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“Analysis and measurement of interactions in European Innovation Systems: A sectoral approach.”

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Abstract

Innovation Systems constitute an analysis framework, which allows comprehending the socio-economic structure of a territory. It consists of analyzing the existence of actors such as government institutions, clusters, universities, industries… their main competences, and the interactions into Innovation Networks among them. Thus, authorities (regional, national, local…) are endowed of a tool that allows the creation and development of competitive and efficient Innovation Systems.

In this context, and due to the importance of interactions inside Innovation Systems, the present research intends to contribute a methodology which helps us to analyze and measure these interactions produced within Innovation Networks.

The methodology developed will be tested in a sector which is present in several European Territories. This way, not only the measures defined but also the differences among the Networks analyzed will be observed and tested.

Keywords:

Innovation Systems, Interactions, Innovation Networks, Measures.

1.- Introduction

Innovation Systems (Freeman, 1987; Lundvall ed, 1992; Nelson ed., 1993; Edquist ed., 1997; Autio et al., 2004) constitute an analysis framework which tries to identify the existence of agents (institutions, clusters, universities, industries…), their main competences and features, and the interactions produced among them within Innovation Networks, endowing authorities of a tool for the definition of Innovation Policies to support the competitiveness of their territories. One of its bases constitutes the interactive learning theory (Lundvall ed., 1992), which is centred on the relations among the several agents that constitute an Innovation System.

In this context, co-operation or interaction related practices become crucial. Nevertheless, the literature related to this topic is quite scarce, especially when offering measures related to interactive behaviour. This fact is the one that motivates this research, whose main objective consists of developing a methodology that allows the measurement of interactions among the agents that constitute an Innovation System. Thus, as a consequence of the research, some new measures related to interactions are expected to be offered, so that they will be helpful for a better understanding of Innovation Systems.

Some of the first approaches that show the relations and flows among the agents within an Innovation System, are the works done by Scherer, (1982), Pavitt (1984), Archibugi (1988), DeBresson (ed., 1996) and Galli and Teubal (1997). In this area, one of the most relevant works has been the one by Andersen (1992, 1996), who incipiently makes use of the "graph theory" and the development of simulation models in the Innovation Systems framework (Andersen and Lundvall, 1997).

Recently, it is possible to find some research projects which study the relations produced within an Innovation System (European Planning Studies, Vol. 8, Not. 4, 2000). Besides, some simulation models have also been developed, trying to measure and identify the main features Innovation Systems have in different environments (Simulating Self-Organizing Innovation Networks" -SEIN-) (see chapter 2.2)

There is a growing need to create measures that allow predicting changes in the Innovative Capacity (see chapter 4), beyond the ones used in the linear model (Smith, 1995). Likewise, some other needs have also been identified when trying to measure processes related to institutional relations and the creation of networks, in order to evaluate the applied Innovation Policies (Saviotti, 1997; Archibugi, Howells and Michie, eds., 1999; Zenker, 2001; Landabaso, Oughton and Morgan, 2001). This fact is revealed by the multiple policies that are been developed, such as the RIS, RTP, RITTS, etc., trying to support the establishment of innovative attitudes and values.

As the literature agrees a lack of measures in these systemic features as interactions are considered to be, and in order to comprehend and study more deeply the way interactions are produced, the way they evolve, and the main factors that explain their behaviour, this research will try to offer a new alternative perspective by means of a methodology and some measures.

In the second chapter of the paper, a revision of the state of the art is done, which not only describes the Innovation System framework from a theoretical point of view, but also the literature related to Innovation Networks, and some empirical works done in that field.

In the third chapter, the main objectives of the thesis are defined, as well as the main hypothesis and research questions formulated.

In the fourth chapter, I will explain an analysis made recently which tries to illustrate with real data the need to undertake the study of interactions within Innovation Systems. In the study, the Spanish Innovation System is analyzed using multiple indicators, showing the crucial role that interactions play in the generation of innovations and wealth.

In the fifth chapter, it will be shown the methodology used to define the sector that will be analyzed along the thesis, to conclude in the next chapter exposing the future steps to be undertaken all along the thesis.

Finally, some conclusions of the work done up to date are shown as well as the main results expected to be obtained with the research.

2.- State of the art

The Innovation Systems framework (Freeman, 1987; Lundvall ed., 1992; Nelson, 1993; Freeman, 1995; Edquist ed., 1997) is mainly based on the interactive learning theory (Lundvall ed., 1992), which makes special emphasis on the existing relations among the several agents that produce innovations. This approach, tries to analyze the existence of agents in a given territory (nation or state, region, etc.) such as government institutions, clusters, universities, industries, etc., their main competences and the interactions produced among them within Innovation Networks, endowing authorities (national, regional or local) of a tool that facilitates the definition and application of more efficient Innovation Policies.

Alongside this chapter, the evolution of the Innovation Systems approach will be shown, offering both knowledge and definitions that facilitate its comprehension, and justifying the need to undertake a further research trying to analyze and measure interactions in Innovation Networks.

Introducing to this general framework, three main research areas can be differed in the development of Innovation Systems (Balzat and Hanusch, 2003):

- Studies based on Innovation Policies, making a benchmark analysis of several Innovation Systems' features;
- Studies that try to offer a new theoretical approach to the Innovation Systems framework using descriptive and analytic models;
- Studies regarding National/Regional Innovation Systems in given country/region.

However, there is a huge area to be undertaken within Innovation Systems. This way, at least it is possible to mention three research areas (Balzat and Hanusch, 2003):

- It is required a more explicit combination between the National Innovation Systems concept and the economic growth.
- The relation between the Innovation System in a given country and the rest of sub-systems around (job market, finance systems, etc.) is far away from being analyzed exhaustively. This limitation is still more relevant as Innovation Systems are considered to be open systems, depending among others, on the relation with many other economic sub-systems.

- Finally, it has to be mentioned the still limited available knowledge about the dynamic properties of Innovation Systems, especially concerning their stability and structural evolution. At this point is where the development of simulation models is considered to be relevant.

Along this chapter it will be seen how the objectives related to the thesis, are strongly related to the later research areas.

In this chapter, at first, the main features of Innovation Systems will be shown in a conceptual approach to this framework. This way it will be possible to see the relevance the literature gives to interactions. In second terms, some of the main works related to the Innovation Network analysis will be shown in a more empirical approach.

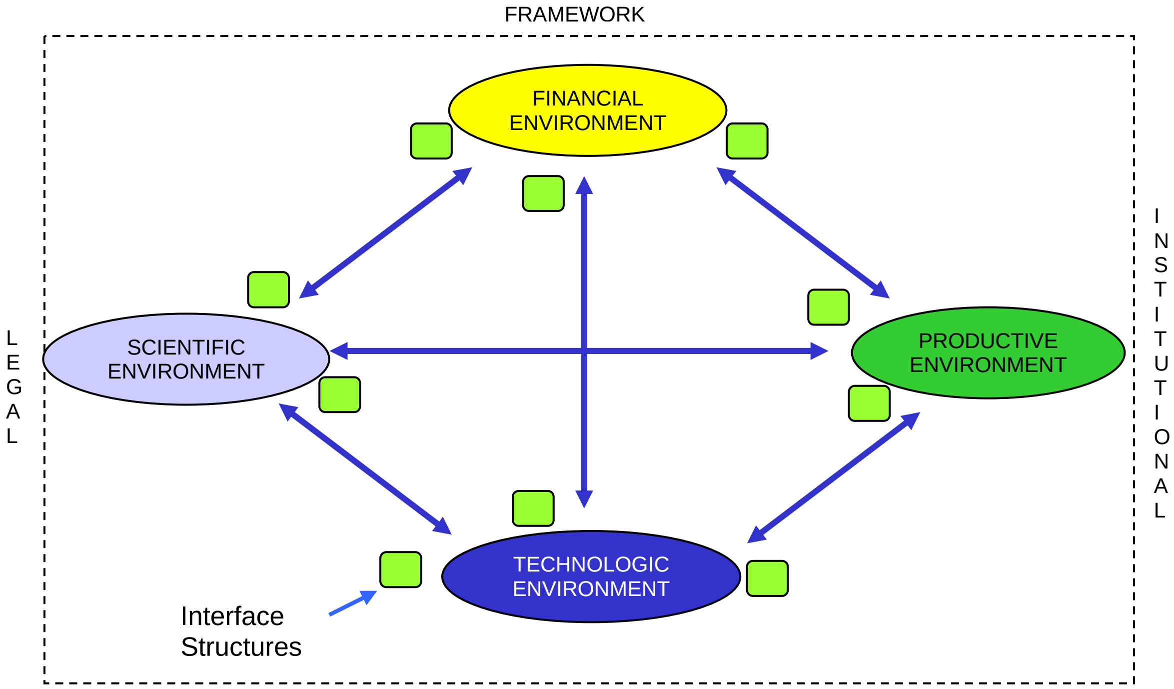
2.1.- Conceptual framework: the need to measure interactions

In the related literature, many definitions about Innovation Systems can be found:

> "network of institutions in the public and private sectors whose activities and interactions initiate, import, modify and diffuse new technologies" (Freeman, 1987).
>
> "a number of elements and the relationships between these elements… which interact in the production, diffusion and use of new, and economically useful knowledge…" (Lundvall ed., 1992).
>
> "The National Systems of Innovation are constituted by "interconnected agents" that interact influencing on the execution of the innovation in the national economy. These interactions occur into a specific context and under certain shared norms, routines and established practices." (Nelson and Rosenberg, 1993).
>
> "specialized cluster of firms supported by a developed infrastructure of supplier firms and regional knowledge and technology diffusion organisations, which tailor their services to the specific need of the dominating regional industry" (Asheim and Isaksen, 1997).

According to the previous definitions, we can conclude that an Innovation System, is an open, dynamic and social system (Lundvall ed., 1992), due to the interactions that occur not only among the socio-economic agents that constitute it, but also due to the ones produced with the surrounding environment (den Hertog, Roelandt, Boekholt, van der Gaag, 1995).

Fig.1: A model concerning Innovation Systems



Source: Fernández de Lucio and Castro (1995).

Industries, as the main agents that participate in the development of innovations (Schumpeter, 1939), scarcely innovate isolately due to the great amount of factors and agents that influence innovation processes. This way, agents interact so as to support, develop and interchange several kinds of knowledge, information, experiences and other sources (Lundvall ed., 1992; Edquist ed., 1997).

Despite most of the definitions consider interactions to be one of the key elements of the Innovation Systems, the models developed within this framework could be improved in their way of representing the system (seer Fig.1), not only due to the interactions produced within the system, but as said before, also owing to the ones between the system analyzed and the rest of the Innovation Systems related with or the ones that could be affected from. To conclude, interactions of the system with its sorrounding environment (North, 1994; den Hertog, Roelandt, Boekholt, van der Gaag, 1995; Galli and Teubal, 1997).

