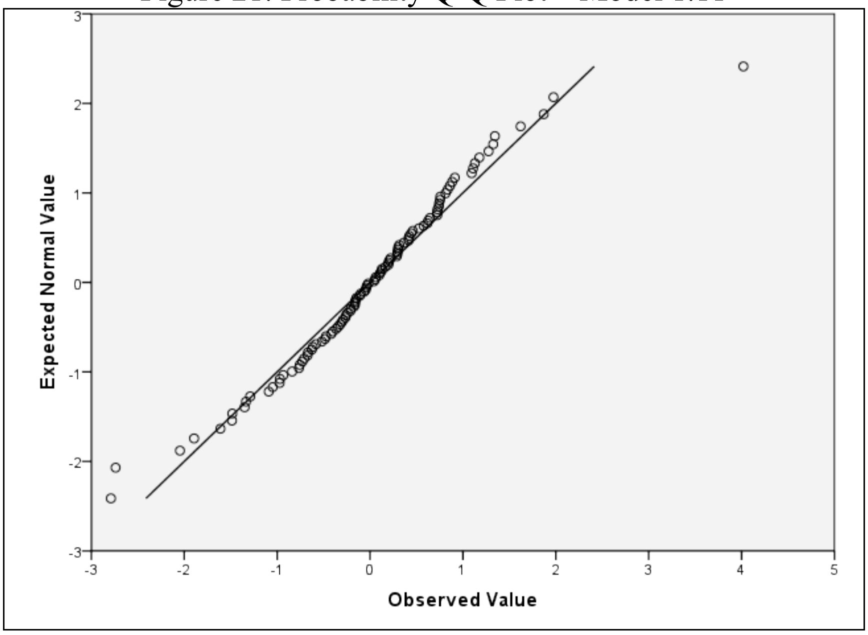


Figure 22: Histogram of residuals – Model 2.11

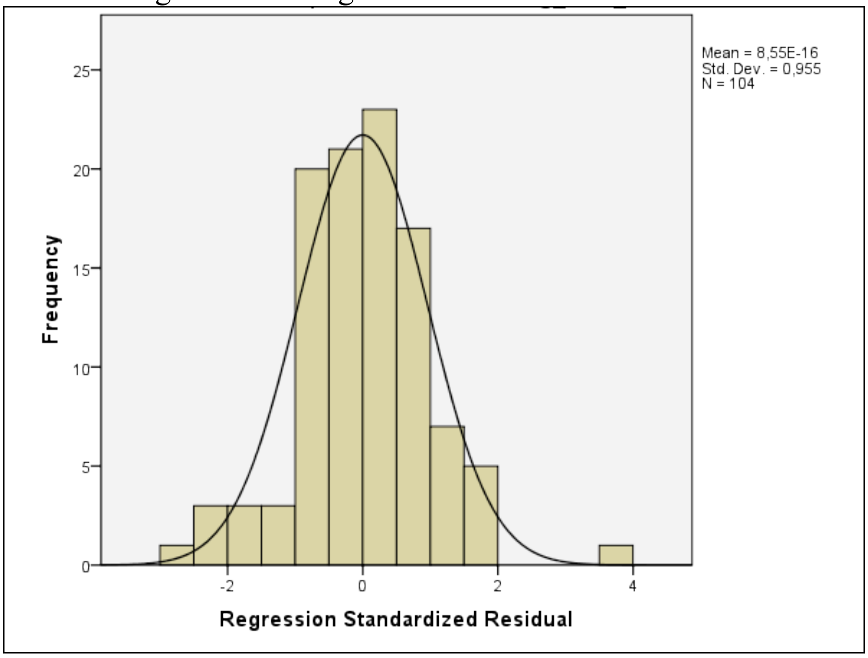
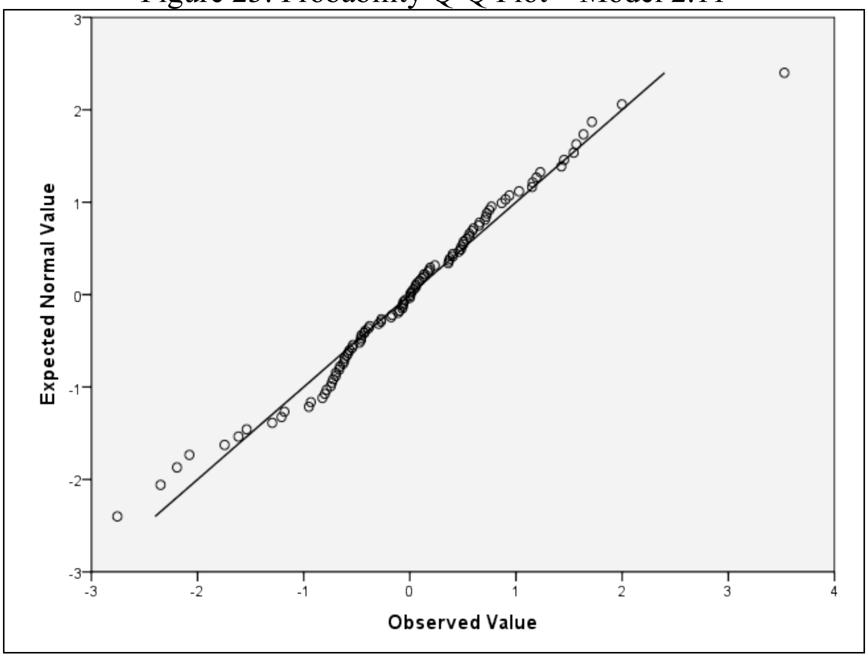


Figure 23: Probability Q-Q Plot – Model 2.11



Avoidance of multicollinearity was already addressed during model setup phase in the previous chapter. There, those variables showing correlations above 0.7 with others were removed (Hair et al., 2003). Following the approach used for models 1.8, 1.9, 2.8 and 2.9 analyzed Condition Indexes (CI) and Variance Inflation Factors (VIF) were also analysed. The condition index is the square root of the ratio between the maximum eigenvalue and the minimum eigenvalue of the variance-covariance matrix; values between 30 and 100 indicate moderate to strong collinearity and value of 30 is usually set as a threshold one. Variance Inflation Factor indicates how much the variance of the regression coefficients is inflated by multicollinearity (Hair et al., 2003) and 10 is the standard limit value for each variable. Table 4-15 and Table 4-16 show Condition Indexes for models 1.11 and 2.11 respectively; Table 4-17 reports Variance Inflation Factors of model 1.11 and Table 4-18 those of model 2.11. Condition Index of model 1.11 is 21.021 and the one of model 2.11 is 11.607, therefore both models respect the upper limit of 30. Variance Inflation Factors are also all respecting the limit, being lower than 10. Therefore, neither model 1.11 nor model 2.11 shown problems of multicollinearity.

Table 4-15: Model 1.11 Condition Index

Eigenvalue	Cond. Index	Variance proportions				
		Biz_RD	*Life_Long*	*Aut_infr*	*Log_Terz*	*Tax_Sp*
0.01	21.02	0.06	0.00	0.00	0.57	0.42

Table 4-16: Model 2.11 Condition index

Eigenvalue	Cond. Index	Variance proportions				
		Biz_RD	*Life_Long*	*Aut_infr*	*PP_Inno*	*Sqr_VC*
0.03	11.60	0.57	0.63	0.38	0.15	0.02

Table 4-17: Model 1.11 VIF

Variable	Tolerance	VIF
Biz_RD	.50	1.98
Life_Long	.39	2.55
Aut_infr	.61	1.62
Log_Terz	.32	3.04
Tax_Sp	.23	4.29

Table 4-18: Model 2.11 VIF

Variable	Tolerance	VIF
Biz_RD	.50	1.98
Life_Long	.49	2.02
Aut_infr	.70	1.41
PP_Inno	.69	1.44
Sqr_VC	.73	1.35

4.4.10 Removing *outliers*

Based on the previous analyses it was decided to remove outliers in models 1.11 and 2.11. Outliers removed from model 1.11 where data from La Rioja (Spain) and Basilicata and Sicily (Italy) regions; data related to Attiki (Greece) and London Area (UK) were also removed from model 2.11. The power of both models increased as expected: Adjusted R^2 of model 1.11 raised from 0.860 up to 0.915 and Adjusted R^2 od model 2.11 raised from 0.824 up to 0.846. A new residual analysis was run, which results are in graphed in Figures 4-10, 11, 12, 13, 14 and 15. The analysis of the previously mentioned graphs compared to those in paragraph 4.4.9, show:

- An increase in fitness of histograms with respect to a normal distribution;
- A better fit of residuals in the interval between -2 and +2 of standardized predicted values;
- More diagonal distribution of residuals in Q-Q probability plots.
- We wanted to further ensure that all outliers were removed, and plotted their centered leverage value vs Cook's Distance (Cook & Weisberg, 1982). Cook's Distance is the normalized measure of each point in all predicted means: in other words it measures the effect of deleting a specific observation. Leverage indicates the distance from corresponding average predictor values. Any point with a combination of high Cook's Distance (CD) and Centered Leverage Value (CLV) will significantly influence one model.

Figure 24: Residual plots after outlier removal – Model 1.11

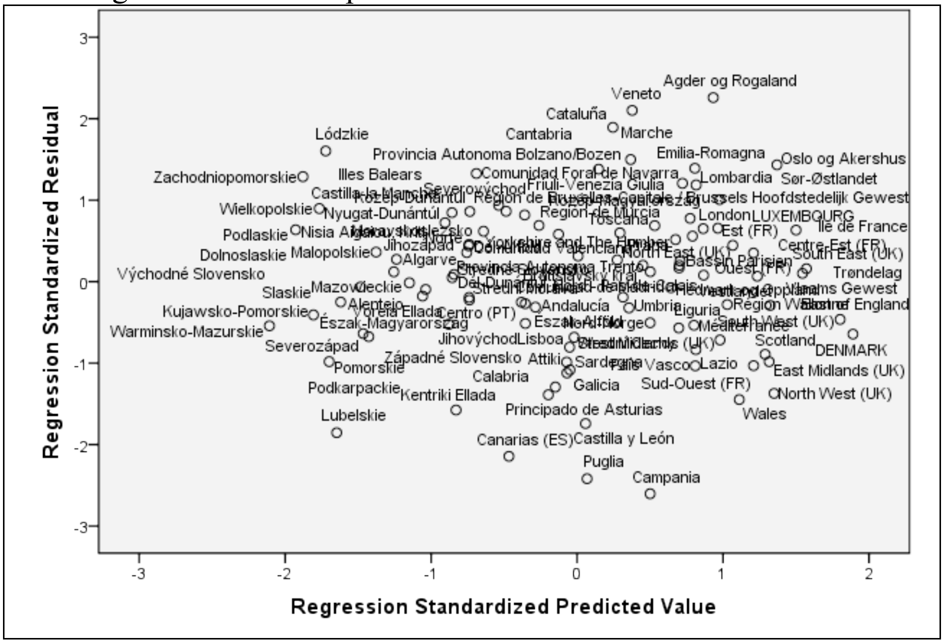
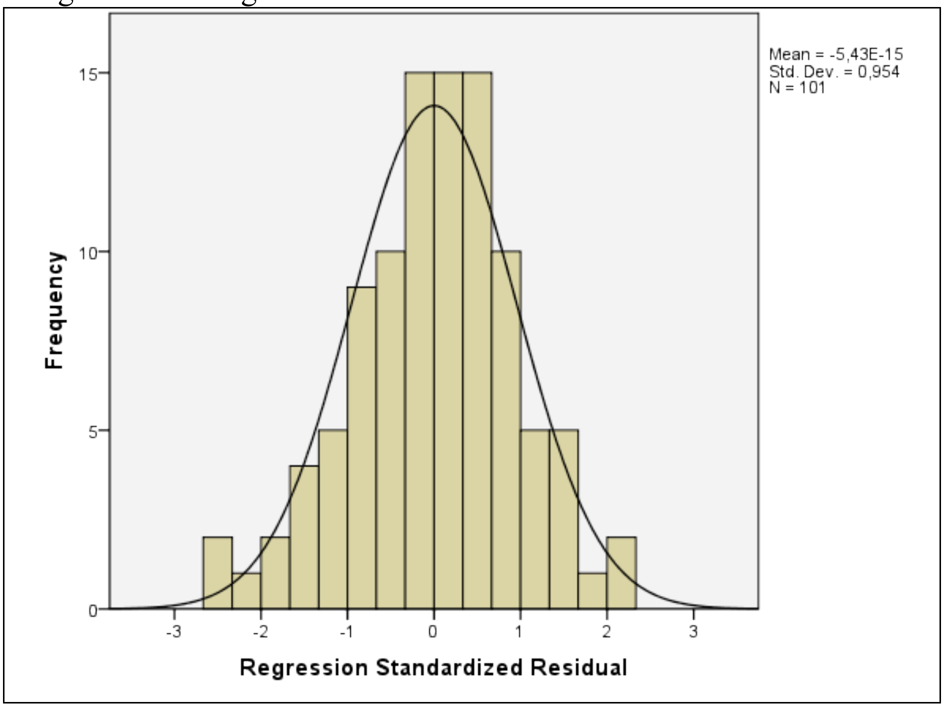


Figure 25: Histogram of residuals after outlier removal – Model 1.11



Graph based on CD and CLV for both models 1.11 and 2.11 were plotted and are visible in Figure 30 and Figure 31. Both models did not show the presence of outliers, with just a potential one for model 2.11 represented by Strednì Cechy (Czech Republic) observations.

- Models 1.11 and 2.11 were therefore good predictors of regional innovation and international collaborative regional innovation. More precisely model 1.11 explained 91.5% of the variance of its dependent variable and model 2.11 explains 84.6% of its dependent variable. These two models, after the exclusion of outliers, are described in Table 4-19. After the previously mentioned analyses, the econometric models answering our research questions R1 and R2 could be described.

