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"Analysis and Measurement of Interactions in Innovation Systems: A Corporative and Sectoral approach."

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Abstract

Innovation Systems constitute an analysis framework, which allows comprehending the socio-economic structure of a territory. In this context, and due to the importance of interactions, the present research intends to contribute a methodology and a set of indicators which help to increase the knowledge about these interactions, and their impact on the innovative capacity of the territories.

The methodology developed will be tested in a multisectoral industrial sector, the Mondragón Cooperative Corporation (MCC) located in the Basque Country. This way, not only the measures defined but also the differences among the Networks that constitute its different sectors will be observed.

Keywords:

Innovation Systems, Interactions, Innovation Networks, Measures, Mondragón Cooperative Corporation.

JEL codes: O31, O32, R11.

1.- Introduction

Innovation Systems (Freeman, 1987; Lundvall ed., 1992; Nelson ed., 1993; Edquist ed., 1997) constitute an analysis framework which allows studying the socio-economic structure of a territory. This approach is based to a great extent on the interactive learning theory (Lundvall ed., 1992). This general theory is mainly focused on the relations produced among the agents within a System. Hence, the Innovation Systems framework consists of analyzing the existence of actors in a given territory (institutions, universities, industries…) their main competences, and the interactions into Innovation Networks that occur among them (Olazarán and Gómez Uranga eds., 2000; Pyka and Küppers eds., 2002), endowing authorities of a tool that allows the construction of more competitive and efficient Innovation Systems.

Interactions among the agents in an Innovation System are considered to be one of the key points in the Innovation Systems literature (Freeman, 1987; Lundvall ed., 1992; Nelson and Rosenberg, 1993; Edquist ed., 1997). Within Innovation Systems, many sorts of interactions can be found (Inzelt, 2004). Hence, it becomes necessary to define what it is understood as an interaction among some agents. In this case, the interactions studied will be the ones among Industries, Universities and Technology Centres (see chapter five). So as to undertake this analysis, some indicators such as joint research projects, joint publications, mobility of personnel, etc. will be defined and contrasted (see Annex2).

This way, the main goal of the present research (see chapter four) will consist of developing a methodoly and a set of measures that help not only to increase the knowledge in the Innovation Systems framework, but also deepen in the study of the relevance of interactions and co-operation activities, and their impact on the growth and efficiency of Innovation Systems.

To get this objective, the empirical set will be carried on a Multisectoral Industrial Group, the Mondragón Cooperative Corporation (MCC) at the Basque Country. This way, with the study of this industrial group, it will be offered an interesting empirical knowledge about the way of behaving of the Basque Innovation System, with its main strengths and weaknesses (Fdez. de Lucio et al., 2000), as the Mondragón Cooperative Corporation is its most relevant industrial group (see chapter five).

Apart from the later, with the methodology developed and the indicators used to understand the Innovation System's some recommendations could also be extracted to improve the competitiveness and efficiency of that Inovation System.

In the second chapter of the paper, a revision of the state of the art is done. On it, not only the Innovation System framework will be described from a theoretical point of view, but also regarding the literature related to Innovation Networks, and some of the last empirical efforts done in that field.

In the third chapter, a recent research done tries to illustrate the impact of the interactive behaviour in the generation of innovations. For that, innovation related data for 17 European Countries, in 1996 and 2000 (EUROSTAT database CIS 2 and 3) have been collected, relating inputs – outputs – co-operation indicators.

In the fourth chapter, the main objectives of the thesis are defined, its main reasons, as well as some of the main hypothesis and research questions formulated.

In the fifth chapter, as recently commented, the main features concerning the Mondragón Cooperative Corporation (MCC) as well as the way the empirical test will be developed on it will be shown.

To conclude, in the last chapters, the future steps to be undertaken will be exposed jointly with the main results expected to be obtained with the research, as well as some conclusions of the work done up to date.

2.- State of the art

All along this chapter, the evolution of the Innovation Systems approach will be shown. Thus, and acording to the related literature, both definitions to facilitate its comprehension and the main reasons justifying the need to undertake a further research analyzing and measuring interactions in Innovation Networks will be offered.

In the 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).
- “We define the concept of RIN 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)

According to the previous definitions, we can conclude that Innovation Systems are considered to be open, dynamic and social (Lundvall ed., 1992), what means that innovations are produced as a result of the social interaction among the the economic actors (Olazarán and Gómez Uranga eds., 2000). This is, a system interacting with its surrounding environment (den Hertog et al, 1995).

Lundvall (ed., 1992) cites Boulding’s (1985) system definition, considering it as any thing that is not chaos, and emphasizing that a system is constituted by some elements and their relations.

Jointly with the National Innovation System approach (Lundvall ed., 1992; Nelson ed., 1993; Edquist ed., 1997), 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 an alternative model for the study of the strengths of Innovation Systems (Chang and Shih, 2004), can be also considered.

Nevertheless, according to the definitions of these last approaches, we can see how the main ideas behind are coincident to a great extent:

- “We define technological systems as a networks or networks of agents interacting in a specific technology area under a particular institutional infrastructure to generate, diffuse and utilize technology. They consist of dynamic knowledge and competence networks” (Carlsson and Stankiewicz, 1991).

As the previous literature agrees, interactions are considered to be crucial in the development of innovations, interactive learning (Lundvall ed., 1992) and technology transfer. However, there is still a lot of work to do in this field, despite networks are one of the key terms in the definition of a system (Saviotti, 1997; Olazarán and Gómez Uranga eds., 2000).

Networks represent a mechanism for the diffusion of innovations by means of co-operation activities and interactions. Interactions within a network not only favour the interchange of products and services, but also the technologic and knowledge transfer (Freeman, 1991, Zuscovitch and Justman, 1995; Vázquez Barquero, 1999; Pyka and Küppers, 2002).

By studying the relationships among the actors in a network, it is possible to draw a more dynamic picture of the system’s boundaries apart from enabling a better capture of some process related to inter-firm interrelations (Tappi, 2003).

As the future economic growth is more and more dependent on the relation of Science and Industry, a deeper study of the rapid growth in the linkages between industries and universities becomes neccesary (Etzkowitz, 1994; Andersen, 1997). Thus, networks can be considered as a useful tool to explain some phenomenon such as the dynamics of the Local Productive or Innovation Systems (Vázquez Barquero, 1999).

According to the Innovation and Social Networks related literature, an Industrial Network (Hakansson and Johanson, 1993) is constituted by actors such as industries, human, natural and other sources, economic activities and their relations. In this sense, a network can be defined as “a long-term relationship of different partners who co-operate on the same hierarchical level in an environment of mutual understanding and trust” (Karlsson and Westin, 1994; Koschatzky, Kulicke and Zenker eds., 2001).