As Niosi and Bellon say (1994), who have developed the notion of “Open Innovation System”, all Innovation Systems are open although with different openness degrees. This way, the relation between Innovation Systems and their dynamics are key points so as to understand their features. In spite of this point, as internationalization processes are growing, it doesn’t involve the systems and local networks to disappear, although their dynamics can be modified (Niosi and Bellon, 1994; Caracostas and Soete, 1997).

From these models, Lundvall (ed., 1992) classifies the agents that constitute an Innovation System in some groups, being the most relevant ones:

- Internal organization of industries,
- Inter-industry relations,
- The role of the public sector
- The institutional set-up of the financial sector,
- R&D intensity and organisation.

Despite this initial classification, some other actors such as industries (suppliers, clients, competitors, etc.), universities, research centres, banks, institutes, government institutions, interface structures, etc. could also be considered (North, 1994; Fernández de Lucio and Castro, 1995; den Hertog, Roelandt, Boekholt, van der Gaag, 1995; Edquist ed., 1997; Galli and Teubal, 1997; Cooke et al., 2000).

Jointly with the National Innovation System approach, some other approaches such as “Sectoral Innovation Systems” (Breschi and Malerba, 1997), “Technological Systems” (Carlsson and Stankiewicz, 1991), “Transition Research Systems” (Cozzens et al. eds., 1990; Zyman, 1994), “Post-modernist Research System” (Rip and VanderMeulen, 1996), and the alternative model for the study of the strengths of an Innovation System developed by Chang and Shih (2004), can be also considered.

As marked before, the previous models, consider those features related to interactions as one of the central characteristics on which Innovation Systems are based on (Edquist ed., 1997). On the other side, these models hardly reflect and measure interactions. This way, and from a theoretical point of view, it could be said that despite Innovation Systems exist in the reality as interactions can be found, as long as the models developed trying to reflect the systems features do not get to represent and allow to know their dynamics and the ones of their interactions, the “system” concept could become a nonsense (Archibugi, Howells and Michie eds., 1999; Kautonen, 2000).

The fact that these and some other aspects regarding Innovation Systems, such as the measurement and study of innovation flows and their interactions in such a dynamic context as the actual, have not been studied deeply yet shows the relative youth of this approach.

As Charles Edquist said (ed., 1997), "…we simply do not know enough about these relations. It is important to be able to capture these interdependencies in empirical works – which includes the development of concepts and indicators - that relate elements to each other. This is needed for the development of a more sophisticated systemic and interactive view of innovation processes".

In this sense, it is necessary both a theoretical approach as a quantitative one regarding Innovation Systems (Leydesdorff and Schrnhorst, 2003). On the one side contributions that offer some quantitative measures so as to generate and validate hypothesis are needed, and on the other, as a consequence of the previous measures, researchers could pay more attention to the development of new theoretical models.

Up to date (Table, 1) many of the the measures defined trying to cover most of the Innovation Systems' features, are still to be measured.

Table 1: Relationship between Databases and an Innovation Systems environments.

	University	**Government**	**Industries**
Science	Science Citation Index		
Technology	Patent Database		
Innovation		Market data	

Source: Leydesdorff, Schrnhorst, 2003.

As the literature agrees, interactions are considered to be crucial in the development of innovations, so that it becomes necessary to talk about Innovation Networks.

So much informal networks as formal ones constitute mechanisms for the diffusion of tacit knowledge (Metcalfe, 1992). Networking can compensate to a great extent the limitations many industries have in their R&D processes (Fransman, 1990), so that become important for the innovation processes. As Lundvall (1992) says, the learning process is interactive and affected by the institutional structure of the territory. These interactions may occur through countries in spite of the reasons that suggest that interactions among institutions within the same country are less costly (Carlsson and Jacobson, 1997). Because of that, despite networks can have an international character, there are same reasons to believe that under certain conditions these will be strongly territory based (Breschi and Malerba, 1997).

Therefore, due to the role that networks play, in an efficient Innovation System, networks and ties among users, suppliers, clients and competitors must be strong as the processes of generation and diffusion of innovations and new technologies rest somehow on the reduction of transaction costs through networks.

As Saxenian says (1994), the starting point in a policy consists of "fostering collective identities and trust to support the formation and elaboration of local networks". Due to economic competence, private agents can develop their own network ties for them to get a dynamic behaviour. However, lock-in related effects could cause the government to act as a "broker" more than as an investor. This is, government Innovation Policies should be capable to involve industries that almost do not relate each other, in strong tied networks (Granovetter, 1973; Alänge and Jacobsson, 1993).

The research area concerning Innovation Networks and interactions are of special interest due to the fact that (Archibugi, Howells and Michie eds., 1999):

- Networks and consequently Innovation Systems, consider all the agents that participate on them. Therefore, in absence of interactions, the existence of a system could not be conceived.
- The relations produced within the system are relevant for the analysis and definition of its dynamics.
- The analysis of the way interactions evolve and change in time provides an adequate perspective for the knowledge of the evolution and the dynamics of the system.

The fact that many public institutions are defining Policies to support Innovation such as RIS, RTP, RITTS, etc. show the growing need to devise some measures that allow to measure those processes related to the establishment and evaluation of networks in those Innovation Policies (Saviotti, 1997; Archibugi, Howells and Michie eds., 1999; Zenker, 2001; Landabaso, Oughton and Morgan, 2001).

Some authors in recent years have used indicators when doing empirical approaches to Innovation Networks framework, in order to identify the interactions that occur within them, without obtaining in contrast a methodology that allows the identification of the dynamic behaviour of these Innovation Networks (Pleschak and Stummer, 2001; Revilla Díez, 2001; Koschatzky and Bross, 2001; Muller, 2001; Navarro Arancegui, 2002; Isaksen, 2003; Koschatzky, 2003; Nooteboom and Gilsing, 2004).

As it will be shown in the following pages, something similar occurs when Innovation Networks are considered not as much from an empirical point of view, but from the theoretical. In this case, some authors have tried to define and qualify Innovation Networks and their main features, without getting a consensus.

Innovation Networks are considered to be a relatively recent phenomena that emerged in the 90's (Callon, 1989 and 1992; Pyka and Saviotti, 2002), as a "useful tool to explain some phenomena as the dynamics of business organizations and the industries in a local productive system" (Vázquez Barquero, 1999).

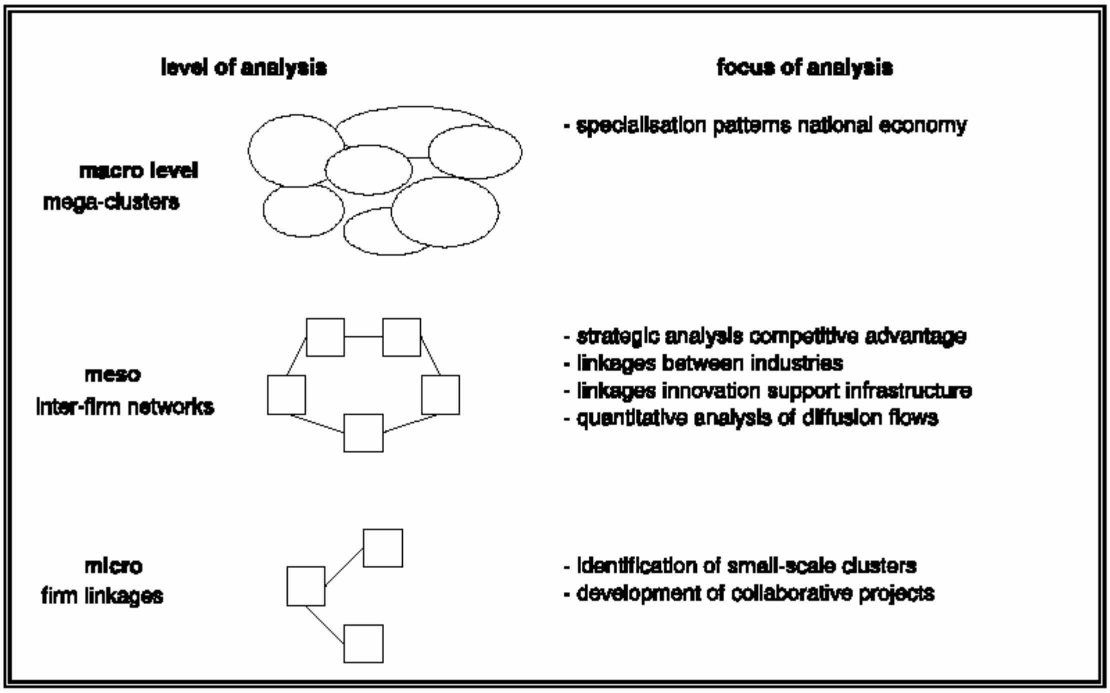
As Innovations occur as a consequence of interactions among economic, politic and scientific agents, it is possible to note that Innovation Networks are understood as "all organizational forms between market and hierarchy which serve for information, knowledge and resources exchange and help to implement innovations by mutual learning between the network partners" (Koschatzky, 2001; Koschatzky, Kulicke and Zenker eds., 2001). Nevertheless, they also can be understood as "a collective action among which local firms and institutions are culturally grounded for the creation and diffusion of additional knowledge" (Pilon and DeBresson, 2003); or such as "interaction processes among many heterogeneous agents, that produce innovations at the national, regional, or supranational levels" (Pyka and Küppers, 2002).

However, it is not only possible to found many definitions about Innovation Networks but also multiple taxonomies and classifications, advantages of networking, network's roles, etc. depending on the author's perspective (Freeman, 1991; DeBresson/Amesse, 1991; Cooke and Morgan, 1993; Guerrieri and Tylecote, 1997; Belussi and Arcangeli, 1998; Vázquez Barquero, 1999; Pleschak and Stummer, 2001; Pyka and Küppers, 2002; Fornhal and Brenner eds., 2003; Koschatzky, 2002 and 2003).

Many authors (Pleschak and Stummer, 2001; Fornhal and Brenner eds., 2003; Pyka and Küppers, 2002; Vaux and Gilbert, 2002; Lutz, Sydow and Staber, 2003) also explain the main features, events or facts that should occur in an Innovation System, the main particularities that the agents that constitute it should have, and the main instruments that could help to improve these interactions. However, as long as these recommendations have not still been tested empirically, and the measures used to measure interactive behaviours do not allow understanding their dynamics, the previous point could not be considered as a tool to define more efficient Science, Technology and Innovation Policies.