R1 states "which are the variables of a regional innovation system effecting its overall patent production?" and is generally described by equation:

3) $Log\_PCT = \alpha + \sum i\ \beta i\ IVi + \sum j\ \beta j\ CVj + \sum k\ \beta k + \varepsilon$

Based on model 1.11 this equation we can now fully describe as follows:

EQ1: $Log\_PCT = 0.581 + 0.390\ Biz\_RD + 0.262\ Life\_Long + 0.114\ Aut\_infr + 0.216\ Log\_Terz - 0.382\ PL - 0.098\ CZ - 0.133\ ES - 0.085\ SK + 0.255\ IT$

where PL, CZ, ES, SK and IT are the dummy variables whose value is 1 if a region belongs to Poland, Czech Republic, Spain, Slovakia and Italy respectively or 0 in the other cases.

Figure 26: Probability Q-Q Plot after outlier removal – Model 1.11

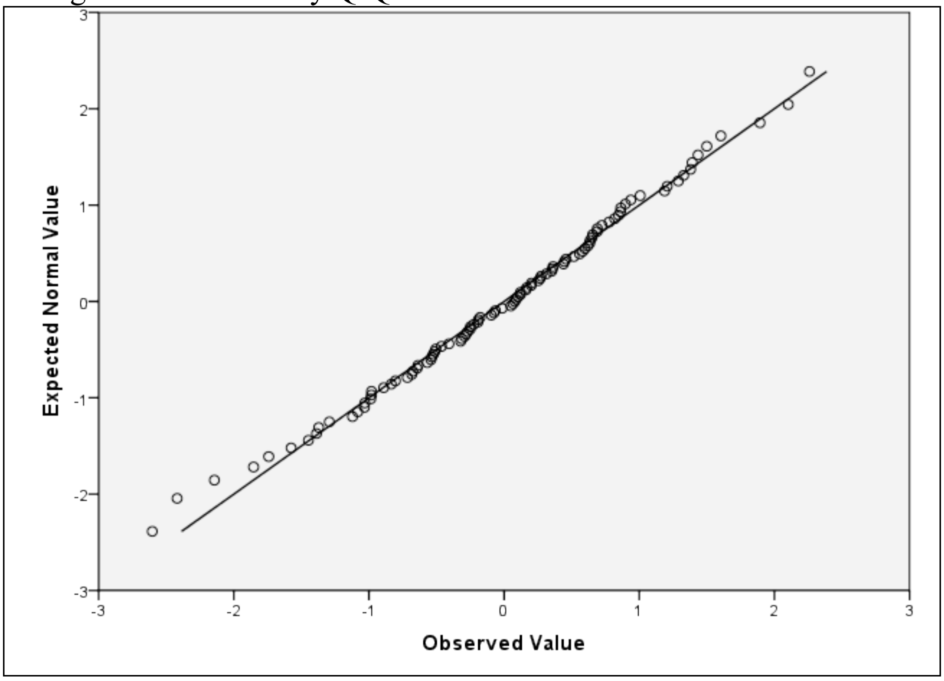


Figure 27: Residual plots after outlier removal – Model 2.11

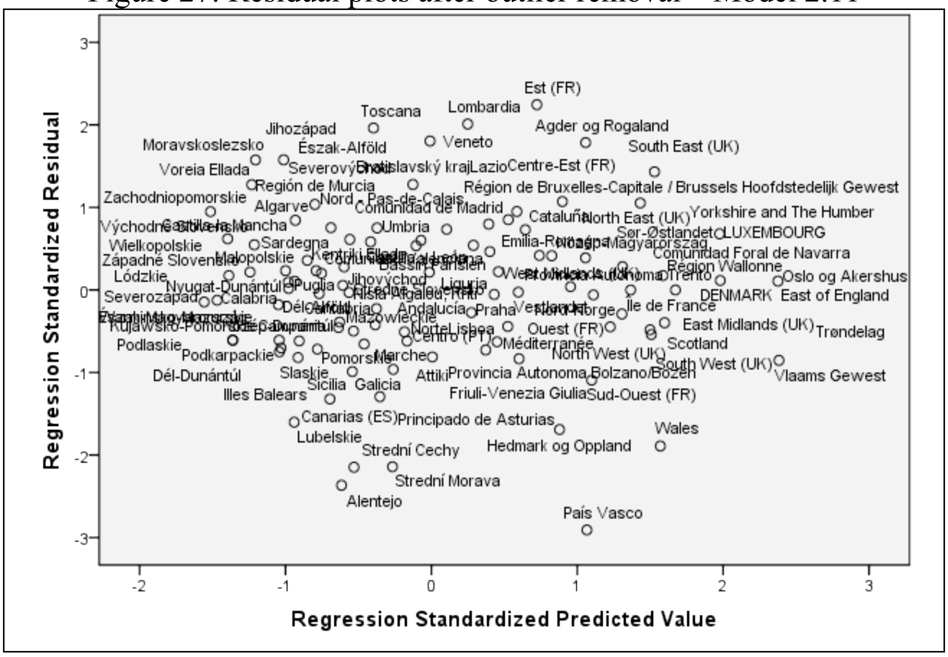


Figure 28: Histogram of residuals after outlier removal– Model 2.11

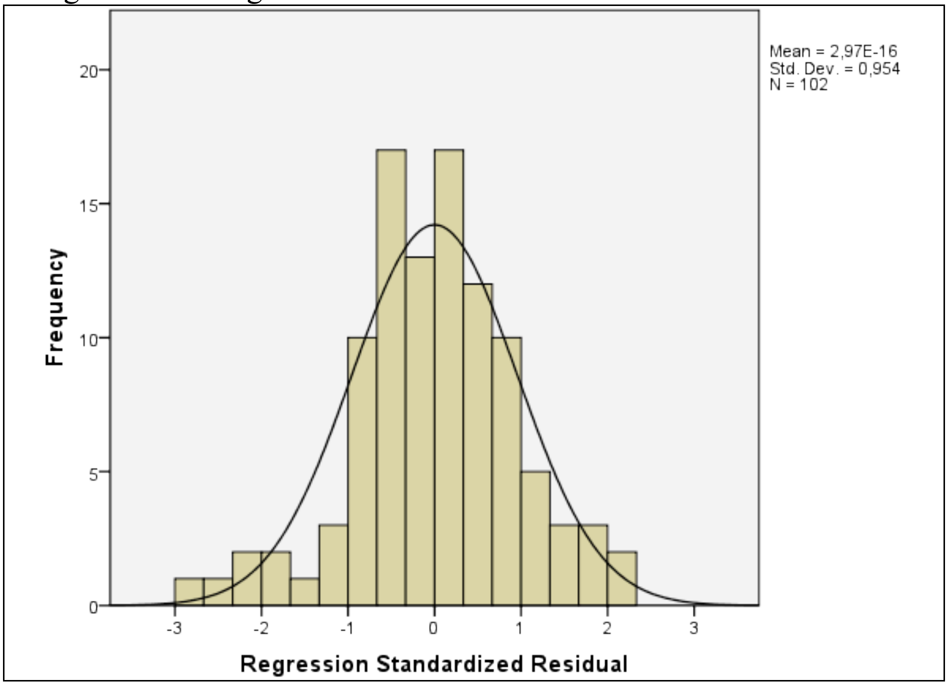
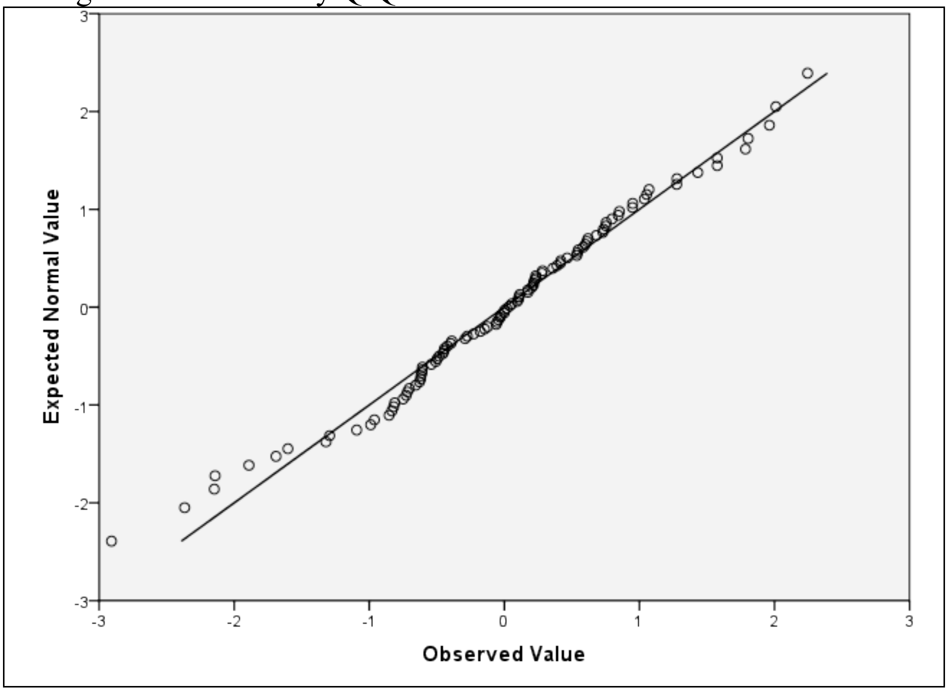


Figure 29: Probability Q-Q Plot after outlier removal– Model 2.11



All other variables, including other dummies, where not significant: Log_PCT is positively influenced by Biz_RD, Life_Long, Aut_infr, Log_Terz and IT dummy and negatively influenced by dummy variables only as PL, CZ, ES and SK. β coefficient of Aut_infr is the smallest among control and independent variables, however this variable spans from 1 to 3, while the maximum value of all other ones is below 1: the overall impact of this variable is therefore at least comparable to the others. Two dummies might have an impact comparable to independent and control variables: PL and IT. Constant is positive and has a magnitude close to the other variables.

Moving to the second research question, R2: it states "which are the variables of a regional innovation system effecting its patent production in cooperation with foreign partners?" and is generally described by equation:

4) $Log\_PCT\_for = \alpha for + \sum i\ \beta for\ i\ IVi + \sum j\ \beta for\ j\ CVj + \sum k\ \beta k + \varepsilon for$

Model 2.11 allows to precisely describe this equation as follows:

EQ2: $Log\_PCT\_for = - 0.707 + 0.336\ Biz\_RD + 0.358\ Life\_Long + 0.264\ Aut\_infr + 0.286\ PP\_Inno + 0.185\ Sqr\_VC - 0.157\ CZ - 0.192\ DK + 0.130\ NO + 0.147\ HU$

Where CZ, DK, NO and HU are the dummy variables whose value is 1 if a region belongs to Czech Republic, Denmark, Norway and Hungary respectively or 0 in the other cases. Here constant term (αfor) is negative and even bigger in absolute value with respect to the one in model 1.11. βfor are similar in size to those of model 1.11: as for the previous model all independent and control variables have a positive correlation with our dependent one. Dummies have coefficient smaller but comparable in size with the other variables: two of them are positively correlated (NO and HU) while two have a negative correlation with the dependent variable (CZ and DK).

Three variables are represented in both models: Biz_RD, Life_Long and Aut_infr. The latter shows a coefficient in model 2.11 which is double with respect to the one in model 1.11; the others have closer coefficients in both models.

Figure 30: Cook's Distance versus Centered Leverage Value – Model 1.11

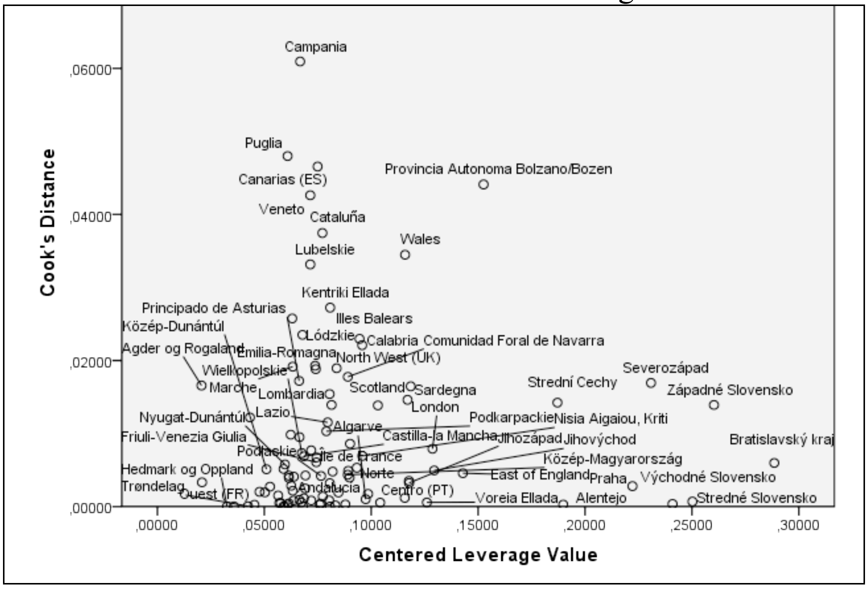


Figure 31: Cook's Distance versus Centered Leverage Value – Model 2.11

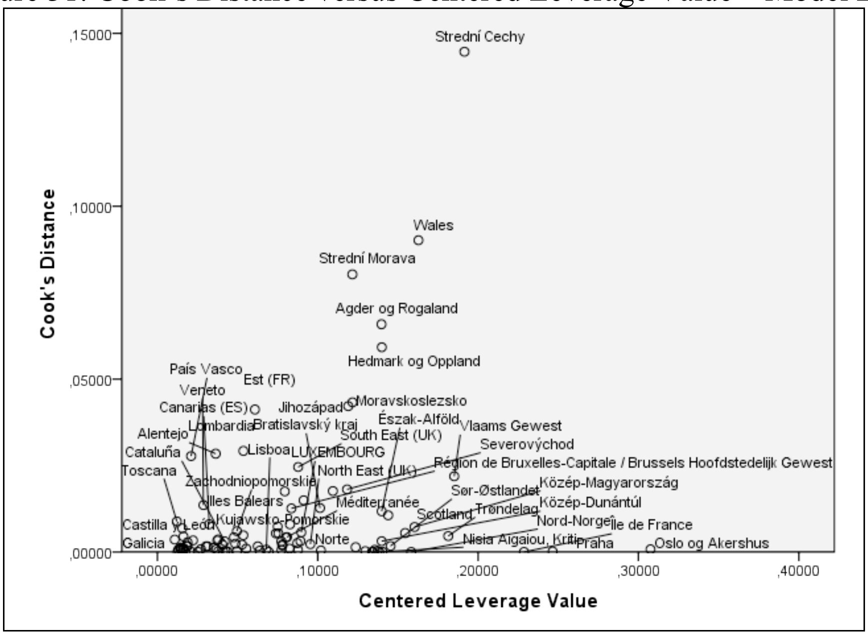


Table 4-19: Models 1.11 and 2.11 without outliers

	1.11	2.11
	step (no out)	*step (no out)*
Constant	0.581***	-0.707***
	(0.131)	(0.08)
PP_inno		0.286***
		(0.117)
Log_Terz	0.216***	
	(0.106)	
Biz_rd	0.39***	0.336***
	(0.151)	(0.182)
SME_coll		
Life_long	0.262***	0.358***
	(0.111)	(0.128)
Extern		
Sqr_Venture		0.185***
		(0.9)
Tax_aut		
Invest_infr	0.114***	0.264***
	(0.03)	(0.031)
dummies	Y	Y
R	0.960	0.927
Rsquare	0.922	0.859
Rsquare Adj	0.915	0.846
F		
nr of observations	104	104