Innovation Networks are a special kind of the later. Hence, Innovation Networks are understood as:

- "organizational forms between the market and the hierarchy which serve for information, knowledge and resources exchange and which help to implement innovations by mutual learning between the network partners" (Fritsch et al. 1998).
- "interaction processes between a set of heterogeneous actors producing innovations at any possible aggregation level (national, regional, supranational)." (Pyka and Küppers, 2002)

According to this late viewpoint, innovations can only be implemented by means of co-operation activities among the different actors (DeBresson and Amesse, 1991) and their relation with the surrounding environment (den Hertog et al., 1995; Vázquez Barquero, 1999).

The interchange of knowledge, information and other sources among different agents, involve an increase in the competitiveness of industries (Vázquez Barquero, 1999). Hakansson and Johanson (1993) point out that the structure of an industrial network depends on the interactions produced among its constituting agents and activities.

Let's focus now the attention on a regional (or even local) level. Innovation is also considered a territorial phenomenon (Asheim and Isaksen, 2000). This means that innovation can be estimulated by the co-operation among the local agents and the particular set of sources that can be found at that place (Olazarán and Gómez Uranga eds., 2000). Despite many authors say that networks might be international in their character, there are some reasons to believe that they do also have a strong regional (or local) dimension (Breschi and Malerba, 1997; Carlsson and Jacobson, 1997). I will come back to this later (see chapter 4), as this constitutes one of the most important questions of this research.

On the other hand, for Niosi and Bellon (1994) who have developed the notion of "Open National Systems of Innovation" "all NSIs are open to a different degree, and the links between national systems and the dynamics of their interdependence are keys to understanding their national characteristics". They argue that three types of Innovation Systems (regional, national, and international) coexist and compete with each other.

As they state, “internationalisation grows but does not suppress local and national networks; it modifies their functioning, however since some previously regional or national activities are transferred to international networks”. As a consequence of this, it is not only relevant to study how, in which direction, for which goals... are interactions produced, which will allow us to better understand the dynamics of Innovation Systems, but also to offer objective and consensued measures for them.

In this sense, interactions and consequently networks differ a lot among themselves, so that to understand their “meaning”, it becomes necessary to categorize them. In the literature it is possible to find some interesting taxonomies.

Interactions can be whether formal, this is explicit, and obeying to decissions that pretend some estrategic objectives, or informal, this is, tacit and spontaneous, such as the personal contacts among people, industries, university staff...(Vázquez Barquero, 1999).

Archibugi and Iammarino, (1999, p.p 247, Table 12.2) relate some categories of innovations (International exploitation of nationally produced innovations, global generation of innovation by MNEs and Global Techno-Scientific collaborations) with their possible sort of co-operations that could be produced within each one of them according to three posible options: Firm-Firm, Government-Government, Government-Firm relations.

Lorenzen and Foss (2003) find four possible different categories of interactive situations:

- downstream situations with agents or retailers (only faced by end producers)
- upstream situations with non-specialised suppliers
- upstream situations with specialised suppliers
- horizontal situations

Guerrieri and Tylecote (1997), in turn, consider three kinds of management interaction:

- Functional; among the different functions and departments within the firm.
- Vertical; up and down the line of command and among the different level of management, as far as the lowest employee.
- External; with other organizations.

Last, Koschatzky (2002) divides the category into three main parts:

- Cooke and Morgan (1993)
    - Intra-industry networks
    - Inter-industry networks
- DeBresson and Amese (1991)
    - User-Supplier Networks
    - Pioneer-Adoptant networks within a sector
    - Inter-Industrial regional Networks
    - International strategic alliances in new technologies
    - Inter.-organizational networks for the enhancement of new technologies
- Freeman (1991)
    - Joint ventures and research projects
    - Mutual agreements on R&D
    - Agreements for the technological exchange
    - Direct investments induced by technologies
    - License agreements
    - Subcontracting
    - Supplier Networks
    - Research Networks
    - Research projects promoted by the public administration
    - Electronic data Banks
    - Networks for the technologic and Scientific exchange

Strongly related to this late work, another very interesting paper offering an exhaustive taxonomy of the posible interactions that can be produced within an Innovation System can be found (Inzelt, 2004). This paper deals with the transformation of relationships between business and universities. Several modes of interaction are described and a very brief discussion about their measurement is also offered. This last point will be considered on the sixth chapter of the paper (see also Annex 2) where some indicators concerning interactive activities are offered.

The last part of this second chapter, will offer a very brief review of some research works concerning the measurement of interactions within the Innovation Systems framework. Thus, for the case of the Regional Innovation System of Baden Württemberg, seven types of interaction (links between SMEs and KIBS, SMEs and ITI, KIBS and ITI, SMEs and Large Manufacturers, KIBS and Large Manufacturers,

KIBS and Service firms, SMEs and Service Firms) have been studied by means of the following measures (Muller, 2001):

- The type of knowledge involved,
- Spatial patterns of the considered interactions,
- Influence in terms of firm's innovations.

Revilla Díez (2001) analyzed the types of co-operation produced in ten European regions such as Barcelona, Vienna and Stockholm by means of: 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 very similar study (but my means of a simulation model), is the one developed by Pyka, Gilbert and Ahrweiler (2002). Almost the same occurs with an empirical work about the inter-industry co-operation on innovation projects in Spain (Navarro Arancegui, 2002) which studies the innovative industries that co-operate in innovation projects according to their size, sectors, types of co-operation, the partners they co-operated with, and their technological level.

Pleschak and Stummer (2001) analyze the competitiveness through innovation in the 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. A similar study to the later also done in Germany (Koschatzky, 2003) measures the interactive potential of five German regions and their degree of co-operation, according to their length and intensity, the established relation, the main obstacles found, and the amount of projects and new organizations created.

To end up with these works, a group of researchers from the Tokio University (Baba et al., 2004), based on patent data show the graphic structure that Innovation Networks adopt in the case of the Tokio University, with the main hubs and their evolution in the 1995-2002 period.

As it has been shown, some initial efforts are being made to analyze the impact of Innovation Networks on the Innovative Capacity. However, as pointed out previously and as it is also remarked by some authors, there is still a lot of research to be done in this field. To show this lack of measures, a pilot study done in the Netherlands (den Hertog et al., 1995), aimed at identifying methods and a set of relevant indicators to asses and analyse the study of Innovation Systems. As it is strongly pointed out, “in a 1995 white paper... the philosophy behind... is the promotion of increased collaboration amongst firms and between firms and technology suppliers. Such an approach acknowledges the importance of networking and interfirm linkages as a vehicle for the diffusion of knowledge... There clearly are some considerable gaps in the available statistical data. These are for instance no or hardly any data available on relevant themes such as mobility of R&D personnel, importance of interaction between users and producers, importance of the property right system, participation in standardisation activities and the degree to which the university knowledge base is used by business firms. Identifying regular statistics on the themes like the specific advantages in transfer and engineering sciences, research co-operation within firms, learning taking place in relations between HEIs and firms and finally R&D co-operation and other forms of co-operation between universities and industry, proved to be difficult as well” (den Hertog et al., 1995).