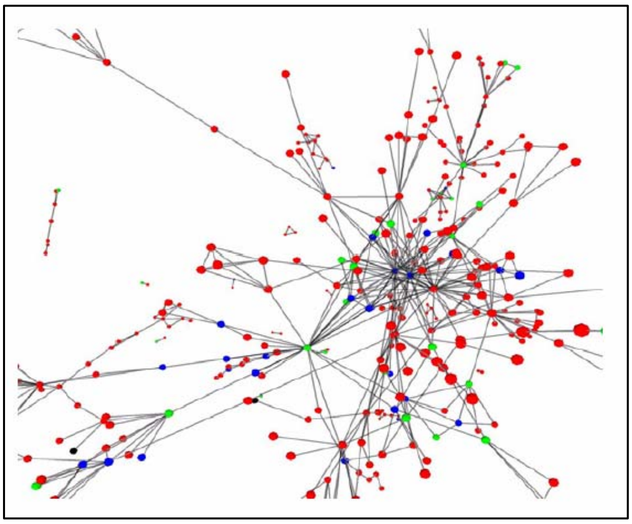
As it will be said in the sixth chapter, one of the ideas that want to be developed along the thesis consists of an interactive and open model of Innovation Systems (see Fig. 9), where interactions could be observed based on the measures to be defined. This objective fits some other approaches done according to Innovation measures (den Hertog, Roelandt, Boekholt, van der Gaag, 1995; Baba, Yarime, Shichijo, Nagahara, 2004) where some clusters are considered as well as their relations from several points of view.

Fig. 2: The Cluster Approaches at different levels of analysis



Source: den Hertog, Roelandt, Boekholt, van der Gaag, 1995.

Fig. 3: Topology of Hashimoto - centred Network (up to 2002)



Source: Baba, Yarime, Shichijo, Nagahara, 2004.

2.2.- Empirical framework: state of the art in the Innovation Networks

Once the theoretical contribution has been presented, subsequently will be shown and commented the main empirical works done trying to measure the interactions produced within an Innovation System.

Two main groups of research work can be distinguished. On the one hand, it is possible to find studies that use some measures trying to give an empirical and quantitative measure of interactions, and on the other hand, studies regarding Simulation Models about Innovation Networks can be considered.

In both groups have been found some research areas that could be improved, and where the thesis will be focused trying to contribute with new knowledge. On the one side, many of the measures used hardly contribute to know the dynamics of interactions and therefore the ones of the system. On the other side, some of these measures are not really interaction referred measures. They mention the agents that constitute the Innovation System, but not directly the interactions among them.

The first studies regarding Innovation Networks (Callon and Law 1989; Andersen 1997) have provided an important empirical evidence for further research. Andersen's work makes use of simulation models to analyze vertical relations between clients and suppliers, being a promising emergent research line (Andersen and Lundvall, 1997) that has involved many other researchers in simulating the evolution of complex and dynamic Productive and Innovative Systems. Nevertheless, it becomes necessary to review it, applying to empirical studies done more recently (Olazaran and Gomez Uranga eds., 2000).

Among the more recent research works, some interesting indicators can be obtained. Thus, interactions produced among the agents that constitute the Regional Innovation System of Baden Württemberg have been studied, by means of the following measures (Muller, 2001):

- o The knowledge used,
- o Spatial considerations regarding interactions,
- o Influence of interactions on Business Innovation.

Related to the later, Koschatzky (2003), studies the features of co-operation developed in five German EXIST regions, by jeans of the promotion of university Start-ups.

Revilla Díez (2001) shows the main results obtained in a project developed to measure the types of co-operation produced in some European regions like Barcelona, Vienna and Stockholm analyzing: the amount of industrial companies in each region, their year of foundation, their sectoral analysis, the technology areas their activities belong to, the sources of information, and the agents co-operating with depending on the phase of the innovation process.

A further study on the way co-operations take place in the industrial sector in Slovenia (Koschatzky and Bross, 2001) analyzes the composition of the industrial population, the sectors, the amount of workers, technology centres and foreign businesses they co-operate with, and the co-operation degree of technology centres with businesses, technology institutes and public administration. A similar study is done by Arne Isaksen (2003) concerning the case of the offshore engineering in the Oslo Region and by Slavo Radosevic (1997) about the transformation of techno-economic networks in Post-Socialist Innovation Systems.

Franz Pleschak and Frank Stummer (2001) analyze the competitiveness through innovation in East German Industrial Research, studying the frequency of interactions between a technology centre and the rest of agents by means of joint projects, acts organized jointly, consultants' support, common use of technological means, and research results' transfer.

An empirical work about the inter-industry co-operation n innovation projects in Spain (Navarro Arancegui, 2002) also studies the innovative industries that co-operated in innovation projects during 1996 according to their size, sectors, types of co-operation, the partners they co-operated with, and their technological level.

Opposite to the descriptive models of Innovation Systems, Furman et al. (2002) have developed a method to compare innovation related activities among countries under the "National Innovative Capacity" concept. Thus, the National Innovative Capacity is defined as "the ability of a country to produce and commercialize a flow of innovative technology over the long term [...depending] on the strength of a nation's common innovation infrastructure [...], the environment for innovation in a nation's industrial clusters, and the strength of linkages between these two" (Furman, Porter and Stern, 2002; Balzat and Hanusch, 2003).

Talking about the possible innovation related measures, it is also necessary to talk about the availability of data. Thus, apart from patent and publications related data, seldom can be found official data for the mobility of personnel for R&D activities, the relevance of interactions among users and suppliers, and the degree of use of the knowledge base available at universities for the industries. The same way, the identification of measures related to the technology transfer, joint co-operation among industries, joint learning among several institutions and the R&D and other kinds of co-operation between universities and industries, becomes a complicated mission (den Hertog, Roelandt, Boekholt, van der Gaag, 1995).

In one of their most recent research works, Nooteboom and Gilsing (2004) analyze the type of existing networks in the DBF and Multimedia Sectors in the Netherlands. However, this analysis is mainly experience based, not based on concrete indicators, so that it is neither possible to evaluate the applied Innovation Policies. At the same time, some possible measures that could be deduced from the type of networks (strong-weak) are identified, despite concrete indicators are not mentioned.

Finally, some of the last research works that have confirmed the interest of the present thesis have been the ones done by a group of researchers from the Tokio University jointly with the Meiji University (Baba, Yarime, Shichijo, Nagahara, 2004), and the one by Annamária Inzelt (2004). The first one, not only offers an interesting literature regarding Network Analysis, but also shows, despite only base don patent data, the graphic structure Innovation Networks adopt in the case of the Tokio University, showing the main nodes and their evolution in the 1995-2002 period. The later study (Inzelt, 2004) does an important revision of the state of the art related to interactions, and offers an interesting taxonomy of the main types of interaction that can be produced within an Innovation System, identifying which in each case are the agents involved in.

In turn, simulation models allow the adoption of a different perspective about measures. This is, modelization can create a demand for the definition of new measures, taking also into account that simulations could be used to produce "virtual" measures. This way, the quantitative results obtained simulating could be contrasted with real data (Leydesdorff and Schrnhorst, 2003; Saviotti ed., 2003).

In reference to the simulation models several studies can be found in the work of Andreas Pyka and Günter Küppers (eds., 2002) where numerous simulation models studying the characteristics of the behaviour of Innovation Networks can be found.

In the later study Andreas Pyka and Pier Paolo Saviotti (2002) compare real measures of an Innovation Network in the biotechnology sector with the ones obtained in a simulation model using the Ucinet software (Borgatti, Everett and Freeman, 1999).

Some other studies such as the role of the knowledge-intensive business services (KIBS) in e-commerce (Windrum, 2002), the Innovation Networks and the transformation of large socio-technical systems in the case of combined heat and power technology (Weber, 2002), and the evaluation of an Innovation Network (Ahrweiler, de Jong and Windrum, 2002) can also be contemplated.

Finally, Daniele Archibugi and Simona Iammarino (1999) make a taxonomy analyzing the behaviour of interactions among some agents of an Innovation System (industry-industry, government-government, government-industry) which depends on the way innovations are produced (Etzkowitz and Leydesdorff eds., 1997).

As explained before, one of the pioneer works in the Innovation Networks simulation has been the one of Esben Sloth Andersen (1997), through a model for the simulation of vertical relations in Innovation Systems.

Related to the later (Andersen and Lundvall, 1997) the authors comment the simulation model developed by Nelson and Winter (1982), which allowed to run simulations using the Schumpeterian model of vertical relations. One of its main goals will be the simulation of different trajectories, specifying those ones that could differ from country to country, so that the hypothesis about the existence of an exclusive optimum economic structure independently to the socio-economic context could be demonstrated.

3.- Research questions

Once both the conceptual and the empirical frameworks for the research have been analyzed, as well as the main research areas to be undertaken within this general framework, the main questions formulated along the research, and the hypothesis defined will be shown.

3.1.- Research objectives

Thus, the main objective the research will try to contribute with and get is the next one:

> "Analize and measure the interactions produced among the agents that constitute an Innovation System, developing a methodology and a set of measures that help to better comprehend the Innovation Capacity of the territories".

3.2.- Main hypothesis and research questions

Along the research, the main hypothesis formulated at the beginning will try to be answered and contrasted with empirical evidence. These hypotheses are:

- The interactions produced within an Innovation System are measurable, by means of new measures.
- The interactions produced among the agents in an Innovation System, influence on the Innovation Capacity of their territory.
- Interactions differ from one territory to another.

Finally, and so as to be able to accept or reject the previous hypothesis, along the research some questions will have to be answered:

- Which types of interactions are produced within an Innovation System? Which agents do participe on them?
- How can we obtain some new measures related to interactions?
- To what extent do interactions explain the dynamics of the Innovation Systems? And what about their Innovation Capacity?
- Do Innovation Networks differ in their dynamics from place to place?

4.- The Spanish Innovation System as an Input-Output-Cooperation model. Empirical evidence for the interest studying interactions.

As it has been said in previous paragraphs, some research can be found analyzing National Innovative Capacity. In this framework, from the European Commission, some work also is done with the “European Innovation Scoreboard”, offering some measures applied in the European Regions, trying to measure their Innovative Capacity (European Innovation Scoreboard, 2001, 2002, 2003).

For the development of this chapter, a research work is been done comparing the results that the European Innovation Scoreboard gives with the ones that could be obtained using some more indicators, also to a regional extent.

Hence, data for 22 indicators have been collected for the 17 Spanish regions in the 1996-2002 period. These indicators, according to a factor analysis were grouped in 4 factors.