Notes:
Dependent variable is Log_PCT for model 1.11 and Log_PCT_for for model 2.11.
Standard errors are in parenthesis. * p<0.10, ** p<0.05, ***p<0.01
F probability to enter = 0.05 - F probability to remove = 0.1

4.5 Analysis of Innovation Policies' Framework

A framework for analysing innovation policies was introduced in the previous Chapter 3. Table 3-9 and Table 3-10 summarise the application of each policy at national and regional level: a null value indicates the absence of the specific policy, a value = 5 refers to partial policy application and value = 10 occurs when policies are fully applied. To see what are the most applied policies at national and regional level we set up a final value named AVG, which is the average value among all countries for each policy.

Rank of policies applied at national level can be seen in Table 4-20, while the rank of policies applied at national level can be found in Table 4-21. In both tables, values of AVG close to 10 indicate that a specific policy is always applied, while values close to zero refer to policies almost not applied by any of the countries considered in the framework.

The difference between the AVG value at regional level and the AVG value a national level for each specific policy shows the difference in application of that policy: a highly positive value indicates a higher application at regional level, while negative values indicate a higher application at national level. These results have been reported in Table 4-22.

Table 4-20: Rank of innovation policies applied at national level

RANK	POLICY	AVG
1	Scholarships for post-graduate studies	10.000
	Competitive R&D funding by PRCs or HEIs	
	Scientific co-operation for HEIs and PRCs	
2	On-going institutional R&D funding in PRCs or HEIs	9.286
3	Targeted human resource training (directly, subsidies)	8.571
	High-level strategic advisory body	
	Public subsidies for private R&D	
	Tax credits for private R&D	
	Innovation advisory or support services (publicly provided, vouchers, subsidies, student placements)	
	Cluster initiatives (often sectoral and mainly firm-based)	
	Branded excellence poles or hubs (label and multiple actors)	
	Public venture capital funds or stakes in private funds	
4	Technology foresight exercises (assessing future needs)	7.857
	Seed funding/projects to start PRCs or HEIs	
	Advisory to spin-off and knowledge-intensive start-up firms	
	Multi-disciplinary technology platforms	
	Guarantees	
5	Other technology transfer centres and extension programmes	7.143
	International trips to develop innovation networks	
	Innovation awards	
6	Quality control and metrology services	6.429
	Science and technology parks	
	Incubators for new firms	
	Public development banks	
	Public procurement policy with innovation focus	
7	Foreign firms eligible for public innovation-related funds	5.714

Notes: PRC=public research centre; HEI=higher education institution.

Table 4-21: Rank of innovation policies applied at regional level

RANK	POLICY	AVG
1	Cluster initiatives (often sectoral and mainly firm-based)	10.000
2	Innovation advisory or support services (publicly provided, vouchers, subsidies, student placements) Incubators for new firms	8.929
3	Branded excellence poles or hubs (label and multiple actors)	8.214
4	Advisory to spin-off and knowledge-intensive start-up firms	7.857
5	Science and technology parks	7.500
6	Other technology transfer centres and extension programmes	7.143
7	Multi-disciplinary technology platforms Scientific co-operation for HEIs and PRCs International trips to develop innovation networks	6.429
8	Targeted human resource training (directly, subsidies) Technology foresight exercises (assessing future needs) On-going institutional R&D funding in PRCs or HEIs Seed funding/projects to start PRCs or HEIs	6.071
9	Competitive R&D funding by PRCs or HEIs Public procurement policy with innovation focus	5.714
10	Public subsidies for private R&D Public venture capital funds or stakes in private funds	5.357
11	High-level strategic advisory body Innovation awards	5.000
12	Quality control and metrology services Guarantees Foreign firms eligible for public innovation-related funds	4.643
13	Scholarships for post-graduate studies	3.571
14	Public development banks	2.143
15	Tax credits for private R&D	0.714

Notes: PRC=public research centre; HEI=higher education institution.

Table 4-22: Difference of average policy application at regional and national levels

POLICY	AVG R - AVG N
Incubators for new firms	2.500
Cluster initiatives (often sectoral and mainly firm-based)	1.429
Science and technology parks	1.071
Innovation advisory or support services (publicly provided, vouchers, subsidies, student placements)	0.357
Advisory to spin-off and knowledge-intensive start-up firms	0.000
Other technology transfer centres and extension programmes	0.000
Branded excellence poles or hubs (label and multiple actors)	(0.357)
International trips to develop innovation networks Public procurement policy with innovation focus	(0.714)
Foreign firms eligible for public innovation-related funds	(1.071)
Multi-disciplinary technology platforms	(1.429)
Technology foresight exercises (assessing future needs) Seed funding/projects to start PRCs or HEIs Quality control and metrology services	(1.786)
Innovation awards	(2.143)
Targeted human resource training (directly, subsidies)	(2.500)
Guarantees Public subsidies for private R&D Public venture capital funds or stakes in private funds On-going institutional R&D funding in PRCs or HEIs	(3.214)
High-level strategic advisory body Scientific co-operation for HEIs and PRCs	(3.571)
Competitive R&D funding by PRCs or HEIs Public development banks	(4.286)
Scholarships for post-graduate studies	(6.429)
Tax credits for private R&D	(7.857)

Notes: PRC=public research centre; HEI=higher education institution.

4.6 Conclusions

In the previous chapter 3 the experimental model of this research was set up. The dataset built to run a multiple linear regression analysis confirmed the validity and reliability of this model; furthermore the number of observations was considered appropriate with respect to of the number of independent variables of this study.

All 22 models showed a correlation between independent and dependent variables, passing the test of null hypothesis of correlation. The power of all models was fund to be strong and increased adding all independent and dummy variables: adjusted R^2 values ranged between 0.606 and 0.892 for the confirmatory models (1.1 to 1.11) and between 0.667 and 0.845 for the exploratory models (2.1 to 2.11). Models including all variables and dummies shown the highest power; yet they shown some multicollinearity problems, still not affecting their power. The hypotheses introduced in this research (H1 and H2) were therefore confirmed by these models.

Exploratory models required in-depth analyses of residuals and the removal of some outliers. Models 1.11 and 2.11 proved to be good predictors of their independent variables, explaining respectively 91.5% and 84.6% of their variance. These two models set up the final equations of the econometric models providing the answers to research questions R1 and R2.

As for the third research question, R3, the innovation policies framework introduced in chapter 3 was further analysed and policies were ranked with respect to their degree of application, both at national and regional level. The differences in application between regional and national levels were measured too.

CHAPTER 5: IMPLICATIONS OF RESULTS

Abstract

In this chapter the results of the econometric models are analysed and economic implications reviewed. After an overview on the role of the RIS model in the global innovation arena, the quantitative results of our models have been commented. Two research questions, H1 and H2, were confirmed, thus offering a first econometric model suitable for representing previous qualitative RIS theories. This model is able to describe with very good power and significance regional innovation performances, both overall and in co-operation with international partners. Country level effects, probably related to NIS, showed little effects and regions emerged as the key players for regional innovative performances. Furthermore two research questions, R1 and R2, were answered and the most significant variables effecting overall regional innovation and internationally co-operative innovation were identified. In both cases RIS showed an important role as learning regions where public institutions act as enablers. However while business R&D expenditures contribute heavily to overall regional innovations (on top of learning and infrastructure), global co-operative innovation occurs when the whole regional private sector (corporations, SMEs, finance and learning in firms and private institutions) is oriented towards research and innovation. Once R2 was answered and the key RIS variables identified, findings have been crossed with the innovation policies framework: their effectiveness proved to be limited as policies potentially impacting RIS variables are the less applied at regional level.

5.1 RIS as innovation enablers

In the systematic literature review reported in Chapter 2 RIS emerged as a new model of networks supporting clustered and non-clustered companies (Cooke, 2005) in their evolutionary paths of innovation, leveraging local specializations (Cooke et al., 1997). This model appeared to be more effective in enabling innovation in the globalized economy than the traditional models of industrial clusters and NIS. In effect industrial clusters, introduced and conceptualized as "*distretti industriali*" (industrial districts) by Becattini (1979), have been considered a benchmark model for economic development (Bellitti et al., 1995) but they showed to miss the required flexibility to operate in the global scenario (Varaldo & Ferrucci, 1996). On the other hand NIS, while keeping an important role in setting up scientific priorities and providing long term funding for both basic research and university education (Cooke, Boekholt, & Todtling, 2000), are not the most suitable model for exploiting radical innovation through global connections (Lane, 2000).

5.1.1 Findings through models 1.8 and 1.9

The analyses of models 1.8 and 1.9 described in Chapter 4 supported the role of RIS previously described. Models 1.8 and 1.9 referred to hypothesis H1 and are shown in Table 5-1.

These two models included all variables representing RIS potential and the dependent variable was Log_PCT, the logarithm transformed number of regional PCT patents per million inhabitants, which expressesed overall innovation performances of each region. The main difference between model 1.8 and 1.9 was the presence of dummy variables related to country level effect: each dummy represented a specific country and had value = 1 when a region belonged to that country and value = 0 elsewhere. The analysis performed in Chapter 4 confirmed the validation of hypothesis H1, therefore supposing that "the higher is RIS potential, the higher will be regional innovation expressed by patent production". As a matter of fact model 1.8 told us that variation of RIS potential influences 78% of the variation of regional innovation performances, as expressed by adjusted R^2 value: in other words, the quantitative RIS model said that nearly 80% of innovation performances are driven by RIS potential. Model 1.9 added to the RIS model the country level effect: it valued how much belonging to a specific country impacted on regional innovation performances, in addition to RIS potential. Looking to adjusted R^2, it increased from 0.78 of model 1.8 to 0.892 of model 1.9: this meant that model 1.9 is able to predict 89.2% of variation in regional innovation performances.

Table 5-1: Models 1.8 and 1.9

	Model 1.8	Model 1.9
Constant	0.014 (0.294)	-0.044 (0.548)
PP_inno	0.249*** (0.153)	0.406*** (0.244)
Log_Terz	0.085 (0.137)	0.112 (0.168)
Biz_rd	0.463*** (0.231)	0.315*** (0.223)
SME_coll	-0.314*** (0.19)	-0.175* (0.344)
Life_long	0.427*** (0.19)	0.29* (0.405)
Extern	0.020 (0.304)	0.031 (0.234)
Sqr_Venture	0.046 (0.723)	0.08* (0.608)
Tax_aut	-0.147* (0.085)	0.053 (0.171)
Invest_infr	0.339*** (0.047)	0.035 (0.063)
dummies	N	Y
R	0.894	0.957
Rsquare	0.799	0.915
Rsquare Adj	0.780	0.892
F	41.539	39.683
nr of observations	104	104

Notes:
Dependent variable is Log_PCT
Standard errors are in parenthesis.
* p<0.10, ** p<0.05, ***p<0.01

Based on the previous findings and review it might be inferred that the developed model confirmed hypothesis H1, and validated RIS potential as a significant influencer of regional innovation performances. As a matter of fact models 1.8 and 1.9 were set up as a representation of Cooke's (2001) one, using variables both at infrastructural and superstructural levels. Table 3-6 showed how independent variables of these models refer to RIS potential ones, while regional innovation performances were measured by regional patent production.

It might be questioned if this finding is influenced by other factors, like industrial clusters or MNCs' subsidiaries, which were found in literature to be potentially significant in delivering innovation performances. As a matter of fact Porter (1998) suggested that clusters are fundamental enablers of innovation in the global markets, while other studies supported the relevance of MNCs in local innovation (Singh, 2007). However, none of the variables used in models 1.8 and 1.9 were set up with specific reference to the presence of industrial clusters or MNCs' subsidiaries in a region; furthermore data collection was performed independently of regional characteristics, therefore independently from any assumption on clusters and MNCs' subsidiaries. These considerations strengthen the confirmation of the research hypothesis H1 without potential biases related to the presence of clusters or MNCs' subsidiaries.