This aspect is coincident with the one by Inzelt (2004), who agrees that “traditional science and technology statistics are not in themselves adequate... innovation activity and knowledge interaction may be based on the results of R&D statistics, innovation surveys and studies concerning exchanges and networks between science and industry.”

Nevertheless, some interesting indicators grouped into four main groups (Intra-firm knowledge flow indicators, Inter-firm knowledge flow indicators, HEIs – firms knowledge flow indicators, RTOs-firms knowledge flow indicators) are offered for the measurement of knowledge flows between actors (den Hertog et al., 1995), which could also be helpful for the study of Innovation Networks (see chapter six):

Apart from these useful indicators, some other stilized facts are also marked, and which could be considered for the definition of new indicators regarding Innovation Networks. (i.e. R&D co-operation with customers, suppliers, HEIs and RTOs, period, intensity and magnitude of the co-operation, distribution between co-operation with national or international partners, show wether co-operation is a well established

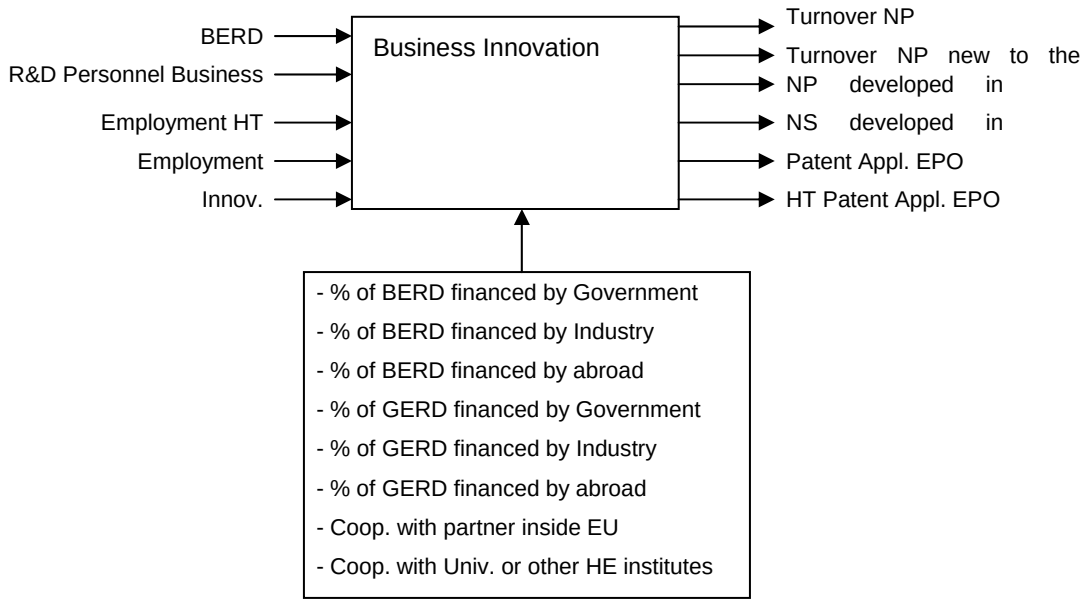
phenomenon or a one-time experience, information sources used for innovation - user-supplier interactions, intra and inter-firm information exchange, informal interactions -).

As it will be shown to a higher extent on the fourth chapter, this is the framework where this research is located at, and where some new contributions are expected as a result of that research.

3.- Relevance of Interactions for the generation of Innovations

For the development of this chapter, a simple model is run with some indicators from the Eurostat regarding the Community Innovation Surveys (CIS) 2 and 3. As it can be seen in the Fig 1. data for 19 indicators have been collected for 17 European Countries in 1996 and 2000. The results obtained, after some factor and regression analysis for these data can be seen in Annex1.

Fig.1: Model developed



In the regression analysis, on the one hand, we can see that for the “Generation of new products and services” (Output1), those co-operation activities to get R&D funds from abroad and for Government and Industry are quite relevant, whilst those co-operation activities developed with Universities and other HEIs and with other agents inside Europe do not have almost any relevance.

On the other hand, for the “Generation of EPO patents” (Output2), all the factors concerning co-operation activities are relevant, being those co-operation activities to get funds for R&D from Government and Industry the most important ones.

With this simple exercise, it is possible to see how not only interactions are considered to be a key point in the Innovation Systems framework according to the existing literature, but also from an empirical point of view (in this case, considering interactions as co-operation activities depending on the agents co-operating with and the origin of funds).

4.- Research Questions

Once the theoretical approach has been presented and the relevance of interactions within that framework has been shown according both to a conceptual approach (see chapter 2) and another with a higher empirical character (see chapter 3), the main questions as well as the hypothesis formulated in the research will be shown subsequently.

With this research, the expected contribution to the state of the art will be:

> “Development of a methodology and a set of measures regarding the interactions produced among the agents that constitute an Innovation System, to better comprehend the Innovation Systems framework, and thus, determine to what extent interactions constraint the Innovation Capacity and efficiency of territories”.

To get this aim it is also to formulate some hypothesis, which should be confirmed or rejected along the research according to the empirical evidence to be developed.

- The interactions produced within an Innovation System, influence on its Innovation Capacity and Efficiency.
- Which is the Innovation model that better adapts to the Mondragón Cooperative Corporation (MCC)? Linear, interactive… or a new Innovation System?
- Might the Mondragón Cooperative Corporation (MCC) be considered as an Innovation System, according to the interactive behaviour of its constituent agents?

- Where are the main agents the MCC interacts with from? Are most of these interactions produced within the MCC or with "foreign" agents (Kautonen, 2000; Koschatzky and Bross, 2001)
- According to the agents collaborating with to get Innovation related goals, what sort of Innovation Networks can be found within the MCC? Which are their objectives (Koschatzky, 2002; Inzelt, 2004)?
- Do the spatial context and the sector of performance influence on the interactive activities (Carlsson and Jacobson, 1997)?
- What sort of interaction (competitive, co-operative) is predominant at the MCC?

5.- Empirical framework for the research

The empirical testing of the research will be developed at the Mondragón Cooperative Corporation (MCC). MCC began its activities in 1956 in Mondragón (Basque Country). It currently consists of 218 entities committed to the creation of a greater social wealth, divided into three groups: Financial, Industrial and Distribution, jointly with Research and Education areas.