Table 2: Factor Analysis for the study of the Spanish Regional Innovation Systems’ Innovative Capacity

Varianza total explicada

Componente	Autovalores iniciales			Sumas de las saturaciones al cuadrado de la extracción			Suma de las saturaciones al cuadrado de la rotación		
	Total	% de la varianza	% acumulado	Total	% de la varianza	% acumulado	Total	% de la varianza	% acumulado
1	13,970	63,502	63,502	13,970	63,502	63,502	11,964	54,382	54,382
2	3,067	13,940	77,442	3,067	13,940	77,442	3,589	16,315	70,697
3	1,561	7,097	84,540	1,561	7,097	84,540	2,894	13,154	83,852
4	1,028	4,671	89,211	1,028	4,671	89,211	1,179	5,359	89,211
5	,629	2,861	92,072						
6	,491	2,230	94,302						
7	,407	1,849	96,151						
8	,317	1,442	97,593						
9	,148	,674	98,268						
10	,133	,603	98,870						
11	,070	,320	99,190						
12	,064	,291	99,481						
13	,041	,187	99,668						
14	,030	,138	99,806						
15	,017	,077	99,883						
16	,011	,049	99,932						
17	,007	,033	99,965						
18	,004	,018	99,983						
19	,002	,010	99,994						
20	,001	,004	99,998						
21	,000	,001	99,999						
22	,000	,001	100,000						

Método de extracción: Análisis de Componentes principales.

Source: Own elaboration

Matriz de componentes rotados[a]

	Componente			
	1	2	3	4
Empl.Serv.High-Tech	,968		,210	
Alum.term.1-2	,968			
Pobl.Ocup.	,951		,205	
PIB	,949		,262	
VAB.Serv.AT.	,948		,198	,218
G.Univ.I+D	,946		,168	
Univ.	,937	,114	,110	
Tesis	,859	,130	-,158	
Empl.Indust.	,815	,205	,411	-,290
Pat.Esp.Sol.	,795	,250	,144	-,155
VAB.AYMAT.	,787	,354	,444	-,137
Empl.AYMAT.	,781	,351	,451	-,181
G.Empr.I+D.	,778	,358	,374	,245
GINN	,758	,322	,432	,150
G.AAPP.I+D	,739	,165		,602
Pat.Eur.Sol.	,621	,340	,581	-,179
%Pobl.25-34.E.Sup.		,906	,121	,214
%VAB.Indus.		,858	,161	-,325
%VAB.AYMAT.	,358	,812	-,105	
PIBcapita	,121	,666	,445	,424
%Tas.Emple.Egr.Sup.			,884	,100
Inst.Tec.	,293	,390	,588	-,350

Factor1 Factor2 Factor3 Factor4

Método de extracción: Análisis de componentes principales.
Método de rotación: Normalización Varimax con Kaiser.

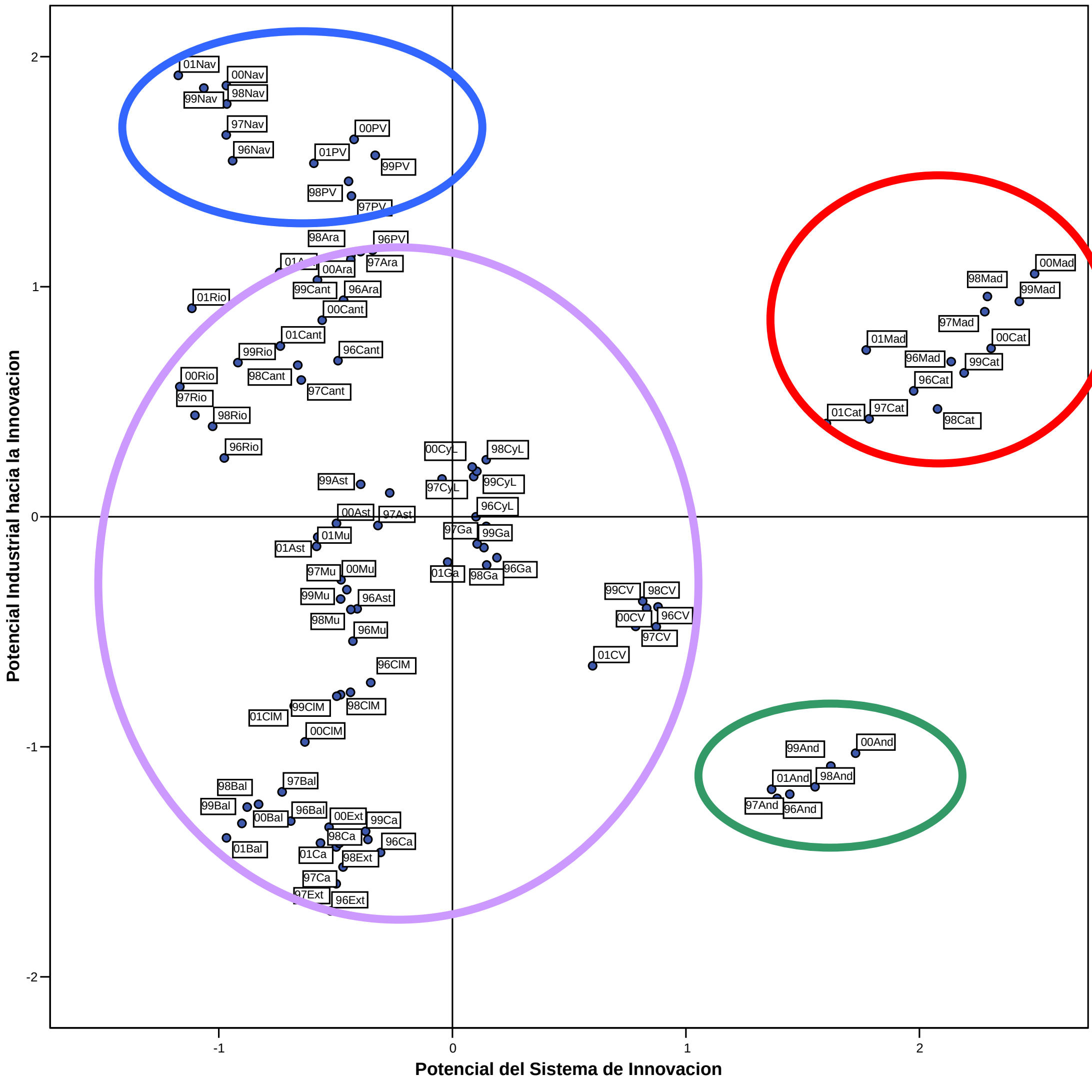
a. La rotación ha convergido en 12 iteraciones.

Source: Own elaboration

As a resume, and as the main objective of this chapter was not as much to talk about the Innovative Capacity of Spanish Regions but to show the relative importance that interactions have within an Innovation System, I will show from a graphical point of view the position each Spanish Region keeps according to the most important factors.

- Factor 1: Innovation System's Potential
- Factor 2: Industrial Potential to Innovation
- Factor 3: Openness degree of the System
- Factor 4: Presence of Public Institutions

Fig 4: Evolution of the Spanish Regional Innovation Systems



Source: Own elaboration

As it can be seen four clear groups of regions can be distinguished. First, the two most competitive regions, such as Madrid and Cataluña are grouped jointly (red), being the ones that more potential have to Innovation. In a second group, the relative position of Andalucia can be seen (green), a very powerful region from a scientific point of view despite to its industrial weakness. On the other side, in the third group the opposite case can be found. In this case, the Basque Country and Navarra are grouped (blue), being these ones regions with a great industrial tradition and strength but with many weaknesses from the scientific point of view. Finally, the rest of the regions are grouped (purple). It can also be seen how some regions such as Aragon and

Comunidad Valenciana are doing many efforts to change their position. This way in the Aragon case it can be seen that most of the efforts are oriented to the industrial sector, while in the Valencian case these ones are from the university side.

In this research work, and for future works, the goal will be to get an efficiency measure for the Spanish Regional Innovation Systems, so that we could compare the position of each Innovation System according to its efficiency and not so much to an input-output analysis as done up to date.

As said before, one of the key goals of this research was to observe if interactions were relevant for the generation of innovations. The literature agrees (see chapter 2) that interactions play an important role within Innovation Systems, and that without them that system could not be conceived. However, from an empirical point of view it was considered an important point to analyze the extent to what interactions are important in the dynamic behaviour of an Innovation System. This way, in case interactions were not considered to be so important, the objective of the thesis should be changed and reformulated.

For this analysis, 52 indicators were used, considering the Spanish country as the unit of analysis, as most of the data are not collected in the regions. The period of time in this case was 1995-2002. The whole amount of indicators, were grouped according to their features in three main groups, Input, Output and Co-operation. This last group is the one that has been considered directly related to the interactive behaviour in the Innovation Systems.

The methodology used was as follows. Once all the data were collected, they were normalized to a N(0,1) distribution, making use of their average and typical deviation (see Table. 3).

Table 3: Indicators for each group of analysis : Input – Output – Co-operation, N(0,1)

	Observations	1995 Spain	1996 Spain	1997 Spain	1998 Spain	1999 Spain	2000 Spain	2001 Spain	2002 Spain
INPUT	G.E.Sup	-1,358	-1,104	-0,391	-0,299	0,022	0,566	1,072	1,491
	G.U.ID	-1,192	-0,887	-0,659	-0,323	-0,133	0,412	1,079	1,703
	G.AAPP.ID	-1,107	-0,828	-0,850	-0,431	0,053	0,445	0,981	1,737
	Emp.Serv.ID	-1,148	-1,057	-0,957	-0,293	0,304	0,810	0,975	1,365
	Emp.Serv.AT	-1,218	-0,992	-0,809	-0,290	0,137	0,641	0,982	1,549
	Empl.Ind.AYMAT	-1,399	-1,149	-0,584	-0,130	0,258	0,624	0,997	1,384
	G.Emp.ID	-1,160	-0,965	-0,825	-0,194	-0,013	0,599	0,848	1,711
	GINN.IDint	-0,760	0,830	0,102	-0,626	-0,819	-1,011	0,424	1,860
	GINN.IDext	-0,509	-1,225	-0,343	0,540	-0,145	-0,830	0,561	1,951
	GINN.Ad.Maq	-1,261	0,073	0,666	1,259	0,844	0,429	-0,527	-1,483
	GINN.Ad.Con	-0,316	-0,813	-0,337	0,139	0,938	1,738	0,129	-1,479
	GINN.Form	-1,199	-1,013	-0,625	-0,237	0,736	1,708	0,779	-0,150
	GINN.Merc	-0,615	-0,534	-0,879	-1,224	-0,171	0,882	1,141	1,399
	GINN.Diseñ	1,011	1,546	0,720	-0,106	-0,720	-1,335	-0,817	-0,300
	EIN	-0,919	-0,831	-0,799	-0,767	-0,057	0,653	1,124	1,596
	Imp.AYMAT	-1,453	-1,088	-0,727	-0,166	0,473	1,034	1,000	0,926
	Imp.MBYBT	-1,200	-1,063	-0,602	-0,415	-0,118	0,995	1,155	1,248
	GINN	-1,427	-1,341	-0,575	0,191	0,700	1,209	0,817	0,426
	Pob.Oc	-1,315	-1,033	-0,726	-0,333	0,222	0,784	1,113	1,289
OUTPUT	Alter.12	-1,793	-0,913	-0,081	0,251	0,385	0,246	0,298	1,608
	Tesis	-0,617	-0,313	-1,991	-0,234	0,849	0,777	0,828	0,701
	VAB.Serv.AT	-1,208	-0,967	-0,645	-0,342	-0,049	0,516	1,058	1,638
	Porc.VAB.AYMAT	-1,936	0,404	0,947	1,205	0,468	-0,080	-0,562	-0,445
	Exp.AYMAT	-1,565	-1,058	-0,541	-0,079	0,206	0,919	1,033	1,086
	Exp.MBYBT	-1,470	-1,101	-0,323	-0,206	-0,086	0,829	1,113	1,245
	Porc.2534.E.Sup	-1,498	-0,979	-0,604	-0,153	0,175	0,648	1,040	1,371
	Porc.VAB.Ind	-0,814	-1,553	-0,040	0,970	1,161	0,947	0,173	-0,843
	PIB.Cap	-1,815	-0,899	-0,117	-0,240	0,243	0,699	0,971	1,157
	Bal.Tec.AYMAT	-1,453	-0,496	0,040	-0,248	-0,546	0,026	0,748	1,929
	Pat.Es	-1,863	-0,810	-0,534	0,024	0,910	0,910	0,738	0,623
	Pat.EPO	-1,548	-1,326	-0,477	0,896	0,280	0,412	0,795	0,967