Furthermore, the difference in power between models 1.8 and 1.9 supports Cooke's thesis that there are still national influences on RIS from a social, political and economic point of view (Cooke, 2001). In effect the difference between these two models is the presence (or not) of country level influence in regional innovation performances, measured by dummy variables: these variables increase by nearly 10% the ability of model 1.9 to explain the variation of regional innovation performances with respect to model 1.8. Weather this difference is due to SIS or other country level factors is still to be determined.

5.2 RIS as enablers for global connections in innovation

In the previous paragraph we confirmed hypothesis H1 and therefore tested that our quantitative model was a good representation of RIS framework. The fact that additional country level dummy variables increased the power of the model was a further confirmation of its ability to represent the theoretical background of RIS studies, claiming that some national level influence is still relevant in analysing innovation performances.

Provided these findings, this research wanted to asses if RIS potential was an enabler of innovation performed in collaboration at international level: in other words if it confirms hypothesis H2.

The literature review in Chapter 2 highlighted that RIS are relevant in enabling global connections. Under this perspective they are far more effective than clusters, as the Varaldo and Ferruci (1996) study noticed. Two different studies performed on the German national network of research (Cantwell, 1995; Lane, 2000) also pointed out that NIS provide limited opportunities for international networking: the few German companies really acting as global players have relocated much of their research centres out of the national network.

Theoretical studies therefore lead to the second research hypothesis, H2, stating that RIS potential is proportional to regional innovation produced in cooperation with foreign players. This hypothesis was tested in Chapter 4 using models 2.8 and 2.9, whom results are reported in Table 5-2.

5.2.1 Findings through models 2.8 and 2.9

Models 2.8 and 2.9 represent RIS potential with respect to collaborative innovation with international partners, expressed by Log_PCT_for, the logarithm of the number of PCT patents filed with foreign partners in region per million inhabitants of the region itself. As for models 1.8 and 1.9, model 2.8 represented RIS potential only while model 2.9 included dummy variables related to country level effects. The analysis performed in Chapter 4 confirmed the validity of hypothesis H2 for both model 2.8 and 2.9: this means that the quantitative model was not only a good representation of a RIS and was able to predict overall regional innovation performances, but it also confirmed that RIS potential is an important determinant of international collaborative innovation at regional level.

More precisely, looking to adjusted R^2 value of model 2.8, it could be noted that RIS potential (excluding country effect) was accountable for 77% of regional patent production with foreign partners. Adding the country effect, therefore referring to model 2.9, the power of model increased to 84.5%. These results were very close to those found for H1: however the increase in power due to country effect was lower in the case of H2.

This indicates that country effects in RIS potential are higher for the overall innovation performances than for foreign collaborative innovation performances. The German case studies previously mentioned (Cantwell, 1995; Lane, 2000) might provide an explanation: while there was good evidence in theoretical literature that country level effects might have been correlated to innovation performances (Cooke, 2001) – as previously mentioned for hypothesis H1 – their role in international networking was less relevant. In other words, when it comes to collaborative innovation at global level, regions play a stronger role than in overall innovation performances: national policies can have a certain influence in supporting innovation, but their contribution to establish international networks is less evident.

This confirms the finding of the case study related to biotech in Massachussets: in his analysis of the Massachusetts RIS case, Cooke (2001) described its role in the national and global context. The regionalization of a previously national level only authority (the opening of a Food and Drug Administration representative office in Boston), speeding up the fundamental regulatory processes underlying this specific industry; then the global connections established by regional biotech firms: "*Then there are the global linkages between the regional cluster and innovation partners elsewhere, from California to Europe, not least in the case of Genzyme with a Dutch CEO, and two enzyme-production plants in the UK plus other European branch operations*" (Cooke, 2001). In synthesis, "*this is the advantage of taking a regional innovation system approach. The rich picture of interactions in the cluster can be set on the canvas of wider, global innovation interactions*".

Table 5-2: Models 2.8 and 2.9

	Model 2.8	Model 2.9
Constant	-0.465* (0.256)	-0.607 (0.559)
PP_inno	0.268*** (0.133)	0.417*** (0.248)
Log_Terz	0.22** (0.119)	0.159 (0.171)
Biz_rd	0.336*** (0.201)	0.302*** (0.227)
SME_coll	-0.125** (0.177)	-0.139 (0.351)
Life_long	0.358*** (0.166)	0.437** (0.413)
Extern	0.053 (0.265)	0.073* (0.239)
Sqr_Venture	0.077 (0.629)	0.097* (0.62)
Tax_aut	-0.129 (0.074)	-0.143 (0.174)
Invest_infr	0.314*** (0.041)	0.042 (0.064)
dummies	N	Y
R	0.889	0.937
Rsquare	0.790	0.878

Rsquare Adj	0.770	0.845
F	39.291	26.251
nr of observations	104	104
Notes: Dependent variable is Log_PCT_for Standard errors are in parenthesis * p<0.10, ** p<0.05, ***p<0.01		

5.3 The determinants of overall regional innovation performances

The previous paragraphs showed that the two research hypotheses of this work were confirmed. Hypotheses H1 and H2 were tested using a linear multiple regression model. While setting up this model in Chapter 3 it was mentioned that linear multiple regression models could be used for confirmatory and exploratory purposes too (Agresti & Finlay, 1997). This gave the opportunity to understand which, out of all the variables representing RIS potential, was significantly correlated to dependent variables. In effect, in models 1.8, 1.9, 2.8 and 2.9 several control and independent variables did not have good significance values, with p-values exceeding 0.1 level and the objective was to set up models for each dependent variable including significant control and independent ones only. In other words two additional research questions were introduced, R1 and R2.

In order to answer the above research questions, two models were built, respectively Model 1.11 for R1 and Model 2.11 for R2. Implications of Model 1.11 are reviewed in this paragraph, while Model 2.11 will be reviewed in the next one.

The final version of Model 1.11 was represented by the following equation:

EQ1: $$\text{Log\_PCT} = 0.581 + 0.390\ \text{Biz\_RD} + 0.216\ \text{Log\_Terz} + 0.262\ \text{Life\_Long} + 0.114\ \text{Aut\_infr} - 0.382\ \text{PL} - 0.098\ \text{CZ} - 0.133\ \text{ES} - 0.085\ \text{SK} + 0.255\ \text{IT}$$

EQ1 represents model 1.11 after outliers have been removed from our database. Model 1.11 had very high power: its adjusted R^2 was 0.915 which meant that was able to explain 91.5% of the variation of our dependent variable, the logarithm of PCT patents per million inhabitants. This model indicated that overall regional innovation performances are influenced by:

- Biz_RD: regional research and development expenses, in percentage of regional GDP, related to companies and private institutions;
- Life_Long: participation in learning programs by the regional population aged between 25 and 64;
- Aut_infr: the regional government’s autonomy in infrastructure investments, whose value ranges from 1 (no autonomy) to 3 (full autonomy);
- Log_Terz: the logarithm of regional population with tertiary education per 100 population aged between 25 and 64;
- PL, CZ, ES, SK and IT are the dummy variables related to country level effects, whose value is 1 if a region belongs to Poland, Czech Republic, Spain, Slovakia and Italy respectively or 0 in the other cases.

5.3.1 Business R&D

Business R&D expenditures, Biz_RD, was the variable with the highest coefficient (0.390). It was introduced in our model as a control for regional embeddedness and the presence of regional private finance, representing one superstructural and one infrastructural characteristic of a RIS (Cooke, 2001). In effect high R&D corporate costs are correlated to the degree of R&D collaboration between firms in any specific region (Miotti & Sachwald, 2003); moreover venture capital operations are significantly driven by business R&D strategies and industrial investments (Guerra, 2011; Peneder, 2008). Surprisingly the independent variable related to regional embeddedness (SME_coll) was not significant and was not added to model 1.11. Also the venture capital one (Sqr_Venture), with direct relationship with regional private finance, resulted not to be significant. These findings might be explained through different approaches.

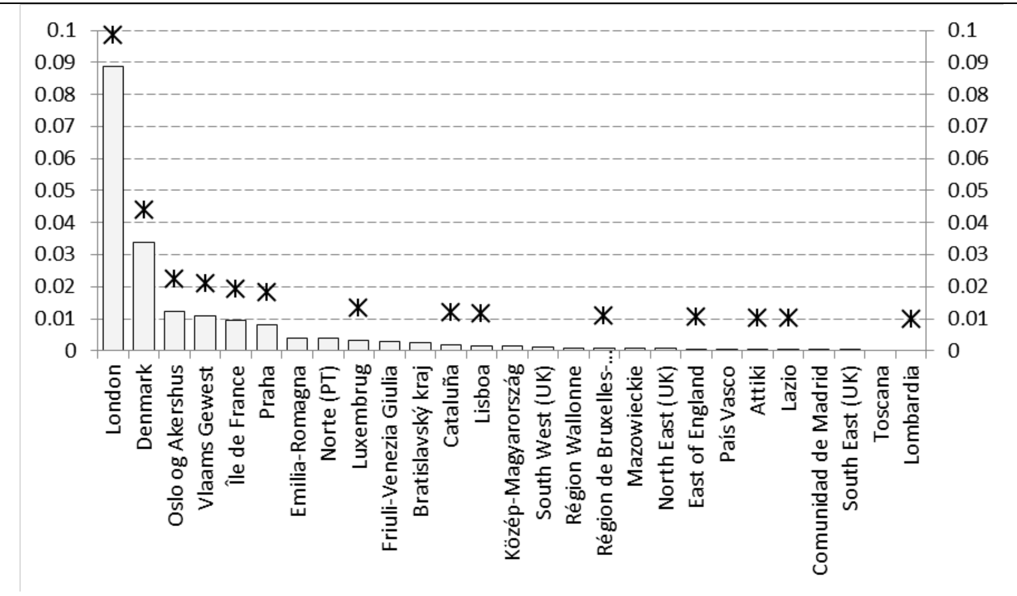
The percentage of SMEs collaborating each other in innovation processes was selected as regional embeddedness independent variable. This variable was collected through the Community Innovation Survey performed by the European Commission (2010). SME_coll was not included in model 1.11, being not significant, however it shown a very high significance in model 1.8 and a good one in model 1.9. In the latter two cases, SME_coll had a negative correlation with global regional innovation; this result was in contradiction with RIS theory, where the higher the embeddedness, the higher RIS potential (Cooke, 2001). How could it be that a control variable had an opposite behaviour with respect to a related independent one? How can we explain this contradiction with RIS theory? In introducing Biz_RD as a control variable we referred to the Miotti and Sachwald (2003) paper, a study performed analysing the same Community Innovation Survey which was used to collect SME_Coll variable too. They found a positive correlation between co-operative attitude and R&D expenditures, however they did not use SME_coll as a dependent variable but, instead, two dummy variables whose value was respectively i) 1 in case a company cooperates with general partners and 0 elsewhere, and ii) 1 in case a company cooperates with US ones, a proxy of foreign cooperation, and 0 elsewhere. Furthermore Community Innovation Survey data have been questioned as a good mean for representing firms cooperation as they do not provide information about the relationships among firms and other agents (Carvalho, 2006). Not to mention that

SME_Coll was itself a variable limited to SME only and did not provide information about all potential co-operation links in the innovation processes of regions.

The absence of the venture capital proxy, Sqr_VC, from this model, beside the strong presence of Biz_RD, might be differently explained. While reviewing the investment strategies of venture capital funds associated to EVCA (2010b) through their websites it was noticed that only a minority of them wss regionally focused, while a significant majority had national or even international scope of investment. Venture Capitalists are often located in economic or political capitals of each country and operate from there: this was also clearly visible from the distribution of the Sqr_VC variable (see Table 5-3). The graph in this table represents regions with venture capital operations, ordered from the one with the highest value to the lowest. Only 25.9% of regions have a venture capital activity (27 over 104) and 51.8% of these regions are economic or political capitals (this percentage goes to 100% for the first six regions). This concentration of venture capital firms might explain the absence of this variable among the significant ones.

Beside the previous analysis regarding Biz_RD variable as a control one for SME_Coll and Sqr_VC, its strong positive correlation with regional innovation gave a relevant implication for this research: regional innovation performances are based on corporate investments in research and development. This finding, combined with the absence of a variable related to public expenditures in R&D, would be of significant interest for policy makers and it will be further reviewed, under the policy making perspective, in the next Chapter.

Table 5-3: Distribution of venture capital operators



Notes:
Horizontal axe includes regions with Sqr_VC <>0 only.
Vertical axe is the value of Sqr_VC variable.
Values marked with star symbol refer to regions related to either economic or political capitals.

5.3.2 The learning regions

Log_Terz and Life_Long were positively correlated to regional innovation, with a beta coefficient lower than Biz_RD, yet important. The first variable was a control for the second and for Sqr_VC, and was a proxy of the percentage of population with a tertiary education degree. As for Biz_RD we noticed the absence of the venture capital variable among the significant ones: this incongruence was explained in the previous paragraph. Still its presence in combination with the variable related to the percentage of adult population (aged 25 – 64) attending learning programs, could be interpreted as the role of learning in the innovation processes. The systemic dimension of learning was one of the key features of a RIS (Cooke et al., 1997), but the connection between learning and innovation goes back to early 1990s with Porter's work (1990). EQ1 told us that a region with high innovative output relies on both the overall degree of education and the continuous learning opportunities pursued by its population: overall production of patents is higher in regions where population is more educated and keeps on learning through formal processes. This was a quantitative confirmation of the qualitative relevance that Cooke gave in all his papers, when he stressed the role of RIS in terms of learning regions.