Nowadays, the MCC is the most important industrial group in the Basque Country and the seventh in the ranking of top companies in Spain, with about 70.000 employed people all over the world (49% of the total employment at the Basque Country, 39% in Spain, and 12% all over the world). Despite most of its plants are located at the Basque Country, some firms can also be found in Mexico, Brazil, France, Poland, Czech Republic, India, China and Thailand among others.

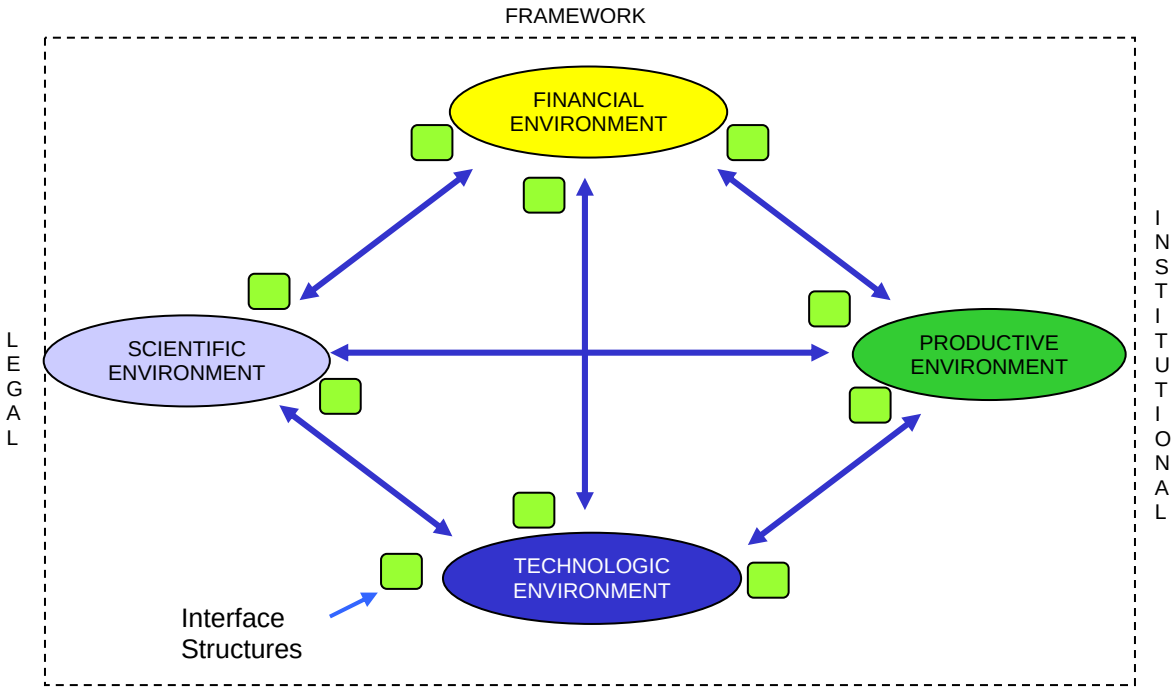
The corporative objectives defined for the 2005-2008 period regarding Innovation activities are:

- 33% of the total sales due to new products and services.
- 10 new spin-offs in new emerging sectors
- Dedicate >6% of the Gross Added Value to Innovation Expenditures
- Develop 100 patents
- Develop 8 new Technology Centres

To carry on the analysis described in the previous chapter, a model concerning Innovation Systems will be followed (Fig.2). According to this model (Fernández de Lucio and Castro, 1995), each of the agents of MCC will be positioned in a determined environment, depending on their activities.

Hence, the banks and other financial entities will be positioned in the Financial Environment, the firms in the Productive Environment, the Technology Centres and other Research Organizations in the Technological Environment, and last Universities and other sources for the development on new knowledge in the Scientific Environment.

Fig.2: A model concerning Innovation Systems



Source: Fernández de Lucio and Castro (1995).

According to this map, the next steps of the research will consist of analyzing the links not only among those actors within the MCC but also with the rest of the world. For that analysis, some possible indicators have been defined (see Annex 2).

With this set of indicators, a better knowledge about the way Innovation activities are developed in an industrial group as the one analyzed is expected. Related to this, according to the indicators defined and the measures obtained, the research is expected to contribute with a methodology for the study of interactions within the Innovation Systems framework. This way, it will be shown empirically whether interactions among different agents are factors hampering competitiveness or not.

In this research, the main focus will be the interactions produced among Universities, firms and Technology Centres, this is, Scientific, Productive and Technologic environments.

6.- Future steps of the research

As it has been commented in the previous chapter, the 218 businesses that currently constitute the MCC have been positioned at the four environments of the model to be used along the research (Fernández de Lucio and Castro, 1995).

At the moment, and according to the indicators defined (Annex 2) for the study of interactions, the definition of a survey is in progress, with questions about R&D and innovation related activities. Once this survey is finished, it will be distributed to the whole amount of organizations. Apart from that, in some particular firms ad hoc visits will be done in order to study their innovation processes from the inside, trying to capture their vision about the future of the MCC related to R&D and Innovation.