	Observations	1995 Spain	1996 Spain	1997 Spain	1998 Spain	1999 Spain	2000 Spain	2001 Spain	2002 Spain
COOP.	**GUIDAAPP**	-1,535	-1,532	0,110	0,169	0,336	0,569	0,790	1,094
	GUIDEmp	-0,706	-0,763	-1,000	-0,531	-0,035	-0,006	1,589	1,452
	GAPIDAAPP	-1,341	-0,932	-0,596	-0,325	0,129	0,473	0,926	1,665
	GEIDAAPP	-1,113	-0,767	-0,516	-0,637	0,067	0,062	1,080	1,824
	GEIDEmp	-1,227	-0,961	-0,871	-0,061	0,038	0,680	0,723	1,680
	EIN.Fin.Ad.Auton	-1,074	-1,074	-0,690	-0,669	0,406	1,481	1,034	0,586
	EIN.Fin.Es	-1,231	-1,231	-0,665	-0,368	0,395	1,158	1,033	0,909
	EIN.Fin.UE	-0,906	-0,432	-1,064	-0,963	0,332	1,627	1,011	0,395
	Emp.Egr.Sup	-1,034	-0,764	-0,405	0,225	0,315	0,944	1,753	-1,034
	EIN.Coop.Esp	-0,799	-0,578	-0,358	-0,175	-0,402	-0,630	0,771	2,172
	EIN.Coop.UE	-0,697	-0,840	-0,555	-0,065	-0,281	-0,498	0,813	2,123
	EIN.Coop.Cand.UE	-0,343	-0,814	0,442	1,227	-0,186	-1,599	-0,108	1,384
	EIN.Coop.USA	-0,660	-0,594	2,423	-0,411	-0,309	-0,207	-0,150	-0,092
	EIN.Coop.Jap	-1,282	-0,955	-0,627	-0,561	0,488	1,537	0,979	0,422
	EIN.Coop.Emp.Grp	-1,216	-1,063	-0,757	-0,359	0,588	1,535	0,935	0,336
	EIN.Coop.Cli	-0,959	-0,569	-0,179	0,210	0,959	1,707	0,179	-1,348
	EIN.Coop.Prov	-1,130	-0,965	-0,635	-0,368	-0,020	0,328	1,039	1,750
	EIN.Coop.Comp	-1,054	-0,902	-0,826	-0,775	0,302	1,379	1,085	0,790
	EIN.Coop.Cons	-1,169	-0,952	-0,734	-0,673	0,199	1,071	1,110	1,148
	EIN.Coop.Un	-0,996	-0,887	-0,670	-0,941	0,083	1,108	1,137	1,166
	EIN.Coop.Ctec	-0,985	-1,111	-0,859	-0,650	1,179	0,608	1,244	0,575

Source: Own elaboration from INE 1995-2002. National Statistic Institute.

With these data, three factor analyses were done, each one for each group (Input, Output, Co-operation) (see Table. 4).

As a resume, the results obtained were:

Table 4: Factors obtained in each level of analysis

Analysis levels	Factor’s observed
INPUT	Input1: Resources dedicated to Innovation
	Input2: Innovation Expenditures`Distribution in the Spanish Industries.
OUTPUT	Output1: Richness generated in the Society for the Technological Innovation
	Output2: Industries` relevance on the Spanish Economy
	Output3: High Technology Industries`relevance on the Spanish Economy
CO-OPERATION	Co-operation1: Co-operations to find funds and agents co-operating with
	Co-operation2: Co-operation depending on geographical aspects (Spain-Europe)
	Co-operation3: Innovative Industries` Co-operation with the USA

Source: Own elaboration

The relative weight of each factor in each level of analysis (input, output, co-operation) was obtained converting the % of the variance observed for them to a 100%.

<u>*Example*</u>: In the case of the Input1 factor the weight will be:

Total Variance observed in the Input: 93’090 %

Variance explained by the Input1 factor: 73’729 %

93’090 $\longrightarrow$ 100%

73’729 $\longrightarrow$ X%

X%= Input1 % = 79’202%

The same previous process was followed with each indicator in each factor (see Table. 8). This way, both the factors that constitute the three levels of analysis as the indicators that constitute each factor have their own weight.

Table 5: Factor Analysis for the Input related indicators

Varianza total explicada

Componente	Autovalores iniciales			Sumas de las saturaciones al cuadrado de la extracción			Suma de las saturaciones al cuadrado de la rotación		
	Total	% de la varianza	% acumulado	Total	% de la varianza	% acumulado	Total	% de la varianza	% acumulado
1	14,031	73,845	73,845	14,031	73,845	73,845	14,008	73,729	73,729
2	3,656	19,245	93,090	3,656	19,245	93,090	3,679	19,361	93,090
3	,828	4,356	97,446						
4	,417	2,193	99,639						
5	,048	,254	99,893						
6	,017	,088	99,981						
7	,004	,019	100,000						
8	2,683E-15	1,412E-14	100,000						
9	5,639E-16	2,968E-15	100,000						
10	4,601E-16	2,421E-15	100,000						
11	3,467E-16	1,825E-15	100,000						
12	2,120E-16	1,116E-15	100,000						
13	1,196E-16	6,294E-16	100,000						
14	1,521E-18	8,007E-18	100,000						
15	-8,33E-17	-4,38E-16	100,000						
16	-1,19E-16	-6,27E-16	100,000						
17	-1,86E-16	-9,81E-16	100,000						
18	-4,20E-16	-2,21E-15	100,000						
19	-4,98E-16	-2,62E-15	100,000						

Relevance of each factor

Método de extracción: Análisis de Componentes principales.

Matriz de componentes rotados[a]

	Componente	
	1	2
Pob.Oc.	,998	
Emp.Serv.I+D	,995	
Empl.Serv.AT	,991	,121
Empl.Ind.AYMAT	,989	
Imp.MBYBT	,987	
G.E.Sup	,979	,125
Imp.AYMAT	,977	-,194
G.Emp.I+D	,974	,188
G.AAPP.I+D	,965	,253
G.U.I+D	,963	,262
%EIN	,958	,229
GINN	,888	-,439
%GINN.Merc.	,876	,227
%GINN.Diseñ.	-,858	,488
%GINN.Form.	,768	-,618
%GINN.I+Dext	,641	,515
%GINN.Ad.Con.	,196	-,961
%GINN.I+Dint.	,284	,878
%GINN.Ad.Maq.	-,194	-,752

Input1

Input2

Método de extracción: Análisis de componentes principales.

Método de rotación: Normalización Varimax con Kaiser.

a. La rotación ha convergido en 3 iteraciones.

Own elaboration

Table 6: Factor Analysis for the Output related indicators

Varianza total explicada

Componente	Autovalores iniciales			Sumas de las saturaciones al cuadrado de la extracción			Suma de las saturaciones al cuadrado de la rotación		
	Total	% de la varianza	% acumulado	Total	% de la varianza	% acumulado	Total	% de la varianza	% acumulado
1	8,769	73,077	73,077	8,769	73,077	73,077	7,770	64,752	64,752
2	1,589	13,240	86,317	1,589	13,240	86,317	2,299	19,156	83,908
3	1,075	8,961	95,278	1,075	8,961	95,278	1,364	11,370	95,278
4	,339	2,823	98,102						
5	,161	1,340	99,442						
6	,062	,513	99,954						
7	,005	,046	100,000						
8	3,000E-16	2,500E-15	100,000						
9	1,207E-16	1,006E-15	100,000						
10	3,611E-17	3,009E-16	100,000						
11	-5,22E-17	-4,35E-16	100,000						
12	-1,68E-16	-1,40E-15	100,000						

Método de extracción: Análisis de Componentes principales.

Relevance of each factor

Matriz de componentes rotados[a]

	Componente		
	1	2	3
Bal.Tec.AYMAT	,975	-,203	
VAB.Serv.AT	,963	,133	-,229
%2534.E.Sup	,950	,285	-,126
Exp.MBYBT	,944	,259	
PIB.Capita	,940	,292	
Alter12	,921	,220	,221
Exp.AYMAT	,907	,394	
Pat.EPO.	,808	,492	,127
Pat.Es.	,770	,599	
%VAB.Ind.	,116	,934	,207
%VAB.AYMAT	,121	,294	,907
Tesis	,522	,492	-,582

Output1

Output2

Output3

Método de extracción: Análisis de componentes principales.

Método de rotación: Normalización Varimax con Kaiser.

a. La rotación ha convergido en 5 iteraciones.