5.3.3 Regional autonomy in investments

Last independent variable included in our model is Aut_Infr, which measured the regional government's autonomy in managing infrastructural investments. This variable depended on country's governance style: some countries give limited or no autonomy to regional governments, others have little central power. There are no "black or white" examples, while the degree of regional autonomy among various states (and in some cases even inside the same country) is more a "grey-scale" of cases. The Italian case, just to cite one, is based on various regional government models. Regions are divided in "ordinary statute regions" and "special statute regions".

Italian ordinary statute regions are 15: they have very limited taxation authority and their financial balance is covered by centrally collected taxes. Spending autonomy depends on area: while the health system and regional public transportation budget are directly managed by the regional governments, universities are centrally managed by the Ministry of Education, University and Research and no budget is managed by regions, apart from specific regionally funded research programs which represent a small minority of university budgets.

On the other hand, the five special statute regions have each diverse statute and powers. To be even more precise, one region, Trentino-Alto Adige (or Trentino-Sud Tirol), is actually the union of two autonomous provinces, each with a special statute and little common ground of governance. While these regions still do not have greater taxation authority, they partially or even never distribute their income to the central government and have additional if not full autonomy in spending. In Trentino-Alto

Adige, for example, universities are almost fully financed by provincial governments, while keeping on following the central ministry's directives for academic career paths and salaries.

Following Cooke (2001), three variables were introduced in our RIS model (see Chapter 3), all related to the autonomy of taxing and spending: i) taxation authority, ii) autonomy in infrastructural investments and iii) autonomy in research budget and investments. Aut_Infr referred to the second one. This supported the pivotal role of general infrastructures identified by Cooke (1997): "*Infrastructures constitute the physical makeup of the regional space and make possible the multiple relations that are established between the different agents in a regional economy*". The level of autonomy given to a region for its infrastructural investment was then positively correlated with overall innovation performances of the region itself. The slope of this relation was however lower with respect to the business R&D variable and the learning region ones.

5.3.4 Country level effects

As mentioned in Chapter 3, while introducing dummy variables in the models, country level variables might still play a relevant role. More precisely it has been referred to the policies on venture capital, now moving up at national level (EVCA, 2010a), and to the persistent role of NIS in dictating one country's innovation agenda (Cantwell, 1995; Lane, 2000). Regarding the venture capital variable, which was also analysed it in this chapter while discussing the implications for Biz_RD variable, a significant concentration of operators in few regions was noticed, while their range of activities is national or international. The role of NIS was also addressed in this chapter, more precisely discussing the implications of results for models 1.8 and 1.9.

As a matter of fact 11% of variance between the two models was due to country level effects, expressed by our dummy variables.

In running an exploratory multiple linear regression, 5 out of 14 dummy variables were significant. The countries which effects influence regional innovation performances were Poland, Czech Republic, Spain, Slovakia and Italy. Four of these countries had a negative influence in regional innovation performances: Poland, Czech Republic, Spain and Slovakia. This meant that regions located in these countries have lower overall innovation performances than hypothetical regions with the same level of all the other variables but located in other countries. In the case of Poland, country level effects have an impact comparable to business R&D expenditures variable. In other words, based on our model 1.11, assuming two regions, one located in Poland and the second in the UK or France, have the same level of learning variables and investment autonomy, their output in terms of patents would be the same if i) the non-Polish region has zero business budget for R&D or ii) the Polish region has a double business budget for R&D with respect to the non-Polish one. Spain country level influence was also not irrelevant, as it coefficient was close to the degree of autonomy in infrastructure investments. Czech Republic and Slovakia (formerly the same country) had a similar while less relevant negative impact.

On the other side, Italian regions enjoyed a positive country level effect. The impact is significant, as the slope of this variable is between those of business R&D expenditures and autonomy in infrastructural investments. Italian regions have therefore a higher degree of innovation with respect to all the other regions located in different countries and having the same level of control and independent variables.

5.4 The determinants of regional innovation performances with global partners

In the previous paragraph the findings related to model 1.11, which was built to answer our first research question R1, were discussed. Model 2.11 was setup in order to answer a second research question, R2, and is represented by the following equation:

EQ2: Log_PCT_for = - 0.707 + 0.336 Biz_RD + 0.358 Life_Long + 0.264 Aut_infr + 0.286 PP_Inno + 0.185 Sqr_VC - 0.157 CZ – 0.192 DK + 0.130 NO + 0.147 HU

The power of model 2.11 was good, with adjusted R^2 of 0.846, therefore explaining 84.6% of the variation of our dependent variable (number of PCT patents filed in cooperation with foreign partners per million inhabitants); still was not as good as model 1.11 (explaining 91.5% of the variations of its dependent variable) and almost as powerful as the confirmatory model 2.9 (which explains 84.5% of the variation of the same dependent variable). The variables included in this model were:

- Biz_RD: regional research and development expenses, in percentage of regional GDP, related to companies and private institutions;
- Life_Long: participation in learning programs by the regional population aged between 25 and 64;
- Aut_infr: the regional government's autonomy in infrastructure investments, whose value ranges from 1 (no autonomy) to 3 (full autonomy);
- PP_Inno: SMEs introducing product or process innovations in percentage to all SMEs located in the same region;

- Sqr_VC: the square root of total asset under management by venture capital operators as percentage of regional GDP;
- CZ, DK, NO, HU: dummy variables related to country level effects, whose value is 1 if a region belongs to Czech Republic, Denmark, Norway and Hungary respectively or 0 in the other cases.

Biz_RD, Life_Long and Aut_infr were variables included in model 1.11 too. There were, however, a few differences with respect to the previous analyses for model 1.11, the general regional innovation one.

5.4.1 The role of the private sector in global co-operative regional innovation

Biz_RD shown a coefficient very close to the one it had in the general regional innovation model. Business R&D expenditures were introduced as a control variable related to regional embeddedness and regional private finance. As for model 1.11, the variable SME_coll (related to regional embeddedness) was not significant: the reasons for this absence have been analysed in the previous paragraph related to research question R1. However the venture capital related one, Sqr_VC was significant in model 2.11, while it was not in model 1.11. This finding is not in contrast with the previous explanations regarding the non-significance of Sqr_VC in model 1.11. In the previous paragraph it was claimed that venture capital operators are concentrated in regions around the economic or political capitals of each country but operate at national or international level, therefore regional presence is biased. To investigate this finding, a series of short phone and personal interviews with 12 European venture capital operators (see Appendix B.1) was performed and discovered that funds' headquarters locations decision are led by three main reasons: i) presence of high level ancillary services, as legal firms and advisors, ii) proximity with some leading knowledge spillovers, as universities and iii) easy accessibility to national and international hubs (in other words logistics). Venture capitalists are therefore located in international hubs, therefore in regions where the opportunity to tighten and manage international relations is higher than in others. Studying the cases of three Italian regions, Emilia Romagna, Friuli and Toscana, the location of venture capital funds close to knowledge spillovers was confirmed. These regions have local venture capital funds (Ingenium, Aladdin and Toscana Innovazione) with regional only scope of investments, which have been established with a strong sponsorship or regional governments to support the creation of spin-off companies from the regional research institutions. All these regions have leading universities, science parks and research institutions with significant international exposure and networks (see detailed cases in Appendix B.2). Last, venture capitalists invest in internationally networked companies only. Even in case of very early stage investments, therefore companies with less than 10 people, they all have established international partnerships if not subsidiaries in foreign countries. Analysing the portfolio of TTVenture, the biggest Italian venture capital fund focused on technology transfer, it could be seen how each company had created a significant international network of partners or exports (see detailed cases in Appendix B.3).

Logistic easiness, the pre-condition of international partnerships in portfolio companies, and previous establishment of internationally connected knowledge spillovers might explained the significance of Sqr_VC variable in model 2.11.

Model 2.11 confirmed that business expenditures in R&D are a fundamental variable even for globally cooperative innovation and not only for general innovation. Furthermore it told us that the presence of venture capital operators reinforces the role of corporate research budgets in creating international networks for innovation. The significance of PP_inno variable was also an indicator of the innovative capabilities of regional corporations, more precisely small businesses. PP_inno is the percentage of regional SMEs who declared to have introduced product or process innovations; this variable was included in the models as a control for externalization. The role of this variable can be understood through the definition of innovation by the UK Department of Trade and Industry (DTI) as mentioned in Pittaway's study (2004): "*innovation is the successful exploitation of new ideas*". PP_inno was collected through the Community Innovation Survey by the European Union and does refer neither to patenting activities nor to direct business R&D expenditures. As Brenner and Broekel noted (2011), "*if the multinational company applies for a thousand patents and the local electronic store for a single one, often the first is perceived as being more innovative. It is neglected that the multinational may have invested 10,000 times the efforts of the local manufacturer*". It was inferred that, when it comes to small businesses, patenting may not be an appropriate measure for their innovativeness; furthermore R&D budgets are tiny and often difficult to be properly accounted. PP_inno therefore indicates how much small businesses in a region are active players in creating innovation through the exploitation of new ideas.

The previous analyses implied that collaborative innovation, at international level, exists in a region when the corporate and financial worlds invest in R&D, through their R&D budgets and venture capital investments, and when the small business community is oriented towards innovation. This was an interesting finding that confirmed the specific role of RIS as network enabling global links for innovation and not just generic innovation; model 1.11 included business R&D expenditures only – which could be referred to bigger corporations (Brenner & Broekel, 2011) – while in model 2.11 all variables related to innovation in big and small corporations, together with the financial sector, were represented. Globally connected innovation occurs with the synchronous contribution of all financial and business players in a region.

The role of RIS as a learning region was confirmed by the significance of Life_long variable, representing the percentage of population aged 25-64 following learning programs. But the absence of Terz, the percentage of population with a tertiary degree within those aged 25-64, was another difference with model 1.11. The absence of Terz variable should not be perceived as a limitation to the concept of learning regions; Cooke (1997) defined the learning economy as "*a dynamic concept; it involves the capability to learn and to expand the knowledge base. It refers not only to the importance of the sciences and technology systems – universities, research organisations, in-house R&D departments and so on – but also to the learning implications of the economic structure, the organisational forms and the institutional set-up*". Life_long represented continuous learning opportunities going beyond formal training. This variable relateed to "*all education or training whether or not relevant to the respondent's current or possible future job. It includes initial education, further education, continuing or further training, training within the company, apprenticeship, on-the-job training, seminars, distance learning, evening classes, self-learning etc. It includes also courses followed for general interest and may cover all forms of education and training as language, data processing, management, art/culture, and health/medicine courses*" (European Commission, 2010). From the previous definitions and findings it could be inferred that global co-operative innovation is driven by learning opportunities going beyond formal academic education (represented by Terz variable), mainly driven by private institutions and firms themselves, where public institutions have more an enabling than a formal role.

The contemporaneous significance of Sqr_vc, Biz_RD, PP_inno and Life_long variables could be therefore seen as the pivotal role of private players in driving global co-operation in regional innovation, leaving to public institutions an enabling role. Such enabling role was confirmed by the significance of variable Aut_infr, which indicated the degree of autonomy in infrastructural investments of regional governments. This variable was analysed for model 1.11 in the previous paragraph, and recalling its previously cited definition by Cooke (1997), clearly underlies the role of infrastructures as network enablers.

5.4.2 Country level effects

Four dummy variables related to country level effects were significant in model 2.11. More precisely they referred to the Czech Republic, Denmark, Norway and Hungary. Czech Republic was the only country which resulted to have significant effects in model 1.11 and 2.11; furthermore, these effects were negative in both models. It seemed that Czech regions are suffering from some country level effects that are reducing their overall innovation performances and global co-operative ones: these effects were limited for overall innovation but had a more relevant impact in global co-operative innovation. A Czech region with very same independent and control variables of another region located in elsewhere (excluding Denmark) would have a lower level of internationally co-operative innovation.

Denmark shown the most significant, yet negative, country effect. Still, the implication of this dummy variable needed to be considered carefully: Denmark is a small country that was considered as a one-region country in several regional NUTS 2 statistics.

Norway and Hungary had, vice-versa, positive country effects on global co-operative regional innovation. Any region located in these countries, if having the same independent and control variables' values of another region located elsewhere, would have a higher number of PCT patents filed with foreign partners.

5.5 Coherence of Innovation Policies with RIS theory

The third research question of this research, R3, relates to the effectiveness of innovation policies with respect to RIS theory. The review of Cooke's works in Chapter 2 showed the policy making relevance of the RIS model. A policy review framework was developed in Chapter 3 (see Table 3-9 and Table 3-10) and analysed in Chapter 4 (see Table 4-20, Table 4-21 and Table 4-22). The combination of the findings of Table 4-22 and those related to R1 and R2 give an interesting interpretation of the innovation policy framework developed under the RIS perspective. More precisely Table 4-22 represents the difference between the average application at regional level and the average application at national level of each specific policy measure; it gives an immediate understanding on which policies are more applied at regional level and vice versa. A positive result indicates that regional level application is higher than national one; negative values (in parentheses) show stronger national application than regional one. Under the RIS perspective, the effectiveness of innovation policies would be optimal in case those impacting the key RIS variables discussed in paragraph 5.3 were fully applied at regional level. Table 5-4 shows a qualitative analysis about the impact of innovation policies on key RIS variables: squared cells marked with "x" indicate the presence of a qualitative impact. For example, the policy "tax credit for private R&D" is considered impacting the business R&D variable, as it enhances private R&D investments. At first sight, the table shows how present policies, mapped by OECD (2011a), with lower regional application are those more impacting key RIS variables: consequently the developed framework shows how present innovation policies are poorly effective in the perspectives of the RIS theory and, more precisely, in the perspective of the RIS key variables this research has introduced.

5.6 Conclusions

The analyses of models 1.8 and 1.9 confirmed that RIS potential is strongly connected to one region's ability to generate an innovation output, expressed in the number of PCT patent applications per million inhabitants. RIS potential explains approximately 78% of the variation in regional PCT patent applications. This result represents a relevant empirical confirmation of the RIS theories introduced and analysed through a qualitative approach by Cooke: regions are therefore an important dimension for policy makers in order to design and implement innovation policies.