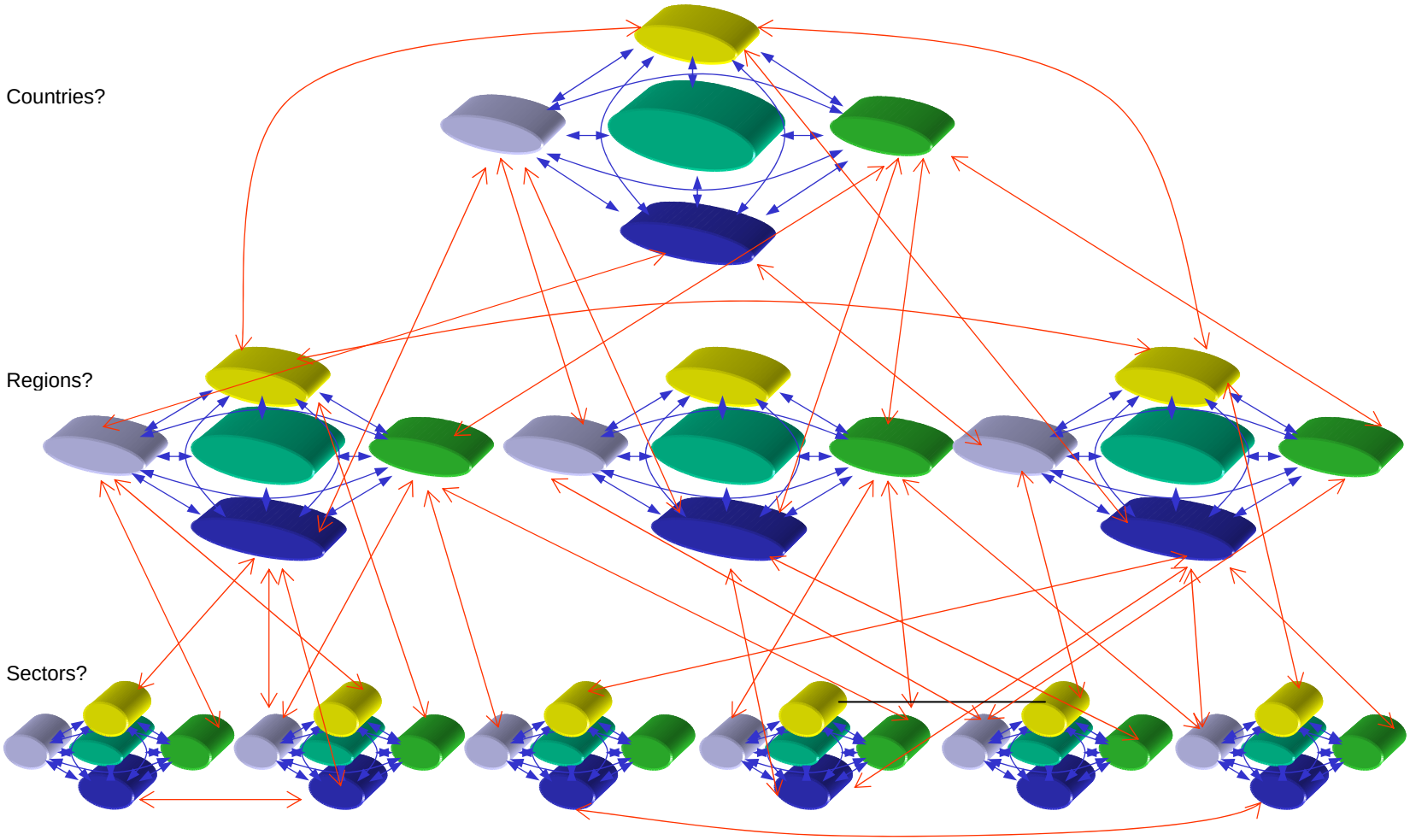
Once all the surveys have been collected, they will have to be deeply studied, so that after some statistical analysis, some interesting issues that could complement the Innovation Policy of the MCC could be defined and transmitted to the corporation.

Due to the special features of the MCC (as it is nor a National, Regional, Sectoral… Innovation System) a new model concerning Innovation Systems is expected to be defined, with a special emphasis on interactions among different actors (see Fig.3). With this model it would be possible to reflect the openness degree of a System, apart from the possibility to analyze Innovation Systems from several points of view, national, regional, sectoral, local, etc.

This need of developing a new model of Innovation is also emphasized by Etzkowitz (1994), who says that: “we need a spiral model with feedback loops at different points: going from basic research to product development, from product development to creating new lines of research... A “spiral model” of interaction in both directions, with cooperative arrangements between university and industry at various stages of research, development and innovation…”. Maybe this new model could contribute to this later need.

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

Fig. 3: An Interactive and Open “Spiral” model of Innovation Systems.



Source: Own elaboration

7.- Conclusions

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. This way, it has been exposed the relevant role that 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 also 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. The reason for this research is the definition of interactive measures among actors belonging to different systems (countries, regions, sectors…).

According to the literature, there is a growing need to define a series of measures that allow predicting changes in the Innovative Capacity beyond the indicators employed in the linear model. The same way, some other needs to measure other processes such as the ones related to the institutional relations and the creation of networks so as to be able to evaluate the innovation policies have also been identified (Archibugi, Howells and Michie, eds., 1999; Zenker, 2001; Landabaso, Oughton and Morgan, 2001). This is confirmed by the fact that policies to support innovation, such as RIS (Regional Innovation Strategies); RTP (Regional Technology Programmes); RITTS (Regional Innovation Technology Transfer Strategies), etc… are being defined.

Systems are developed following different historic and technologic trajectories, so that their dynamic analysis and the study of their interactions becomes necessary, in order to understand the evolution of the Innovation Systems, and the main changes produced in the design and development of current and future Innovation Policies.

Relevant References

- Andersen, E. S., 1997. Innovation Systems: Evolutionary Perspectives, in Edquist, C. (ed.). *Systems of Innovation: Technologies, Institutions and Organizations*. London. Pinter, p.p. 174-179.
- Archibugi, D., Howells, J., Michie, J. (eds.), 1999. *Innovation Policy in a Global Economy*. Cambridge, Cambridge University Press.
- Archibugi, D., Iammarino, S., 1999. The policy implications of the globalisation of innovation, in Archibugi, D., Howells, J., Michie, J. (eds.). *Innovation Policy in a Global Economy*. Cambridge, Cambridge University Press, p.p. 242-271.
- Asheim, B.T,. Isaksen, A., 1997. Location, agglomeration and innovation: towards regional innovation systems in Norway, *European Planning Studies*, 5(3); p.p. 299-330.
- Asheim, B.T,. Isaksen, A., 2000. Los sistemas regionales de innovación, las PYMEs y la política de innovación, in Olazaran, M., Gómez-Uranga M. (eds.). *Sistemas Regionales de Innovación*. Servicio Editorial de la Universidad del País Vasco, p.p. 93-114.
- Baba, Y., Yarime, M., Shichijo, N., Nagahara, Y., 2004. The Role of University – Industry Collaboration in New Materials Innovation: Evolving Networks of Joint Patent Applications. *Paper prepared for the International Schumpeter Society Conference "Innovation, Industrial Dynamics and Structural Transformation: Schumpeterian Legacies"*, Bocconi University, Milan 9-12 June, 2004.
- Boulding, K.E., 1985. *The World as a Total System*, Beverly Hills, Sage Publications.
- Breschi, S., Malerba, F., 1997. Sectoral Innovation Systems: Technological Regimes, Schumpeterian Dynamics, and Spatial Boundaries, in Edquist, C. (ed.). *Systems of Innovation: Technologies, Institutions and Organizations*. London. Pinter, p.p. 130-156.
- Carlsson, B., Jacobson, S., 1997. Diversity Creation and technological Systems: A Technology Policy Perspective, in Edquist, C. (ed.). *Systems of Innovation: Technologies, Institutions and Organizations*. London. Pinter, p.p. 266-294.
- Carlsson, B., Stankiewicz, R., 1991. On the nature, function and composition of technological systems. *Journal of Evolutionary Economics*, 1(2); p.p. 93-118.
- Chang PL., Shih, HY., 2004. The Innovation Systems of Taiwan and China : A Comparative Analysis, *Technovation,* Volume 24, Issue 7, July 2004, p.p. 529-539.
- Cooke, P., Morgan, K., 1993. The Networks Paradigm: New departures in corporate and Regional Development, *Society and Space*, 11; p.p. 543-546.
- Cozzens, S., Healey, P., Rip, A., Ziman, J. (eds.), 1990. *The Research System in Transition*. Kluwer Academic Publishers, Boston.
- DeBresson, C. and Amesse, F., 1991. Networks of innovators. A review and introduction to the issue, *Research Policy*, 20; p.p. 363-379.
- den Hertog, P., Roelandt, Theo J.A., Boekholt, P., van der Gaag, H., 1995. *Assesing the Distribution Power of National Innovation Systems Pilot Study: The Netherlands*. Apeldoorn, TNO.