Source: Own elaboration

Table 7: Factor Analysis for the Co-operation related indicators

Varianza total explicada

Componente	Autovalores iniciales – Total	Autovalores iniciales – % de la varianza	Autovalores iniciales – % acumulado	Sumas de las saturaciones al cuadrado de la extracción – Total	Sumas de las saturaciones al cuadrado de la extracción – % de la varianza	Sumas de las saturaciones al cuadrado de la extracción – % acumulado	Suma de las saturaciones al cuadrado de la rotación – Total	Suma de las saturaciones al cuadrado de la rotación – % de la varianza	Suma de las saturaciones al cuadrado de la rotación – % acumulado
1	14,449	68,805	68,805	14,449	68,805	68,805	9,449	44,995	44,995
2	4,014	19,115	87,920	4,014	19,115	87,920	8,925	42,502	87,497
3	1,328	6,325	94,245	1,328	6,325	94,245	1,417	6,749	94,245
4	,643	3,061	97,307						
5	,366	1,745	99,052						
6	,161	,768	99,820						
7	,038	,180	100,000						
8	1,092E-15	5,202E-15	100,000						
9	3,119E-16	1,485E-15	100,000						
10	2,646E-16	1,260E-15	100,000						
11	1,498E-16	7,132E-16	100,000						
12	1,383E-16	6,587E-16	100,000						
13	8,786E-17	4,184E-16	100,000						
14	2,636E-17	1,255E-16	100,000						
15	-2,86E-17	-1,36E-16	100,000						
16	-1,73E-16	-8,22E-16	100,000						
17	-2,35E-16	-1,12E-15	100,000						
18	-2,85E-16	-1,36E-15	100,000						
19	-3,61E-16	-1,72E-15	100,000						
20	-7,21E-16	-3,43E-15	100,000						
21	-2,67E-15	-1,27E-14	100,000						

Método de extracción: Análisis de Componentes principales.

Relevance of each factor

Matriz de componentes rotados[a]

	Componente 1	Componente 2	Componente 3
EIN.Coop.Emp.Grp.	,933	,338	
EIN.Coop.Jap.	,928	,364	
EIN.Fin.Ad.Auton.	,895	,427	
EIN.Fin.UE.	,877	,305	-,328
EIN.Coop.Cli.	,855	-,424	,117
EIN.Coop.Comp.	,844	,501	-,151
%Emp.Egr.Sup	,832		
EIN.Fin.Es.	,810	,580	
EIN.Coop.C.Tec	,775	,493	
EIN.Coop.Cons.	,746	,653	
EIN.Coop.Univ.	,727	,641	-,123
EIN.Coop.UE		,997	
EIN.Coop.Esp.		,995	
GEID(AAPP)	,380	,912	
EIN.Coop.Prov.	,453	,891	
GAPID(AAPP)	,519	,848	
GUID(Emp)	,403	,847	-,216
GEID(Emp)	,518	,824	
GUID(AAPP)	,607	,661	,405
EIN.Coop.UE2	-,498	,627	,443
EIN.Coop.USA			,903

Co-operation1

Co-operation2

Co-operation3

Método de extracción: Análisis de componentes principales.

Método de rotación: Normalización Varimax con Kaiser.

a. La rotación ha convergido en 5 iteraciones.

urce: Own elaboration

Table 8: Weights of factors and indicators after the factor analysis

		%	Indicator	1995 Spain	1996 Spain	1997 Spain	1998 Spain	1999 Spain	2000 Spain	2001 Spain	2002 Spain
INPUT	INPUT1 (79.202 %)	7,96%	Pob.Oc	-1,315	-1,033	-0,726	-0,333	0,222	0,784	1,113	1,289
		7,93%	Emp.Serv.ID	-1,148	-1,057	-0,957	-0,293	0,304	0,810	0,975	1,365
		7,9%	Emp.Serv.AT	-1.22	-0,992	-0,809	-0,290	0,137498951	0,641260433	0,982238568	1,54860903
		7,88%	Empl.Ind.AYMAT	-1,399	-1,149	-0,584	-0,130	0,258	0,624	0,997	1,384
		7,87%	Imp.MBYBT	-1,200	-1,063	-0,602	-0,415	-0,118	0,995	1,155	1,248
		7,8%	G.E.Sup	-1,358	-1,104	-0,391	-0,299	0,022	0,566	1,072	1,491
		7,79%	Imp.AYMAT	-1,453	-1,088	-0,727	-0,166	0,473	1,034	1,000	0,926
		7,76%	G.Emp.ID	-1,160	-0,965	-0,825	-0,194	-0,013	0,599	0,848	1,711
		7,69%	G.AAPP.ID	-1,107	-0,828	-0,850	-0,431	0,053	0,445	0,981	1,737
		7,68%	G.U.ID	-1,192	-0,887	-0,659	-0,323	-0,133	0,412	1,079	1,703
		7,64%	EIN	-0,919	-0,831	-0,799	-0,767	-0,057	0,653	1,124	1,596
		7,08%	GINN	-1,427	-1,341	-0,575	0,191	0,700	1,209	0,817	0,426
		6,98%	GINN.Merc	-0,615	-0,534	-0,879	-1,224	-0,171	0,882	1,141	1,399
	INPUT2 (20,798 %)	11,58%	GINN.Diseñ	1,011	1,546	0,720	-0,106	-0,720	-1,335	-0,817	-0,300
		14,67%	GINN.Form	-1,199	-1,013	-0,625	-0,237	0,736	1,708	0,779	-0,150
		12,22%	GINN.IDext	-0,509	-1,225	-0,343	0,540	-0,145	-0,830	0,561	1,951
		22,81%	GINN.Ad.Con	-0,316	-0,813	-0,337	0,139	0,938	1,738	0,129	-1,479
		20,84%	GINN.IDint	-0,760	0,830	0,102	-0,626	-0,819	-1,011	0,424	1,860
		17,85%	GINN.Ad.Maq	-1,261	0,073	0,666	1,259	0,844	0,429	-0,527	-1,483
OUTPUT	OUTPUT 1 (67,96%)	11,2%	Bal.Tec.AYMAT	-1,453	-0,496	0,040	-0,248	-0,546	0,026	0,748	1,929
		11,07%	VAB.Serv.AT	-1,208	-0,967	-0,645	-0,342	-0,049	0,516	1,058	1,638
		10,92%	Porc.2534.E.Sup	-1,498	-0,979	-0,604	-0,153	0,175	0,648	1,040	1,371
		10,85%	Exp.MBYBT	-1,470	-1,101	-0,323	-0,206	-0,086	0,829	1,113	1,245
		10,8%	PIB.Cap	-1,815	-0,899	-0,117	-0,240	0,243	0,699	0,971	1,157
		10,58%	Alter.12	-1,793	-0,913	-0,081	0,251	0,385	0,246	0,298	1,608
		10,42%	Exp.AYMAT	-1,565	-1,058	-0,541	-0,079	0,206	0,919	1,033	1,086
		9,28%	Pat.EPO	-1,548	-1,326	-0,477	0,896	0,280	0,412	0,795	0,967
		8,85%	Pat.Es	-1,863	-0,810	-0,534	0,024	0,910	0,910	0,738	0,623
		6%	Tesis	-0,617	-0,313	-1,991	-0,234	0,849	0,777	0,828	0,701
	OUTPUT 2 (20,105 %)	100%	Porc.VAB.Ind	-0,814	-1,553	-0,040	0,970	1,161	0,947	0,173	-0,843
	OUTPUT 3 (11,93%)	100%	Porc.VAB.AYMAT	-1,936	0,404	0,947	1,205	0,468	-0,080	-0,562	-0,445

		%	Indicator	1995 Spain	1996 Spain	1997 Spain	1998 Spain	1999 Spain	2000 Spain	2001 Spain	2002 Spain
COOP.	*COOPERACION 1 (47,74%)*	*10,11%*	**EIN.Coop.Emp.Grp**	-1,216	-1,063	-0,757	-0,359	0,588	1,535	0,935	0,336
		10,06%	**EIN.Coop.Jap**	-1,282	-0,955	-0,627	-0,561	0,488	1,537	0,979	0,422
		9,7%	**EIN.Fin.Ad.Auton**	-1,074	-1,074	-0,690	-0,669	0,406	1,481	1,034	0,586
		9,51%	**EIN.Fin.UE**	-0,906	-0,432	-1,064	-0,963	0,332	1,627	1,011	0,395
		9,27%	**EIN.Coop.Cli**	-0,959	-0,569	-0,179	0,210	0,959	1,707	0,179	-1,348
		9,15%	**EIN.Coop.Comp**	-1,054	-0,902	-0,826	-0,775	0,302	1,379	1,085	0,790
		9,02%	**Emp.Egr.Sup**	-1,034	-0,764	-0,405	0,225	0,315	0,944	1,753	-1,034
		8,78%	**EIN.Fin.Es**	-1,231	-1,231	-0,665	-0,368	0,395	1,158	1,033	0,909
		8,4%	**EIN.Coop.Ctec**	-0,985	-1,111	-0,859	-0,650	1,179	0,608	1,244	0,575
		8,09%	**EIN.Coop.Cons**	-1,169	-0,952	-0,734	-0,673	0,199	1,071	1,110	1,148
		7,88%	**EIN.Coop.Un**	-0,996	-0,887	-0,670	-0,941	0,083	1,108	1,137	1,166
	COOPERACION 2 (45,907 %)	*13,11%*	**EIN.Coop.UE**	-0,697	-0,840	-0,555	-0,065	-0,281	-0,498	0,813	2,123
		13,08%	**EIN.Coop.Esp**	-0,799	-0,578	-0,358	-0,175	-0,402	-0,630	0,771	2,172
		11,99%	**GEIDAAPP**	-1,113	-0,767	-0,516	-0,637	0,067	0,062	1,080	1,824
		11,72%	**EIN.Coop.Prov**	-1,130	-0,965	-0,635	-0,368	-0,020	0,328	1,039	1,750
		11,15%	**GAPIDAAPP**	-1,341	-0,932	-0,596	-0,325	0,129	0,473	0,926	1,665
		11,14%	**GUIDEmp**	-0,706	-0,763	-1,000	-0,531	-0,035	-0,006	1,589	1,452
		10,84%	**GEIDEmp**	-1,227	-0,961	-0,871	-0,061	0,038	0,680	0,723	1,680
		8,69%	**GUIDAAPP**	-1,535	-1,532	0,110	0,169	0,336	0,569	0,790	1,094
		8,25%	**EIN.Coop.Cand.UE**	-0,343	-0,814	0,442	1,227	-0,186	-1,599	-0,108	1,384
	COOP3 (7,161%)	*100%*	**EIN.Coop.USA**	-0,660	-0,594	2,423	-0,411	-0,309	-0,207	-0,150	-0,092

Source: Own elaboration from INE 1995-2002. National Statistic Institute.