Table 5-4: Impact of Regional Policies on RIS Key Variables

POLICY	AVG R - AVG N	Business R&D	Terzialization	Lifelong Learning	Infrastr. Autonomy	Prod.& Proc. Innovation	Venture Capital
Incubators for new firms	2.500						
Cluster initiatives (often sectoral and mainly firm-based)	1.429					X	
Science and technology parks	1.071						
Innovation advisory or support services (publicly provided, vouchers, subsidies, student placements)	0.357						
Advisory to spin-off and knowledge-intensive start-up firms	0.000						
Other technology transfer centres and extension programmes	0.000						
Branded excellence poles or hubs (label and multiple actors)	(0.357)						
International trips to develop innovation networks Public procurement policy with innovation focus	(0.714)						
Foreign firms eligible for public innovation-related funds	(1.071)						
Multi-disciplinary technology platforms	(1.429)						
Technology foresight exercises (assessing future needs) Seed funding/projects to start PRCs or HEIs Quality control and metrology services	(1.786)						
Innovation awards	(2.143)						
Targeted human resource training (directly, subsidies)	(2.500)			X			
Guarantees Public subsidies for private R&D Public venture capital funds or stakes in private funds On-going institutional R&D funding in PRCs or HEIs	(3.214)	X				X	X
High-level strategic advisory body Scientific co-operation for HEIs and PRCs	(3.571)						
Competitive R&D funding by PRCs or HEIs Public development banks	(4.286)	X					
Scholarships for post-graduate studies	(6.429)			X			
Tax credits for private R&D	(7.857)	X					

The comparative analysis of models 1.8 and 1.9 also gave an indication that country level effects do contribute to regional innovative performances too; however they are able to give an additional 11% contribution to the explanation of the variation of the number of PCT patents filed in one region per million inhabitants.

Models 2.8 and 2.9 demonstrated that RIS are also contributing to global co-operative innovation. More precisely, model 2.8 showed us that 77% of the variation of PCT filed in a region with foreign partners per million inhabitants is due to RIS potential. Cooke’s theory of RIS represented these specific regional networks as the enablers of innovation through international connections: this is a specificity of a RIS that deeply differentiates this model from other models like industrial districts (Cooke, 1997) and that has been verified by the econometric model developed in this work. Country level effects do have some relevance too, but they are able to explain an additional 7% only of our dependent variable variation.

In other words, models 1.8, 1.9, 2.8 and 2.9 were able to confirm research hypotheses H1 and H2.

The two research questions, R1 and R2, were answered too, and the significant variables related to RIS models were identified and were able to explain the variations of dependent ones. The first analysis was performed using model 1.11, which was related to overall regional innovation performances, expressed by the number of PCT patents filed in a region per million inhabitants. Business R&D expenditures, the learning environment and the autonomy of regional governments in infrastructure investments were the key RIS drivers for generic regional innovation performances. Country level variables emerged in five cases: four with a negative impact (Czech Republic, Slovakia, Poland and Spain) and one with a positive impact (Italy).

Findings on global collaborative innovations were slightly different. Model 2.11 was set up in relation with the number of regional PCT patents with foreign partners per million inhabitants. The role of RIS as a network of various actors with a specific enabling support of public institutions emerged clearly. Variables representing corporate expenditures in R&D, small businesses innovativeness, venture capital and continuous learning outside the standard academic paths are the determinants for global connections in regional innovation. Public institutions play an important role through infrastructure investments, providing the pillars for the setup of the RIS network. Country level variables influence four countries: two positively (Norway and Hungary) and two negatively (Czech Republic and Denmark, although the latter is questionable).

Last, the comparative analysis of i) the key RIS variables introduced by models 1.11 and 2.11 and ii) the innovation policy framework introduced in Chapters 3 and 4 shows a potential lack of efficiency of today's innovation policies: as a matter of fact those with higher impact on RIS key variables are the less applied at regional level.

CHAPTER 6: CONCLUSIONS

Abstract

In this chapter it will be shown how this research contributes to knowledge, more precisely in the regional innovation economy area, with specific reference to innovation networks and their role in global innovation processes. RIS theories, introduced and exploited in Cooke's studies, have been quantitatively confirmed through the present econometric model and the most significant variables of RIS were identified. An analysis on common policy practices for innovation, at national and regional level, in various European countries is introduced and compared with research findings. It will be introduced how this research offers a pivotal turn in policy making approaches at national and regional level. Still, several limitations should be taken into account while reviewing our results, from the variable set to the geographical coverage of the data sample and the use of some specific variables. Last, an overview of new research streams that emerged from our study is offered.

6.1 The aim of this research, research objectives and contribution to knowledge

The aim of this research was to investigate the global dimension in networked innovation processes. More precisely, though its literature review, it was decided to contribute to researches related to RIS. This research began using the same approach of a previous systematic work on networking and innovation (Pittaway et al., 2004) and through a similar approach a research framework was developed (see Appendix B). Through this framework it was identified a new stream of research: understanding how globally co-operative innovation occurs outside of MNCs and, more precisely, the role of RIS in enabling networked innovation in the global arena.

RIS theoretical model was introduced and analysed by Cooke and other scholars in the late 1990s (Cooke, 1997; Cooke, 2001; Cooke et al., 1997; Cooke et al., 1998). RIS have been defined as networks supporting clustered and not clustered in their evolutionary paths of innovation, leveraging local specializations; they support a systematic dimension of learning across all regional actors and represent a foundation of knowledge economies. RIS also overcome the lock in effects visible in industrial clusters and are enablers of global connections in innovation processes. These networks seem to have an important role in co-operative innovation at a global level and they might be considered the pivotal players outside MNCs.

Cooke developed a schematic qualitative RIS model, dividing its variables into infrastructural and superstructural ones (Cooke, 2001). This model is the most cited one in RIS studies and represented a good basis for developing a quantitative one: Cooke referred to regions with lower and higher RIS potential, thus underpinning a sort of continuous variable representing it.

6.1.1 Contribution to existing theory

The overall objective of this research was to provide an econometric model supporting the RIS theory, which has been so far based on qualitative models.

The research objective was deployed into i) two hypotheses to be tested and ii) three research questions to be answered. Hypotheses and research questions were approached building a multiple linear regression model, plus a framework developed specifically for the third research, R3, question focused on policy making. The econometric model was set up to answer to research questions R1 and R2 through literature review for determining each independent, dependent and control variable representing the qualitative variables introduced in Cooke's model. Secondary data have been used from various databases together with primary data related to regional governance autonomy which have been collected via specific surveys. The multiple linear regression model was a suitable one as it can be used for both confirmatory and exploratory means (Hair et al., 1998; Seltman, 2012).

The first hypothesis, H1, was that RIS potential influences regional innovation output. This output was measured through the number of PCT patent applications per million inhabitants for a specific region in a specific year. The present model confirmed this hypothesis and indicated that RIS potential explains 78% of the variation of regional innovation output. This percentage increased up to 86% when considering country level effects, represented by dummy variables. This quantitative finding contributes to RIS theories as it represents the first empirical confirmation of previous qualitative models. Furthermore country level effects were isolated and discovered that regional level variables have a much higher role in driving regional innovation performances than national ones. Still, some 11% of regional PCT patent production variation relies on national level effects. This is an interesting quantitative finding that confirms that NIS policies cannot be fully neglected (Freeman, 1995; Reddy, 1997). Furthermore it supports Cooke's understanding of NIS impact on RIS performances, as they set up scientific priorities and provide long term funding for both basic research and university education (Cooke, Boekholt, & Todtling, 2000).

The second hypothesis confirmed by the developed model, H2, was that RIS potential is linked to the ability of regional players to establish global connections in their innovation processes. For each region, global co-operative innovation output was measured with the number of PCT patents filed with foreign partners per million inhabitants. It was found that 77% of the variation of global co-operative innovation output is explained by RIS potential. As for H1, country level effects give additional 7.5% explanation. This finding represents a quantitative confirmation of RIS theories too: in his analysis of a Massachusetts biotech case study, Cooke (2001) highlighted the objective of RIS to provide the opportunity to enable connections between its members and global players. NIS still might have a role, as we discovered for H1, however their contribution is lower for global co-operative innovation than in the case of general innovation. This might be considered as a further confirmation of studies on NIS, claiming their limited ability to provide, to their members, access to global innovation sources (Lane, 2000).

The population under analysis referred to level 2 NUTS regions as defined by the European Union (2003) and data were collected independently of the presence of clusters or MNCs' subsidiaries: biases related to clusters and MNC's subsidiaries are supposed to be very limited. This reinforces the role of RIS of being a supporting network for "numerous clustered and non-clustered industries" (Cooke, 2005) and able to catalyse innovations across industry or cluster borders (Cooke, 2010). Therefore the verification of hypotheses H1 and H2 by models 1.8, 1.9 and 2.8, 2.9 confirms that RIS model goes beyond the cluster and MNCs subsidiary ones, considered as the enablers of innovation in the global context (Porter, 1998; Singh, 2007).

Two research questions were also addressed. The first one, R1, wanted to understand the RIS determinants of overall regional innovation output. An exploratory linear multiple regression analysis was performed, using regional PCT patents per million inhabitants as a dependent variable. Three main drivers were identified: i) business R&D expenditures, ii) the regional learning environment and iii) regional government's autonomy in infrastructural investments. Business R&D expenditures were introduced as a control variable in the model, but were not explicitly cited in Cooke's RIS theory: however, while benchmarking the US and European RISs, Cookes highlighted that European "*public innovation systems, where they exists, and that is by no means everywhere, are uncompetitive with the private systems operating in the United States*" therefore "*policy should stimulate the growth of strong private* *investing organizations that will have the profit-motive as the incentive to be more proactive than the public system has shown itself to be capable of.*" (Cooke, 2001). The profit driver of private organizations is not limited to private financial sources as venture capital, but might be related to business R&D investments too. This represents a new theoretical finding as it might lead to a revision of Cooke's RIS model (see Table 2-3) which could also include Business R&D expenditures among at infrastructural level.

The presence of learning variables, such as the percentage of population attending continuous learning programs and the percentage of population with tertiary education, is a quantitative confirmation of Cooke's definition of a RIS as a "learning region" (Cooke, 1997) and Porter's studies (Porter, 1990). This work also gives a quantitative confirmation of the role of regional governments as innovation enablers: in effect, RIS theory considers infrastructures as "*the physical makeup of the regional space and make possible the multiple relations that are established between the different agents in a regional economy*" (Cooke, 1997). It is interesting to note that the variable specifically connected to research infrastructure was not significant: this can be interpreted as the confirmation of the role of regional governments as enablers more than active players directly involved in research and innovation processes. Last, we got further confirmation of country level effects: we discovered that Poland, Czech Republic, Slovakia and Spain have a negative effect in innovative performances of their regions, while Italian regions enjoy a sort of "premium" performance with respect to regions belonging to other countries with same RIS potential.

The second research question answered, R2, was related to understanding the determinants of globally co-operative innovation output of a region. As for R1 an exploratory linear multiple correlation model was used; the dependent variable was the number of PCT patents filed with foreign partners per million inhabitants. It has been found that the private sector is the main driver of global co-operative innovation. Four variables represent it: i) business R&D expenditures, ii) SME innovative orientation, iii) regional private finance (venture capital), and iv) learning in private institutions (lifelong learning). This finding gives further contribution to RIS theories: globally networking innovation occurs when the private sector is directly engaged in research and innovation – even in small firms –, in learning and in finance for innovation; it confirms that RIS are networks linking various regional players with foreign partners in order to pursue innovation. The centrality of the private sector in driving innovation performances at regional level emerges if we consider both the findings of the analyses on models 1.11 and 2.11 and the answers to research questions R1 and R2. As we previously discussed for R1, Cooke suggested that the causes for the gap in innovation performances between US and European regions rely on the profit-driven approach of the firsts and on the public based one of the latters. This is another relevant contribution to theory, as a new, stronger role of private institutions, industrial, educational and financial, in regions could be highlighted in the qualitative RIS model.

Furthermore, like the R1 case, public institutions, more precisely regional government, act as networking enablers through their ability to autonomously invest in infrastructures: a finding confirmed by the significance of the variable related to the degree of regional autonomy in infrastructural investments. Country level effects have been also confirmed in four cases: Czech Republic and Denmark have a negative effect, while regions in Norway or Hungary enjoy a positive country level influence.

6.1.2 Contribution to future theories on RIS

This research confirms, through a quantitative model, present RIS theories, introduced qualitatively. Furthermore it opens new potential streams of theory building research focused in understanding the key determinants of RIS, which might have a relevant impact to policy makers, as discussed in the following paragraph. Cooke's theory describes RIS as complex systems where several variables provide an interlocked contribution to increase the RIS potential. Still, understanding which variables are most influencing the development of a RIS would represent an enhancement of existing theory on these specific networks. The setup of a quantitative model enabled to answer research questions R1 and R2 which represent the first attempt to select the most influential variables of RIS. More precisely R2, which refers to global cooperative innovation, introduced a relevant role of private players, in parallel to the catalyst one of regional public administration. This finding represents a significant novelty in RIS theory and should be further exploited in future quantitative researches related to RIS, taking into consideration the limitations of the present work (see paragraph 6.3) which nevertheless represents the first attempt in this direction.

Furthermore the identification of country-level effects in the present quantitative model means that there are also exogenous variables to RIS which effect the potential of these regional networks. Under a broader perspective, setting up and widening the model introduced in this research (through additional variables and data) would enable a deeper understanding of RIS, introducing cultural, geographical and other variables not yet fully deployed in the qualitative theory of RIS.