- Edquist, C. (ed.), 1997. *Systems of Innovation: Technologies, Institutions and Organizations*. London. Pinter.
- Etzkowitz, H, 1994. .Academic-Industry Relations: A sociological Paradigm for Economic Development, in Leydesdorff, L. and van den Besselaar, (eds). *Evolutionary Economics and Chaos Theory: New directions in Technology Studies*, St. Martin's Press, New York, p.p. 139-151.
- Eurostat 2002 Database. Community Innovation Surveys 2 and 3. http://epp.eurostat.cec.eu.int/portal/page?_pageid=1090,1137397&_dad=portal&_schema=PORTAL
- Fernández de Lucio, I., Castro, E., 1995. La nueva política de articulación del Sistema de Innovación en España. VI Seminario Latinoamericano de Gestión Tecnológica, ALTEC, Concepción (Chile).
- Fernández de Lucio, I., Gutiérrez, A. Jiménez, F., Azagra, J., 2000. Las debilidades y fortalezas del sistema valenciano de innovación, in Olazarán, M., Gómez-Uranga M. (eds.). *Sistemas Regionales de Innovación*. Servicio Editorial de la Universidad del País Vasco, p.p. 251-278.
- Freeman, C., 1987. *Technology Policy and Economic Performance: Lessons from Japan,* London: Pinter.
- Freeman, C., 1991. Networks of innovators: A synthesis of research issues, *Research Policy*, 20; p.p. 499-514.
- Fritsch, M., Koschatzky, K., Schätzl, L., Sternberg, R., 1998. Regionale Innovationspotentiale und innovative Netzwerke, *Raumforschung und Raumordnung*, 56, p.p. 243-252.
- Guerrieri, P., Tylecote, A., 1997. Interindustry Differences in Technical Change and National Patterns of Technological Accumulation, in Edquist, C. (ed.). *Systems of Innovation: Technologies, Institutions and Organizations*. London. Pinter, p.p. 107-129.
- Hakansson, H., and Johanson, J., 1993. The Network as a Governance Structure. Interfirm cooperation beyond markets and hierarchies, in Grabher, G. (ed.), *The embedded firm. On the Socioeconomics of industrial networks*, Routledge, London, p.p. 35-51.
- Inzelt, A., 2004. The evolution of university-industry-government relationships during transition. *Research Policy*, 33, p.p. 975-995.
- Karlsson, C. and Westin, L., 1994. Patterns of a Network Economy – An Introduction, in Johansson, B., Karlsson, C., Westin, L., (eds.) *Patterns of a Network Economy*. Berlin, Springer, p.p. 1-12.
- Kautonen, M., 2000. El Sistema de innovación regional desde la perspectiva de las trayectorias tecnológicas, in Olazaran, M., Gómez-Uranga M. (eds.). *Sistemas Regionales de Innovación*. Servicio Editorial de la Universidad del País Vasco, p.p. 135-156.

- Koschatzky, K., Bross, U., 2001. Innovation Networking in a Transition Economy: Experiences from Slovenia in Koschatzky, K., Kulicke, M. and Zenker, A. (eds.). *Innovation networks: Concepts and Challenges in the European Perspective*, Heidelberg, Physica-Verlag, p.p. 127-152.
- Koschatzky, K., Kulicke, M., Zenker, A. (eds.), 2001. *Innovation networks: Concepts and Challenges in the European Perspective*, Heidelberg, Physica-Verlag.
- Koschatzky, K., 2002. Fundamentos de la Economía de Redes. Especial Enfoque a la Innovación. *Revista Economía Industrial,* 346; p.p. 15-26.
- Koschatzky, K., 2003. Entrepreneurship Stimulation in Regional Innovation Systems – Public Promotion of University-based Start-Ups in Germany, in Fornhal, D. and Brenner, T. (eds.). *Cooperation, Networks and Institutions in Regional Innovation Systems,* Cheltenham, Edward Elgar, p.p. 277-302.
- Landabaso, M. Oughton, C., Morgan, K., 2001. Innovative Networks and Regional Policy in Europe, in Koschatzky, K., Kulicke, M. and Zenker, A. (eds.). *Innovation networks: Concepts and Challenges in the European Perspective*, Heidelberg, Physica-Verlag, p.p. 243-273.
- Lorenzen, M., and Foss, N.J., 2003. Cognitive Coordination, Institutions and Clusters: An Exploratory Discussion, in Fornhal, D., Brenner, T. (eds.), *Cooperation, Networks and Institutions in Regional Innovation Systems,* Cheltenham, Edward Elgar, p.p. 82-104.
- Lundvall, B.-A. (ed.), 1992. *National Systems of Innovation. Towards a Theory of Innovation and Interactive Learning*. London. Pinter.
- Mondragón Corporación Cooperativa, MCC. http://www.mondragon.mcc.es/
- Muller E., 2001. Knowledge, Innovation Processes and Regions, in Koschatzky, K., Kulicke, M. and Zenker, A. (eds.). *Innovation networks: Concepts and Challenges in the European Perspective*, Heidelberg, Physica-Verlag, p.p. 37-51.
- Navarro Arancegui, M., 2002. La cooperación para la innovación en la empresa española desde una perspectiva internacional comparada. *Revista Economía Industrial*, 346; p.p. 47-66.
- Nelson, R.R. (ed.), 1993. *National Innovation Systems: A comparative Analysis*, New York, Oxford University Press.
- Nelson, R.R., Rosenberg, N., 1993. Technical innovation and national systems, in Nelson, R.R. (ed.). *National Innovation Systems: A comparative Analysis*, New York, Oxford University Press, p.p. 3-21.
- Niosi, J., Bellon, B., 1994. The global interdependence of national innovation systems: evidence, limits and implications. *Technology in Society*, 16 (2), p.p. 173-197.
- Olazarán, M., Gómez-Uranga M. (eds.), 2000. *Sistemas Regionales de Innovación*. Servicio Editorial de la Universidad del País Vasco.
- Pilon, S., DeBresson, C., 2003. Local Culture and Regional Innovation Networks: Some Propositions, in Fornhal, D. and Brenner, T. (eds.). *Cooperation, Networks and Institutions in Regional Innovation Systems,* Cheltenham, Edward Elgar, p.p. 15-37.