With the previous factors and weights, three indicators can be obtained, each one for each level of analysis for the period observed (see Table. 9)

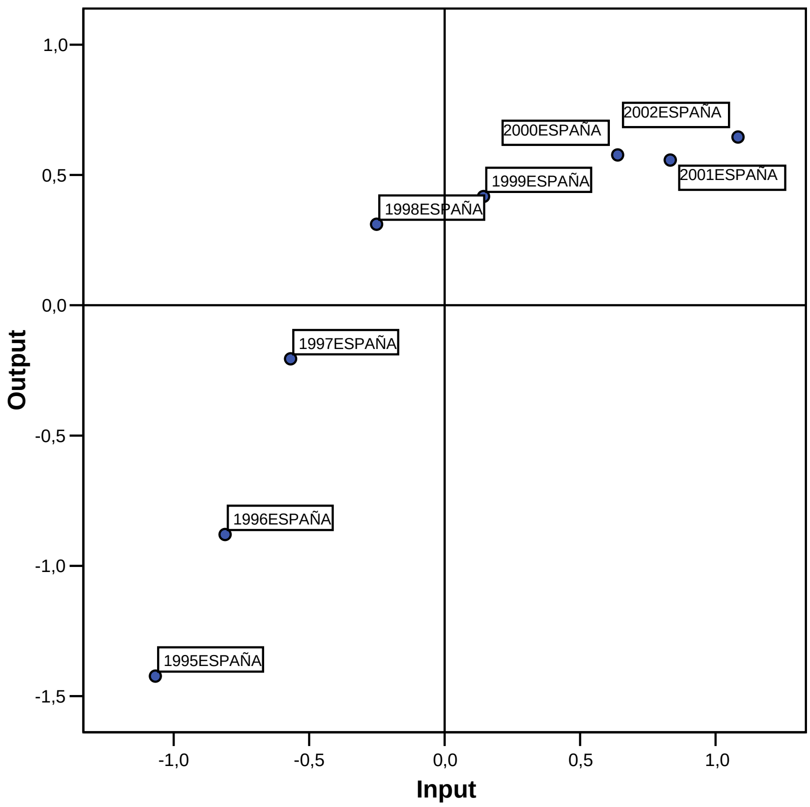
Table 9: Input – Output – Co-operation indicators alter the Factor Analysis

	Input	Output	Co-operation
1995 Spain	-1,0675851	-1,423362	-1,00912559
1996 Spain	-0,81031	-0,8799066	-0,87154835
1997 Spain	-0,5685469	-0,2054257	-0,36807279
1998 Spain	-0,2512156	0,31097207	-0,32797484
1999 Spain	0,14347994	0,41760349	0,182342653
2000 Spain	0,63861542	0,57711164	0,58145389
2001 Spain	0,83272304	0,55753688	0,880393221
2002 Spain	1,08283926	0,64554209	0,9325318

Source: Own elaboration from INE 1995-2002. National Statistic Institute.

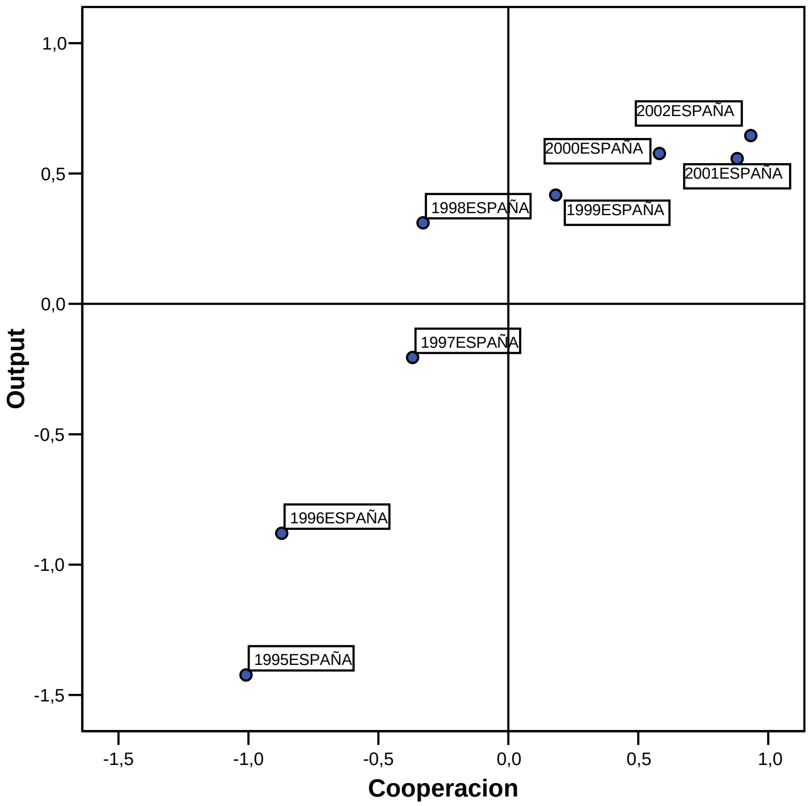
Representing the relation among these variables or levels of analysis in a matrix, we can foresee the dependence of the inputs and co-operations to generate outputs. As a resume, to generate wealth and innovation.

Fig. 5: Evolution of the Spanish Innovation System: Input – Output analysis



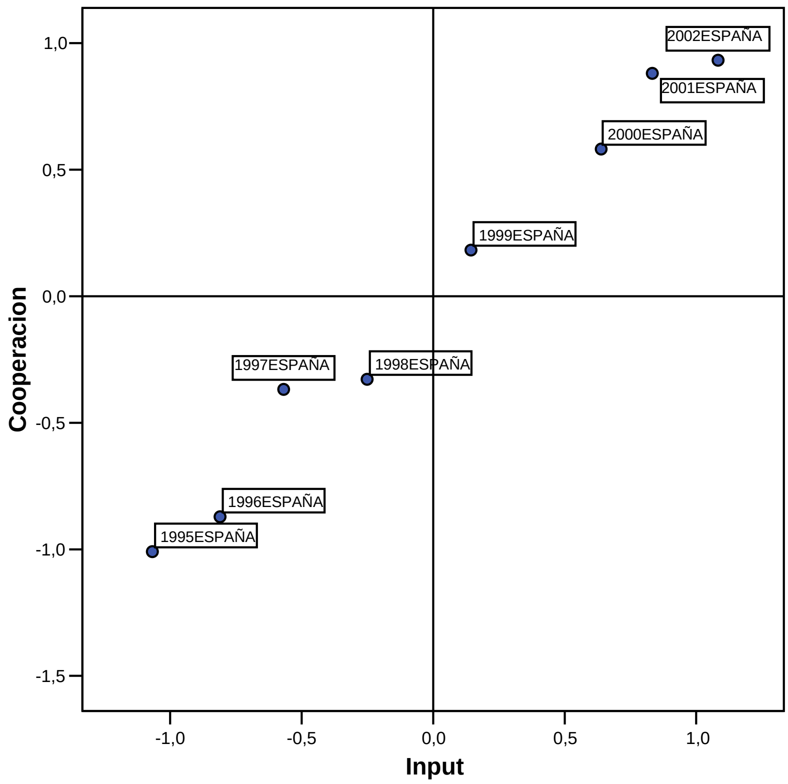
Source: Own elaboration

Fig. 6: Evolution of the Spanish Innovation System: Co-operation - Output analysis



Source: Own elaboration

Fig 7: Evolution of the Spanish Innovation System: Input – Co-operation analysis



Source: Own elaboration

But it has to be empirically tested that co-operations are crucial for the development of innovations and that in their absence the Innovation System will not generate the same output. To demonstrate it, I will show the regression analysis made, having Outputs as the dependent variable and being both Inputs and Co-operations the independent variables (See Table 10).

Table 10: Regression Analysis for Outputs depending on Inputs and Co-operations

Variables introducidas/eliminadas[b]

Modelo	Variables introducidas	Variables eliminadas	Método
1	Cooperacion, Input[a]	.	Introducir

a. Todas las variables solicitadas introducidas

b. Variable dependiente: Output

Resumen del modelo

Modelo	R	R cuadrado	R cuadrado corregida	Error típ. de la estimación
1	,897[a]	,805	,728	,403070

a. Variables predictoras: (Constante), Cooperacion, Input

Coeficientes[a]

Modelo		Coeficientes no estandarizados		Coeficientes estandarizados	t	Sig.
		B	Error típ.	Beta		
1	(Constante)	8,988E-06	,143		,000	1,000
	Input	,250	1,472	,259	,170	,872
	Cooperacion	,651	1,550	,640	,420	,692

a. Variable dependiente: Output

Source: Own elaboration

As it can be see the R^2 is quite high so with the measures used, it is possible to get quite a representative image of the Spanish Innovation System. The same way, we can observe by means of the “t” that co-operations are more important than inputs for the generation of innovations, in this case named as Outputs.

To conclude, with this analysis done, it is possible to demonstrate that in the Spanish Innovation System, interactions play a role in the generation of Innovations, so their deep study becomes necessary to develop more efficient Innovation Systems.

Furthermore, and as the main goal of the thesis is the development of some measures that could help us to know something more about the role that interactions play, as demonstrated, in the Innovation Systems, some questions are wondered:

- Which could be considered to be the main outputs of an Innovation System?
- Which variables could be relevant for the study of interactions so that they will be helpful to define new “interactive” measures?

5.- Selection of the sector of study

Once it has been shown that interactions are really important for the study of Innovation Systems, and some more research is needed to be done in that sense, continually I will show the process followed to define the sector where interactions will be studied empirically.

At the beginning of the research, it was thought to study the interactions in several sectors within a region and the interactions in the same sector but in different European Regions.

Due to the great amount of sectors, regions and to the difficulty of getting data, the analysis will be focused to the study of interactions in one sector which is present in several European Regions.

Hence, the first step was to define the sector where the measures to be defined will be tested empirically.

Making use of the EUROSTAT 2002 Database for the 15 European Countries and for 17 sectors, including both manufacturing and services sectors, three indicators were considered to be crucial.

- % of Innovative Industries
- % of the Innovation Expenditure oriented to the acquisition of external R&D
- % of Innovative Industries that Co-operate with agents

The reason why these indicators were selected was to obtain a sector were interactions are produced. Due to that the aim of the thesis is to analyze and measure interactions, it is considered that a sector where interactions are produced is needed, so that the measures created could be tested. Otherwise in case a sector were there are almost no interactions will be selected, the empirical test could be even more difficult.

This way, with the % of Innovative Industries, I wanted to be sure that there is a dynamic sector, this is, a sector where innovations are continually been developed. With the % of Innovative Industries that Co-operate I wanted to choose a sector where many interactions could be found. Last, with the % of Innovation Expenditure for the acquisition of external R&D I wanted to see the strong ties among the agents, this is the quality of these interactions.

The criteria used to select the sector with these indicators, was that the selected sectors should be present in the top values of the three indicators (see Table. 11).