Last, the presence of clusters and MNCs subsidiaries in regions, and their contribution to regional innovation performances in the global arena might be better investigated. Literature review indicated that both clusters and MNCs subsidiaries can support regional innovation, however the dataset built for this research was built independently of these variables. Combining cluster and MNCs' subsidiaries related variables might increase the power of the models developed in this work, as it occurred for country level dummy variables.

6.1.3 Contribution to RIS research methodologies

Chapters 2 and 3 highlighted how RIS theory was modelled on Cooke's theories, which have been built through case studies. Qualitative studies were performed for theory confirmation too. Quantitative studies resulted to be less common in RIS: Fritsch (2001, 2002, 2008, 2010) was among the most active author using quantitative methods aimed at analysing RIS models in terms of quality and efficiency. Factor analysis was selected by Evangelista et al. (2002) and by Buesa et al (2006) in order to identify various typologies of RIS. The present works contributes to RIS research methodologies as it developed a quantitative model which proved to be suitable for to purposes: i) confirmation of RIS theories and ii) identification of key RIS variables. The linear regression model developed gave good results both for confirmatory and exploratory purposes. Furthermore, the results of the exploratory models 1.11 and 2.11 highlighted potential novelties for the improvement of the qualitative RIS models setup by Cooke in his theory building works.

6.2 Relevance for policy makers

Innovation is among the most important topics policy makers are now considering. Using OECD (2009) words: "*Governments also need to focus on medium to long-term actions to strengthen innovation. A broad range of policy reforms will be needed in OECD countries and non-OECD economies to respond to the changing nature of the innovation process and strengthen innovation performance to foster sustainable growth and address key global challenges. This involves, amongst others, fostering* *innovation in all its forms and broadening the focus of innovation policies beyond support for R&D.*" OECD (2011a) also noticed that a new paradigm in innovation policies is required as "*globalisation and agglomeration trends represent a challenge for public policy, exacerbating some of the classical tensions and trade-offs that policy makers have traditionally dealt with.*" More specifically OECD suggested that regional and national policies should i) go beyond "localism" and refer to global challenges, ii) consider the fragmentation of global supply chain which requires stronger international cooperation in R&D, iii) act against the "drain brain" flows from Europe's less-favoured regions and iv) deal with the present financial and economic crisis and the problems associated with globalisation and spatial knowledge agglomeration.

The findings of this research highlighted that present innovation policies are not effective in supporting the key RIS variables which emerged from the answers to research questions R1 and R2. More precisely, there is a gap in terms of level of application of some policies: those more impacting RIS variables are actually the less applied at regional level. Based on this analysis, it might be inferred that our research represents a pivotal turn in policy making strategies. The results of this research showed that business R&D, learning and private finance are driving variables of RIS, supported by a catalyst role of regional governments through infrastructural investments; it was also highlighted that national level effects have a limited impact in explaining regional innovation (from 7%, when considering global cooperative innovation, to 11%, when considering overall regional innovation).

This work therefore suggests that policies supporting private R&D, learning and venture capital have a significant influence in RIS potential and should be considered by regional policy makers more than national ones.

As a matter of fact, present regional policies seem to be more "soft" policies aimed at providing consulting services and networking opportunities: incubators and science park policies are the only "hard", infrastructural regional policies currently applied; it seems that infrastructures (in an holistic term) are missing from present innovation regional policies.

Could be that general infrastructural investments were not considered by innovation-related policies by OECD in its study; still this indicates that among policy makers, the role of general infrastructure as a catalyst for innovation is not fully understood, while, together with the support to private investments, it should be considered as one of the key enablers at regional level.

6.3 Limitations of the research

Some limitations should be considered through our research process, model and data analysis.

First, the independent variables identified might not be exhaustive in representing Cooke's RIS model. Table 6-1 represents which qualitative variable of Cooke's RIS model is expressed by a quantitative one, among the dependent variables used in this research. The reasons for having referred to secondary data and not fully cover all Cooke's variables through a specific survey were discussed in Paragraph 3.4. As a consequence, the superstructural level of RIS might not be fully represented by the present quantitative model. More specifically, none of the policy organizational dimension variables have been represented: still, these variables are very sensible and could be measured only referring to people's perceptions, which might introduce bias in any survey based data collection.

The second limitation related to data availability, under several perspectives. In building the present model 104 dataset were collected, which should be balanced against 9 independent and control variables. The ratio between the number of observations and the number of independent and control variables is important in order to measure the reliability of the model: it has been previously shown in paragraph 4.4.3 how the present dataset has a ratio of 11.5, thus meeting the 5:1 and 10:1 ratio (Howitt & Cramer, 2011) but did not met the 20:1 and the Tabachnick and Fidell (2007) condition (which gives a 122 minimum number of observations).

Table 6-1: Qualitative and Quantitative Variables in RIS model

LOW RIS POTENTIAL	HIGH RIS POTENTIAL	Model Variable *(present research)*
Infrastructural level		
Autonomous Taxing and Spending	Decentralised Spending	Tax_Sp
Regional Private Finance	National Financial Organization	Sqr_VC
Policy Influence on Infrastructure	Limited Influence on Infrastructure	Aut_Infr
Regional University-Industry Strategy	Piecemeal Innovation Projects	
Superstructural level		
Institutional Dimension		
Co-operative Culture	Competitive Culture	SME_Coll
Interactive Learning	Individualistic	Life_Long
Associative-consensus	Institutional Consensus	
Organizational Dimension (Firms)		
Harmonious Labour Relations	Antagonistic Labour Relations	
Worker Mentoring	Self-acquired skills	
Externalization	Internalization	Ext
Interactive Innovation	Stand Alone R&D	SME_Coll
Organizational Dimension (Policy)		
Inclusive	Exclusive	
Monitoring	Reacting	
Consultative	Authoritative	
Networking	Hierarchical	

Third, there is a limitation in the time horizon of the model too. Latest data collection was performed in different years for different variables and regions, as reported by the European Commission (2010). The survey used for this study, about regional autonomy, was deployed in 2010 and data collection about venture capital started in

2009. This lack of homogeneity in time of data might have influenced our findings, especially in times of high economic and financial instability as those occurring after 2007.

Fourth, geographical range of our dataset is also limited. The available 104 observations relate to regions in 13 European countries: extension of findings to other world's regions, North and South America, Russia, Middle and Far East, Africa, needs to be proven. Furthermore some leading European countries, like Germany, Switzerland and Sweden, were not included in the model, due to lack of data, and their absence might have influenced overall findings.

Fifth, the use of patent related metrics as a measure of innovation performances might be a limited approach too. The concept of innovation is itself diversified: the UK Department of Trade and Industry (DTI) refers to innovation as "the successful exploitation of new ideas" (Pittaway et al., 2004), which is a broader definition than patent production itself. Patenting is also a significant investment which SME are not always able to cover, which means that they still introduce innovation into the market even if their patent production is much lower than MNC (Brenner & Broekel, 2011). As mentioned in Chapter 3, there are three main limitations in the use of patents as measure of innovation output: i) patents refer to inventions not always to innovations, ii) several innovations are not patented or patentable and iii) patent appropriate localization might be questionable for patents filed by multinational corporations as sometimes ownership refers headquarters location and not to the R&D facility that drove the invention. On top of this, the aggregation of patent production at regional level and the identification of overall regional innovation performances need to be carefully performed and might need to use relative innovation performances, setting up a regional benchmark, rather than using absolute values (Broekel & Brenner, 2007). Furthermore, not all patens are equal. World Intellectual Property Organisation has divided patents into various families, based on their originating application (IPC Union, 2004). More precisely WIPO divides patent families into i) artificial, ii) complex, iii) domestic, iv) extended, v) national and vi) simple; the concept behind this division is the strength and commonality of the originating applications. For example a simple patent family has exactly the same originating application while a complex patent family has at least one common originating application: this lead to a significantly different degree of protection between patent families, therefore a different impact of an innovation in the market. This research has not considered the differences between patent families but used data related to PCT patent applications only: the real impact of innovations produced by each region might not be considered.

Sixth, it should be also highlighted a specific limitation of the venture capital related independent variable. As mentioned in Chapter 3, venture capital variable was setup considering the ratio between venture capitalist assets under management (fund sizes in local currencies) and regional GDP (in local currencies). The use of this ratio first does not indicate how much of the available capital was invested and, moreover, how much was divested (which represents the real performance of a venture capital fund); it represents the availability of capital for venture operations. While availability of capital is reasonable under the perspective of defining regional private finance in the RIS model, still invested capital better indicates how much private finance was used to support innovation. A region with poor capital usage might indicate that it was not able to offer a reasonable quantity and/or quality of deals, thus showing limited technology transfer abilities. Furthermore, it was noticed that venture capital fund are located in the premises of economic or political capitals of each country and operate at national or international level: few funds have a regional perspective. This means that we were not able to precisely track the capitals invested in each region by venture capitalists and therefore could have not precisely measured RIS potential in some of them. Still, the analysis performed on the Italian case in paragraph 3.4.1.5 showed a good and significant correlation between the availability of venture capital funds in a specific region and the amount of venture capital operations in the same region.

Last, the influence of country level effects in regional performances through dummy variables was tracked. It was found that national effects are responsible for a limited, yet not fully neglectable. However these generic variables do not say anything about the key national economic determinants impacting regional innovation performances, which might be in theory very different country by country.

6.4 Areas of future research

The present study contributed to bring additional knowledge in RIS researches as provides the first econometric model describing RIS theory implemented by Cooke. Thanks to its findings it is now possible to offer a new perspective for policy makers willing to support innovation performances at regional level, in order to compete in the global markets. This work opens new opportunities for further researches too.

First of all, while this work confirmed Cooke's RIS qualitative theories through a quantitative model, it would be important to perform new studies aimed at extending the number of quantitative variables for better covering the superstructural dimension of RIS, and in particular the policy organizational dimension. Once new variables would be added, and the overall RIS model quantitatively confirmed, we would achieve a more exhaustive result in proofing RIS theory.

Second, the extension of this study under a geographical perspective would help in answering new questions and overcome some limitations of present research. It would increase the number of observations and overall reliability of the present econometric model. Moreover it would help to identify if our results are common across all continents and economies: are, on example, RIS determinants the same for developed or underdeveloped countries? This question could be crucial for policy makers willing to boost economic development through innovation. The geographical extension will also enable to verify if economic grow rate is linked to regional innovation performances, provided that growth is very different across the world.

Third, the role of national level variables in regional performances remains untapped. Why are some countries negatively or positively impacting the performances of their regions? In the present study it was discovered the presence of country level influence, but it was not possible to understand which variables, at national level, were impacting regional performances; nor it could have been verified if these variables were related to NIS and were the same all over the countries. A multilevel study, introducing national and regional variables, to be performed through a large number of countries could be appropriate to address these questions.

Fourth, this study showed that there is a correlation between dependent and independent variables, while it missed to identify the cause-effect link. This would be an important question to be answered as it would give additional strength to new policies. On example, it was verified that business R&D is one of the most important variables driving regional innovation and global cooperative innovation: but regional innovation measured by patents could be based, extremely, on university driven patents only. It would therefore be needed to understand if the presence of high business R&D budgets in a region occurs because local universities are attracting R&D investments from local companies or because patent production even in universities happens only when regional companies decide to heavily invest in R&D.

The role of MNC in a region would be another interesting research stream. The literature review of this research clearly represented how MNC operate, even at local level, in order to enhance their innovation performances; it was also seen what the drivers are for a MNC to choose an appropriate location for an R&D subsidiary and how positive is the influence, in a cluster, of MNC subsidiaries in enhancing local economic and innovation performances. This study did not measure the presence of MNC in a region as a potential independent variable explaining regional innovation performances and global cooperative innovation in a region. Moreover, under this perspective, it could be also investigated if the presence of high RIS potential is positively correlated to the location of MNC subsidiaries as it would represent a driver in MNC localisation strategies. Further studies in this direction will provide significant new knowledge to this research and new opportunities to policy makers.

Last, a refinement in modelling venture capital operations would reinforce the understanding on the role of this variable. In particular a new model, considering regional venture investments and not just fund sizes, would be able to better explain if this specific financial instrument, which often considered a key tool by policy makers, is really a driver in regional innovation.

6.5 Summary of this study

This research aimed at confirming and understanding the role of RIS as key players in the global innovation context. More precisely an econometric model describing the RIS theory exploited by Cooke's studies was developed. This model analysed 104 European regions and their performances in terms of total patent production and cooperative patent production with international players.

The model first confirmed that RIS potential is correlated with regional innovation performances and regional global cooperative innovation performances. Regional variables account for nearly 78% of regional innovation output, while there are still some national level effects that are accountable for 7 to 11% of our output.

This research also identified the specific RIS variables driving i) overall regional innovation and ii) global cooperative one. In the first case it was found that business R&D budgets and the learning environment of a region are fundamental drivers, together with the ability of regional governments to autonomously define and execute infrastructural investments. In the second case evidence raised of an even greater role of the private sector, not only in terms of R&D expenditures and learning, but also in terms of financial investments in high tech, fast growing companies through venture capital; still the role of regional governments in infrastructural investments remains crucial.

A new approach to innovation policies, more precisely the balance between national and regional level ones, was suggested through the findings of this research.