- Pleschak, F., Stummer, F., 2001. East German industrial research; improved competitiveness through innovative networks, in Koschatzky, K., Kulicke, M. and Zenker, A. (eds.). *Innovation networks: Concepts and Challenges in the European Perspective*, Heidelberg, Physica-Verlag, p.p. 175-189.
- Pyka, A., Gilbert, N., Ahrweiler, P., 2002. Simulating Innovation Networks, in Pyka, A. and Küppers G. (eds.). *Innovation Networks: Theory and Practice*, Cheltenham, Edward Elgar, p.p. 169-196.
- Pyka, A., Küppers G., 2002. The Self-Organisation of Innovation Networks: Introductory Remarks, in Pyka, A. and Küppers G. (eds.). *Innovation Networks: Theory and Practice*, Cheltenham, Edward Elgar, p.p. 3-21.
- Pyka, A., Küppers G. (eds.), 2002. *Innovation Networks: Theory and Practice*, Cheltenham, Edward Elgar.
- Revilla Díez, J., 2001. Innovative Links between Industry and Research Institutes – How Important Are They for Firm Start Ups in the Metropolitan Regions of Barcelona, Vienna and Stockholm? In Koschatzky, K., Kulicke, M. and Zenker, A. (eds.). *Innovation networks: Concepts and Challenges in the European Perspective*, Heidelberg, Physica-Verlag, p.p. 93-108.
- Rip, A., VanderMeulen, B., 1996. The post-modern research system. *Science and Public Policy*, 23(6); p.p. 343-352.
- Saviotti, P.P., 1997. Innovation systems and evolutionary theories, in Edquist, C. (ed.). *Systems of Innovation: Technologies, Institutions and Organizations*. London. Pinter, p.p. 180-199.
- Tappi, D., 2003. On the units of análisis in the study of networks, in Fornhal, D., Brenner, T. (eds.). *Cooperation, Networks and Institutions in Regional Innovation Systems,* Cheltenham, Edward Elgar., p.p. 149-170.
- Vázquez Barquero, A., 1999. *Desarrollo, redes e innovación: lecciones sobre desarrollo endógeno*, Madrid, Ediciones Pirámide.
- Zenker, A., 2001. Innovation, Interaction and Regional Development: Structural Characteristics of Regional Innovation Strategies, in Koschatzky, K., Kulicke, M. and Zenker, A. (eds.). *Innovation networks: Concepts and Challenges in the European Perspective*, Heidelberg, Physica-Verlag, p.p. 207-222.
- Zuscovitch, E. and Justman, M., 1995. Networks, sustainable differentiation, and economic development, in Batten, D., Casti, J., and Thord, R., (eds.). *Networks in Action, Economics and Human Knowledge*, Berlin. Springer-Verlag, p.p. 269-286.
- Zyman, J., 1994. *Prometheus Bound: Science in a Dynamic Steady State*. Cambridge University Press, Cambridge.

Annex 1: Results of the factor and regression analysis to show the relevance of interactions for the generation of innovations

INPUT: Factor Analysis' Results

Varianza total explicada

Componente	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
1	2,147	42,935	42,935	2,102	42,040	42,040
2	1,866	37,310	80,245	1,910	38,205	80,245
3						
4						
5						

Método de extracción: Análisis de Componentes principales.

Matriz de componentes rotados[a]

	Componente	
	1	2
Business (Private) Expenditure on R&D as a percentage of GDP	,129	,946
R&D Personnel on Business Sector	,944	
Percentage of the employment of High Tech Manufactures	,319	,620
Percentage of the employment of Knowledge Intensive Services	-,428	,789
Total innovation expenditures	,954	

Método de extracción: Análisis de componentes principales.

Método de rotación: Normalización Varimax con Kaiser.

a. La rotación ha convergido en 3 iteraciones.

Input1: R&D expenditure and employment in HT sectors

Input2: Human Resources for R&D and Innovation

OUTPUT: Factor Analysis' Results

Varianza total explicada

Componente	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
1	3,883	64,713	64,713	3,883	64,710	64,710
2	1,821	30,357	95,070	1,822	30,360	95,070
3						
4						
5						
6						

Método de extracción: Análisis de Componentes principales.

Matriz de componentes rotados[a]

	Componente	
	1	2
Turnover New products. relating to product innovators	,971	
Turnover of new products also new to the market. relating to product innovators	,990	
New products developed in collaboration with other enterprises	,993	
New services developed in collaboration with other enterprises	,980	
Patents applications to the EPO. per million people in population		,955
High tech patents applications to the EPO. per million people in population		,947

Método de extracción: Análisis de componentes principales.

Método de rotación: Normalización Varimax con Kaiser.

a. La rotación ha convergido en 3 iteraciones.

Output1: Generation of new products and services

Output2: Generation of EPO patents

CO-OPERATION: Factor Analysis' Results

Varianza total explicada

Componente	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
1	3,230	40,372	40,372	2,806	35,079	35,079
2	2,104	26,297	66,669	2,190	27,374	62,452
3	1,705	21,316	87,985	2,043	25,532	87,985
4						
5						
6						
7						
8						

Método de extracción: Análisis de Componentes principales.

Matriz de componentes rotados[a]

	Componente		
	1	2	3
Percentage of BERD financed by government	,257	,525	,297
Percentage of BERD financed by industry	-,894	-,346	-,157
Percentage of BERD financed by abroad	,975	,141	
Percentage of GERD financed by government		,963	-,105
Percentage of GERD financed by industry	-,232	-,917	,124
Percentage of GERD financed by abroad	,960		
Coop with Partner inside the EU			,966
Coop with Universities or other higher education institutes			,983

Método de extracción: Análisis de componentes principales.
Método de rotación: Normalización Varimax con Kaiser.
a. La rotación ha convergido en 4 iteraciones.