Table 11: Sector's selection in the EU countries for the study of interactions (1)

	% de EIN	%GINNI+Dext	%EINcooperan
d Manufacturing	51.000	9.000	26.000
da Manufacture of food products; beverages and tobacco	50.000	3.000	25.000
db_dc Manufacture of textiles and textile products; manufacture of leather and leather products	35.000	2.000	14.000
dd_de Manufacture of wood and wood products, manufacture of pulp, paper and paper products;	45.000	2.000	18.000
df_dg Manufacture of coke, refined petroleum products and nuclear fuel, manufacture	70.000	10.000	40.000
dh_di Manufacture of rubber and plastic products, manufacture of other non-metallic mineral proc	51.000	6.000	29.000
dj Manufacture of basic metals and fabricated metal products	48.000	25.000	25.000
dk Manufacture of machinery and equipment n.e.c.	68.000	16.000	29.000
dl Manufacture of electrical and optical equipment	69.000	10.000	36.000
dm Manufacture of transport equipment	56.000	5.000	34.000
dn Manufacturing n.e.c.	48.000	4.000	17.000
e Electricity, gas and water supply	35.000	14.000	31.000
g_to_q Services	40.000	6.000	24.000
g51 Wholesale trade and commission trade, except of motor and motorcycles	34.000	5.000	22.000
i60_to_i62 Land transport; transport via pipelines; water transport; air transport	24.000	13.000	15.000
i642 Telecommunications	65.000	13.000	46.000
j Financial intermediation	54.000	6.000	23.000
k72 Computer and related activities	68.000	4.000	34.000
k742 Architectural and engineering activities and related technical consultancy	55.000	4.000	24.000

Source: Own elaboration from EUROSTAT 2002

With this criterion three sectors were selected:

- o Manufacture of coke, refined petroleum products and nuclear fuel, manufacture of chemicals, chemical products and man-made fibres.
- o Manufacture of electrical and optical equipment.
- o Telecommunications.

Nevertheless as the data used for the previous table were for the 15 European Countries (Eurostat 2002), I wanted to contrast which ones will be the selected sectors in the case that the same criteria will be applied country by country. The results obtained in this case can be seen in the Table 12.

Table 12: Sector's selection in the EU countries for the study of interactions (2)

	EU	AT	BE	DK	FIN	FR	GER	IR	IT	NET	NOR	PO	SP	SV	UK
Manufacture of food products; beverages and tobacco															
Manufacture of textiles and textile products; manufacture of leather and leather products															
Manufacture of wood and wood products, manufacture of pulp, paper and paper products; publishing and printing															
Manufacture of coke, refined petroleum products and nuclear fuel, manufacture of chemicals, chemical products and man-made fibres															
Manufacture of rubber and plastic products, manufacture of other non-metallic mineral products															
Manufacture of basic metals and fabricated metal products															
Manufacture of machinery and equipment n.e.c.															
Manufacture of electrical and optical equipment															
Manufacture of transport equipment															

	EU	AT	BE	DK	FIN	FR	GER	IR	IT	NET	NOR	PO	SP	SW	UK
Manufacturing n.e.c.															
Electricity, gas and water supply															
Services															
Wholesale trade and commission trade, except of motor and motorcycles															
Land transport; transport via pipelines; water transport; air transport															
Telecommunications															
Financial intermediation															
Computer and related activities															
Architectural and engineering activities and related technical consultancy															

Source: Own elaboration from EUROSTAT 2002

Hence, if we join both analyses, we can see that there is another sector that also could be considered to be important as 7 countries out of 15 get that sector as a result:

- Computer and related activities

This way, the four possible sectors that could be studied due to their interactive features will be:

- Manufacture of coke, refined petroleum products and nuclear fuel, manufacture of chemicals, chemical products and man-made fibres.
- Manufacture of electrical and optical equipment.
- Telecommunications.
- Computer and related activities.

As it will be seen in the next chapter, the next step will be to graph the main nodes of the Network for one out of these sectors in Europe making use of Patent, Publications and Employment data. With these graphs, the territories were the empirical test will be applied will be selected.

Anyway, which out of these sectors will be the one considered to be the most interesting one to be studied? And to get data from?

6.- Future steps in the research

After explaining the main contribution to carry out, the following phases for the research will be shown.

Up to date, two main tasks have been developed. On the one hand, it has been seen that the literature considers interactions to be a key point in the Innovation Systems framework, and an interesting research area to be covered. On the other hand, it has been shown in the Spanish Innovation System, that interactions are crucial for the generation of innovations.

As said before, the next step in the thesis will be to graphic the network of relations produced among the agents that constitute a Sectoral Innovation System (out of the four sectors selected previously) in the European Union. For that, Patents, Publications and the Employment data in the sector will be used.

With this analysis, the main nodes of the whole European network will be seen. The goal of this phase will be then the selection of the main nodes of that network. Thus, these will be the territories where the measures developed through the thesis will be tested.

Fig. 8: Territories' Selection in a Sectoral Innovation Network Analysis

Source: Own elaboration

After having selected both the territories and the sector of analysis, the central aspects of the research will be done:

1.- Study of the literature and state of the art.

The bibliography to be considered can be divided into two main groups. First of all, it will be necessary to identify the main features of interactions in the Innovation Systems, so as to identify the variables that could help to define some measures. Second, both theoretical as empirical studies regarding Innovation Networks should be reviewed to know the state of the art as well as in the construction of simulation models and in the definition and measurement of possible indicators to be used.

2.- Definition of a taxonomy of possible kinds of interaction within an Innovation System.

As exposed above, several approaches provided by many authors intend to identify and classify possible types of interactions produced in Innovation Systems. For the thesis, this will be an essential point, as the level of analysis of interactions will be selected.

3.- Define measures to identify interactions.

Making use of the features observed in the literature regarding Innovation Systems and Networks, the variables considered to be imperative and the taxonomy of the interactions to be used, some measures for interactions might be defined.

4.- *Test in the selected sector and territories* if the measures developed get a significant representation of the way interactions are produced within Innovation Systems.

7.- Main conclusions and expected results

Along the paper, many aspects related to the Innovation Systems literature have been shown. Thus, the framework where the research will be developed has been detailed, remarking the main areas where future researches could take place. This way, it has been exposed the relevance interactions play within Innovation Systems, and the need to undertake a research in this line.

Recently, many authors have defined a new approach in the Innovation Systems framework, through Innovation Networks. Their evolution, definition and some of the empirical research works done lately have been detailed.

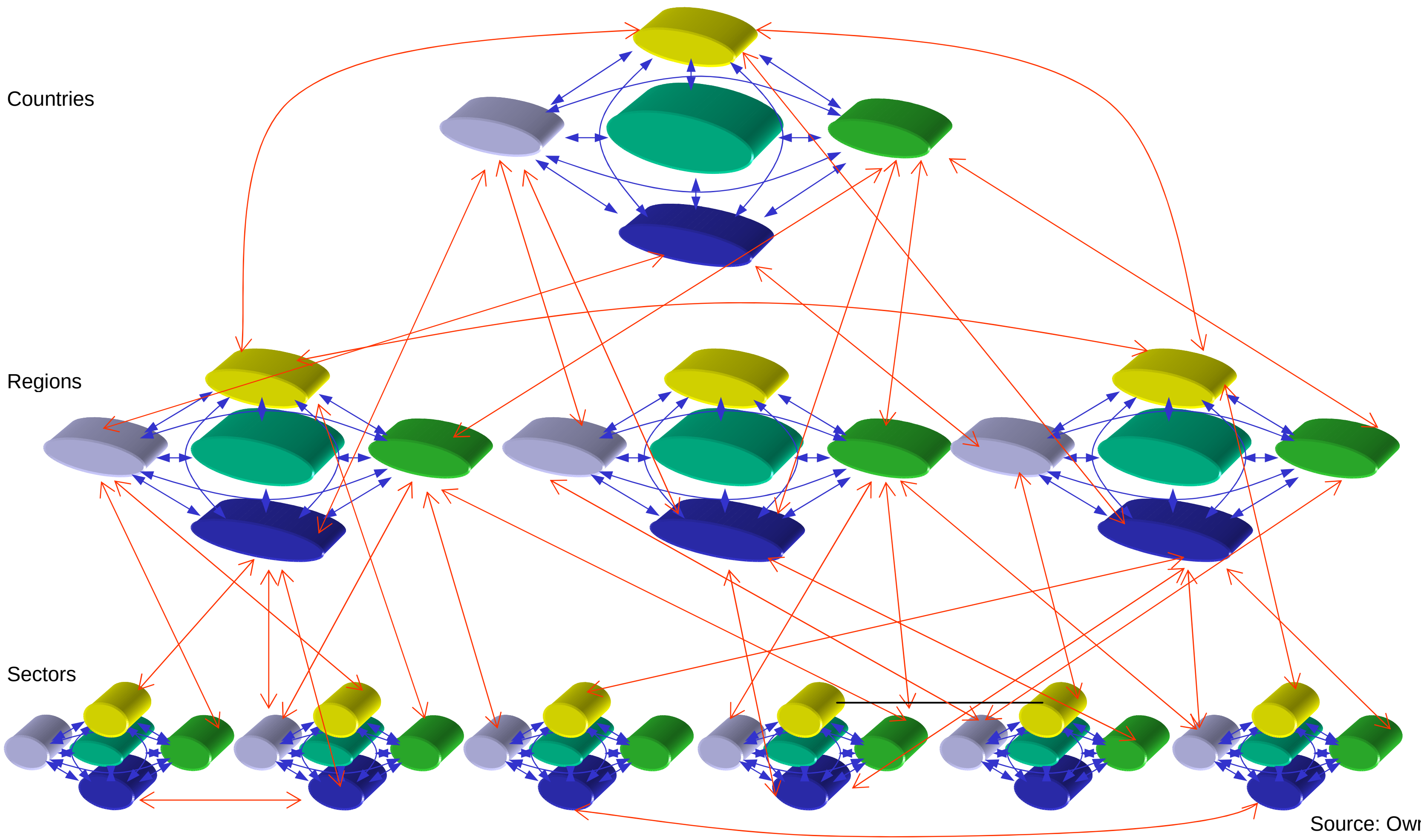
As the main goal of the thesis consists of measuring and analyzing the interactions produced within Innovation Systems, one of the expected results of this research will be the development of a methodology that allows measuring these interactions. This way, with this method, the knowledge about Innovation Systems could be increased.

The reason for this research is the definition of interactive measures not only among the actor in a National Innovation System but also among actors belonging to different countries. This is the reason why the measures to be defined should also have a relation with the special dimension (see Fig. 9). With this Innovation Systems' model it would be possible to reflect the openness degree in the Innovation Systems, as these are considered to be "open and dynamic".

With this model it is also possible to analyze an Innovation System from several points of view, national, regional, sectoral, local, etc.

To conclude, the main contributions that could be expected with the thesis will be in the first place focused on the development of Science and Technology indicators by means of measures that could be helpful to know how interactions are produced in the Innovation Systems, and second, to the design and implementation of more efficient Science, Technology and Innovation Policies so as to increase the competitiveness of Innovation Systems.

Fig. 9: Interactive and Open model of Innovation Systems



Source: Own elaboration.

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