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APPENDIX A : SYSTEMATIC LITERATURE REVIEW

A.1 Keywords synonyms

Innovation	Innovation, research and development, new product development
Networking	Networking, industrial clusters, industrial districts, value chain, embeddedness, proximity
Globalisation	Globalisation, internationalisation, trade, multinational

A.2 Search Strings

Web of Science	(innovat* OR (research SAME development) OR (new SAME product SAME development)) AND (network* OR (industr* SAME cluster*) OR (industr* SAME district*) OR (value SAME chain) OR embedded* OR (industr* SAME geographic* SAME proximity)) AND ((global* SAME ((supply SAME chain) OR market* OR econom* OR industry* OR competit* OR societ* OR network*)) OR internationali?ation OR (international* SAME trade) OR multinational*) NOT (innovative OR (information SAME technolog*) OR (information SAME system*) OR (wireless SAME network*) OR p2p OR (transport* SAME network*) OR (neural SAME networks) OR internet OR urban OR umts OR gsm OR gps OR (sequence SAME alignment))
Science Direct and ProQuest	(innovat* OR (research W/3 development) OR (new W/3 product W/3 development)) AND (network* OR (industr* W/3 cluster*) OR (industr* W/3 district*) OR (value W/3 chain) OR embedded* OR (industr* W/3 geographic* W/3 proximity)) AND ((global* W/3 ((supply W/3 chain) OR market* OR econom* OR industry* OR competit* OR societ* OR network*)) OR internationali?ation OR (international* W/3 trade) OR multinational*) AND NOT (innovative OR (information W/3 technolog*) OR (information W/3 system*) OR (wireless W/3 network*) OR p2p OR (transport* W/3 network*) OR (neural W/3 networks) OR internet OR urban OR umts OR gsm OR gps OR (sequence W/3 alignment))

A.3 Short listed journals

Journal	% citations	% paper
Academy of Management Journal	4,9%	0,7%
Cambridge Journal of Economics	7,1%	1,0%
Economic Geography	8,3%	2,0%
Entrepreneurship and Regional Developm	0,6%	1,6%
Environment and Planning A	4,4%	4,3%
European Planning Studies	0,8%	3,3%
Harvard Business Review	6,3%	2,3%
International Journal of Technology Mana	0,5%	4,6%
International Journal of Urban and Region	1,6%	1,6%
Journal of Economic Geography	0,2%	1,6%
Journal of Institutional and Theoretical Ec	1,8%	0,3%
Journal of International Business Studies	1,8%	2,3%
Organization Science	5,0%	2,0%
Organization Studies	1,4%	1,3%
R & D Management	1,6%	2,6%
Regional Studies	7,1%	1,6%
Research Policy	9,6%	7,2%
Review of International Political Economy	2,6%	1,0%
Strategic Management Journal	10,4%	4,9%
Technology Analysis & Strategic Manager	1,1%	3,0%
Technovation	0,3%	2,3%
Total	**77,3%**	**51,5%**

A.4 test search strings for bibliography check

Base search string

TS=((Innovat* AND network* AND (incuba*? OR cluster*)) NOT ((information SAME technology) OR (information SAME systems) OR (neural SAME networks) OR Internet))

Modified search string with globalisation variable

TS=((Innovat* AND network* AND (incuba*? OR cluster*) AND global*) NOT ((information SAME technology) OR (information SAME systems) OR (neural SAME networks) OR Internet))

APPENDIX B : VENTURE CAPITAL

B.1 Interviewed Venture Capital Funds

FUND NAME	LOCATIONS	INVESTMENT AREA
TTVenture	Milan (IT)	Italy
Innogest	Turin, Milan (IT)	Italy
360 Capital Partners	Paris (FR), Milan (IT)	Europe, Israel
Atlante Ventures	Milan (IT)	Italy
Sofimac Partners	Lyon, Paris, Clermont Ferrand (FR)	France, Switzerland, North Italy, Denmark, UK
Axon Capital	Madrid (ES)	Spain
Terraventure	Jerusalem (ISR)	Israel
Sofinnova	Paris (FR)	Europe
Index Ventures	Zurich (CH), London (UK)	Europe
Connect Ventures	London (UK), Milan (IT)	Europe
Earlybird	Hamburg, Berlin, Munich (DE), Milan (IT)	Europe
Basf Venture	Ludwigshafen (DE), Fremont – CA (US), Hong Kong, Tokyo (JP)	Worldwide

B.2 Cases of Regional Venture Funds in Italy

FRIULI VENEZIA GIULIA		
FUND	**UNIVERSITIES**	**TECH PARKS, R&D CENTRES**
Aladinn (managed by Friulia SGR)	• University of Trieste • University of Udine • SISSA • MIB	• Area Science Park • Polo Pordenone • Friuli Innovazione • Agemont • CBM • Ditenave
Aladinn fund has been subscribed by the regional holding company (Friulia), local bank foundations and local banks. It has 28.6M Eu of capitalisation. Invests in lifesciences, cleantechs, nanotechs, ICT and industrial components.		
Sources: www.regione.fvg.it www.friuliasgr.it/it/aladinn_ventures/il_fondo.aspx http://www.businessfvg.it		

EMILIA ROMAGNA		
FUND	**UNIVERSITIES**	**TECH PARKS, R&D CENTRES**
Ingenium (managed by Meta Group)	• University of Bologna • University of Modena e Reggio • University of Ferrara • University of Parma • Catholic University in Piacenza	• National Research Council Area, Bologna • Democenter • Aerospace Park in Forlì • Almacube • Cermet • Citimap • CRIT • Nr. 10 Technopoles
Ingenium fund has 14M Eu capitalisation from European POR FESR funds. It is a “matching fund” as it invests only in partnership with private investors. It covers all high tech, industrial companies.		
Sources: www.zernikemetaventures.it/fondi/IngeniumIIER/Pagine/default.aspx www.investinemiliaromagna.it/ www.reteaster.it www.regione.emilia-romagna.it		

<table>
<tr><th colspan="3">TUSCANY</th></tr>
<tr><th>FUND</th><th>UNIVERSITIES</th><th>TECH PARKS, R&D CENTRES</th></tr>
<tr><td>Toscana Innovazione (managed by SICI SGR)</td><td>• University of Pisa
• University of Siena
• University of Florence
• Scuola Normale Pisa
• Scuola S.S.Anna
• IMT
• European University Institute

Campuses of foreign universities
• Syracuse Un. (USA)
• New York Un. (USA)
• Harvard (USA)
• Un. of Michigan (USA)
• Monash Un. (AUS)</td><td>• Pontech
• Florence University Incubator
• Florence Incubator
• Toscana Life Science
• LENS
• CERM
• National Research Council Area, Florence and Pisa
• Polo Tecnologico Navacchio
• Polo Tecnologico Lucchese</td></tr>
<tr><td colspan="3">Toscana Innovazione has 44.4M Eu of capitals, from the regional government and regional bank foundations. It invests in high tech startups of any technological sector.</td></tr>
<tr><td colspan="3">Sources:
www.fondisici.it
www.regione.toscana.it
www.investinstuscany.com
www.incubatoritoscani.it</td></tr>
</table>

B.3 TTVenture Portfolio Companies

COMPANY (Sector)	LOCATION	SUBSIDIARIES	INT.L PARTNERSHIPS, EXPORT
Bluegreen (pharmaceutical)	Milan (IT)	-	• University of Southampton Medical School • Rikshospitalet University Hospital, University of Oslo • France (undisclosed partner)
Directa + (nanotechnologies)	Como (IT)	Cleveland (US) Ulm (DE)	• ZSW (DE) • Singapore
Personal Factory (building materials)	Simbario (IT)	-	• Brazil • Russia • Egypt • Tunisia
M31 (ICT, optics)	Padua (IT)	Santa Clara (US)	• USA
IpadLab (agro-diagnostics)	Lodi (IT)	Montpellier (FR)	• Japan • France • Tunisia • Georgia • Cile
Glomeria (med tech)	Pescara (IT)	-	• USA (undisclosed partner) • Mexico (undisclosed partner) • Romania (undisclosed partner)
Bionsil (human diagnostics)	Milan (IT)	-	-
BioUniverSa (human diagnostics)	Salerno (IT)	-	• USA (undisclosed partner) • UK (undisclosed partner)
PilegrowthTech (nanotechnologies)	Como (IT)	-	• ETH, Zurich (CH)
Fluidotecnica S.S. (clean technologies)	Bari (IT)	-	• Nigeria • Cote D'Ivoire
D-Orbit (space)	Milan (IT)	• Florence (IT) • Simi Valley (USA) • Lisbon (PT)	• USA (undisclosed partner) • Munich (Ger – undisclosed partner) • NASA • ESA

Notes:
Source: interviews with fund managers and companies' CEOs
Several information on partners are strictly confidential as by contractual agreements.

APPENDIX C : SUMMARY OF EUROPEAN INNOVATION POLICIES

POLICY TYPE	AUSTRIA		BELGIUM		CZECH REP		DENMARK		FINLAND		FRANCE		GERMANY	
	N	R	N	R	N	R	N	R	N	R	N	R	N	R
Human capital investment														
Scholarships for post-graduate studies	X		X	X	X		X		X		X	S	X	X
Targeted human resource training (directly, subsidies)	X	X		X	X	X	X	X			X	S	X	X
Strategy and foresight														
High-level strategic advisory body	X	X	X	X	X	X	X		X		X	X	X	S
Technology foresight exercises (assessing future needs)	X	X	X	X	X	X	X		X	X	X		X	S
R&D investment (including large infrastructure)														
On-going institutional R&D funding in PRCs or HEIs	X	X		X	X	X	X		X		X		X	X
Seed funding/projects to start PRCs or HEIs	X	X		X	X	X	X			X	X		X	X
Competitive R&D funding by PRCs or HEIs	X	S	X	X	X	X	X		X		X	X	X	X
Public subsidies for private R&D	X	S		X	X				X	X	X		X	X
Tax credits for private R&D	X	X	X		X				X		X			
Technology transfer and innovation services to firms														
Quality control and metrology services	X	X		X	X		X		X				X	X
Innovation advisory or support services (publicly provided, vouchers, subsidies, student placements)	X	X		X	X	X	X	X		X	X	X	X	X
Advisory to spin-off and knowledge-intensive start-up firms	X	X		X	X	X	X			X	X	X	X	X
Other technology transfer centres and extension programmes	X	X		X	X	X	X	S			X	X	X	X
Innovation collaboration														
Cluster initiatives (often sectoral and mainly firm-based)	X	X		X	X	X	X	X	X	X	X	X	X	X
Branded excellence poles or hubs (label and multiple actors)	X	X		X	X	S	X	X	X	X	X	S	X	X
Multi-disciplinary technology platforms	X	X		X			X	S			X	S	X	S
Science and technology parks	X	X		X	X	X	X					S		X
Incubators for new firms	X	X		X		X	X	S	X	X			X	X
Financing for innovative firms														
Public development banks	X	S		X	X						X		X	S
Public venture capital funds or stakes in private funds	X	S		X	X		X	S	X	S	X	S	X	X
Guarantees	X	S		X	X				X	X			X	S
International collaboration														
Scientific co-operation for HEIs and PRCs	X	X	X	X	X	X	X		X	X	X	S	X	X
Foreign firms eligible for public innovation-related funds	X	X			X	X			X	X	X	X		X
International trips to develop innovation networks	X	X		X	X	X	X	X			X	S	X	X
Other programmes														
Public procurement policy with innovation focus	X	X		X			X	X	X	X			X	X
Innovation awards	X	X		X			X				X	S	X	X

Legend: X = Full application; S = Partial application

POLICY TYPE	HUNGARY		ITALY		NORWAY		POLAND		PORTUGAL		SPAIN		UK	
	N	R	N	R	N	R	N	R	N	R	N	R	N	R
Human capital investment														
Scholarships for post-graduate studies	X		X	S	X	X	X		X		X	X	X	
Targeted human resource training (directly, subsidies)	X		X	X	X	X	X	X	X		X		X	
Strategy and foresight														
High-level strategic advisory body	X			S			X	X	X		X		X	X
Technology foresight exercises (assessing future needs)	X			S	X	X	X	S				X	X	X
R&D investment (including large infrastructure)														
On-going institutional R&D funding in PRCs or HEIs	X		X	S	X	X	X	S	X	S	X	X	X	X
Seed funding/projects to start PRCs or HEIs	X		X	S	X		X	X	X	S		X	X	S
Competitive R&D funding by PRCs or HEIs	X		X	S	X	X	X	X	X		X	X	X	
Public subsidies for private R&D	X		X	X	X		X	X	X	X	X	X	X	
Tax credits for private R&D	X		X		X		X		X		X		X	
Technology transfer and innovation services to firms														
Quality control and metrology services	X			S			X	X		X	X		X	X
Innovation advisory or support services (publicly provided, vouchers, subsidies, student placements)	X		X	X	X	X	X	X	X	S	X	X	X	X
Advisory to spin-off and knowledge-intensive start-up firms	X		X	S	X	X	X	X	X	S	X	X		X
Other technology transfer centres and extension programmes	X		X	S	X	S	X	X	X	S		X		X
Innovation collaboration														
Cluster initiatives (often sectoral and mainly firm-based)	X	X	X	X	X	X	X	X	X	X		X	X	X
Branded excellence poles or hubs (label and multiple actors)	X		X	S	X	X	X	X	X	X		X	X	X
Multi-disciplinary technology platforms	X		X	S	X	X	X	X	X	X	X	X	X	X
Science and technology parks	X			X	X	X	X	X	X	X	X	X	X	X
Incubators for new firms	X	X		X	X	X	X	X	X	X	X	X		X
Financing for innovative firms														
Public development banks			X	S	X		X		X		X	S		
Public venture capital funds or stakes in private funds	X		X	S	X	X	X	X	X			S	X	S
Guarantees	X		X	X	X		X	X	X	X	X	S	X	
International collaboration														
Scientific co-operation for HEIs and PRCs	X		X	S	X	X	X	X	X		X		X	X
Foreign firms eligible for public innovation-related funds	X		X	S			X	X	X					
International trips to develop innovation networks	X		X	X	X	X		S	X			S	X	S
Other programmes														
Public procurement policy with innovation focus	X			S	X	X	X	X	X				X	S
Innovation awards			X	S	X	X	X	S	X		X	X	X	S

Legend: X = Full application; S = Partial application