Coop1: Coop. to finance R&D from abroad

Coop2: Coop. to finance R&D from Government and Industry

Coop3: Coop. activities

Regression Analysis: Output1=f(Input, Co-operation)

Modelo	R	R cuadrado	R cuadrado corregida	Error típ. de la estimación
1	,988[a]	,976	,952	,10123370

a. Variables predictoras: (Constante), Coop3, Coop1, Input2, Coop2, Input1

ANOVA[b]

Modelo		Suma de cuadrados	gl	Media cuadrática	F	Sig.
1	Regresión	2,071	5	,414	40,425	,000[a]
	Residual	,051	5	,010		
	Total	2,123	10			

a. Variables predictoras: (Constante), Coop3, Coop1, Input2, Coop2, Input1

b. Variable dependiente: Output1

Coeficientes[a]

Modelo		Coeficientes no estandarizados		Coeficientes estandarizados	t	Sig.
		B	Error típ.	Beta		
1	(Constante)	-,176	,067		-2,630	,047
	Input1	,365	,091	,826	4,023	,010
	Input2	-,024	,054	-,044	-,451	,671
	Coop1	-,047	,032	-,105	-1,452	,206
	Coop2	,067	,067	,126	,998	,364
	Coop3	,146	,281	,119	,521	,624

a. Variable dependiente: Output1

Regression Analysis: Output2=f(Input, Co-operation)

Modelo	R	R cuadrado	R cuadrado corregida	Error típ. de la estimación
1	,909[a]	,826	,651	,59087630

a. Variables predictoras: (Constante), Coop3, Coop1, Input2, Coop2, Input1

ANOVA[b]

Modelo		Suma de cuadrados	gl	Media cuadrática	F	Sig.
1	Regresión	8,272	5	1,654	4,738	,056[a]
	Residual	1,746	5	,349		
	Total	10,018	10			

a. Variables predictoras: (Constante), Coop3, Coop1, Input2, Coop2, Input1

b. Variable dependiente: Output2

Coeficientes[a]

Modelo		Coeficientes no estandarizados		Coeficientes estandarizados	t	Sig.
		B	Error típ.	Beta		
1	(Constante)	-,561	,391		-1,434	,211
	Input1	,968	,529	1,009	1,830	,127
	Input2	1,311	,316	1,098	4,145	,009
	Coop1	-,262	,188	-,272	-1,398	,221
	Coop2	,764	,393	,660	1,943	,110
	Coop3	-2,997	1,639	-1,121	-1,829	,127

a. Variable dependiente: Output2

Annex 2: Indicators defined for the measurement of Interactions

Environments	Input/Output	Productive Environment		Technology Environment		Scientific Environment		Interface (intermedium) structures and Institutional indicators	
		Input	Output	Input	Output	Input	Output	Input	Output
Productive Environment	Input	- Business expenditure on R&D - Business expenditure on Innovation - Percentage of firms with intra-firm R&D cooperation, - Percentage of personnel that attended training programmes. - Period and intensity of the co-operation	- Number of suppliers of the same product/service within the network - Type of co-operation with customers and suppliers (who is stronger) - Number of organizations that participate in the same project - Which are the main information sources for innovation? - Does co-operation exist with the main sources for innovation in the development of the new products/services? - Relation between the intensity of co-operation and the product/service life cycle co-operating for - Nº of organizations that cooperate in the		- Number of suppliers of the same product/service within the network - Type of co-operation with customers and suppliers (who is stronger) - Nº of organizations that cooperate in the development of new products and services - Number of organizations that participate in the same project - Which are the main information sources for innovation? - Does co-operation exist with the main sources for innovation in the development of the new products/services? - Number of joint patents - Percentage of		- Number of suppliers of the same product/service within the network - Type of co-operation with customers and suppliers (who is stronger) - Nº of organizations that cooperate in the development of new products and services - Number of organizations that participate in the same project - Which are the main information sources for innovation? - Does co-operation exist with the main sources for innovation in the development of the new products/services? - Number of joint patents - Percentage of		- Number of organizations that participate in the same project - Which are the main information sources for innovation? - Does co-operation exist with the main sources for innovation in the development of the new products/services? - Percentage of personnel that attended training programmes. - Technology balance of payments - Corporation funded R&D expenditure executed by firms - Period and intensity of the co-operation

			development of new products and services - Number of projects in which an organization participates in - Do those foreign capital firms established in a territory co-operate inside or in their origin regions? - Number of joint patents - Type of innovation looking for when co-operating (incremental, radical…) - Percentage of firms with inter-firm R&D cooperation - Technology balance of payments - Percentage of the R&D co-operation developed with customers and suppliers - Percentage of the Innovation co-operation developed with customers and suppliers -		personnel that attended training programmes. - Technology balance of payments - Percentage of the R&D co-operation developed with customers and suppliers - Percentage of the Innovation co-operation developed with customers and suppliers - Technology Centres funded R&D expenditure executed by Firms - Percentage of firms with R&D cooperation with RTOs - Percentage of the R&D co-operation developed with RTOs - Percentage of the Innovation co-operation developed with RTOs - Buying RTOs Research Results from Firms - Period and intensity of the co-operation - Mobility of R&D personnel from RTOs towards industry		personnel that attended training programmes. - Technology balance of payments - Percentage of the R&D co-operation developed with customers and suppliers - Percentage of the Innovation co-operation developed with customers and suppliers - University funded R&D expenditure executed by Firms - Percentage of firms with R&D cooperation with HEIs - Percentage of the R&D co-operation developed with HEIs - Percentage of the Innovation co-operation developed with HEIs - Buying University Research Results from Firms - Period and intensity of the co-operation - Mobility of R&D personnel from Univs towards industry - Employment of Univs members as		

					- Employment of RTOs members as regular consultants		regular consultants - Nº of students from the university involved in firms (projects) -		

Environments	Input/Output	Productive Environment		Technology Environment		Scientific Environment		Interface (intermedium) structures and Institutional indicators	
		Input	Output	Input	Output	Input	Output	Input	Output
Productive Environment	Output		- Number of KIBS, Start-ups, Spin-offs - Degree of renewal of the range of products - Number of new products sent to the market each year - Number of products/services commercialized - % of the turnover sub-contracted	- Relation between the intensity of co-operation and the product/service life cycle co-operating for - Number of projects in which an organization participates in - Do those foreign capital firms established in a territory co-operate inside or in their origin regions? - Type of innovation looking for when co-operating (incremental, radical…) - % of the turnover sub-contracted - Technology Centres' expenditure on R&D – Innovation		- Relation between the intensity of co-operation and the product/service life cycle co-operating for - Number of projects in which an organization participates in - Do those foreign capital firms established in a territory co-operate inside or in their origin regions? - Type of innovation looking for when co-operating (incremental, radical…) - % of the turnover sub-contracted		- Relation between the intensity of co-operation and the product/service life cycle co-operating for - Number of projects in which an organization participates in - Do those foreign capital firms established in a territory co-operate inside or in their origin regions? - % of the turnover sub-contracted - Business funded R&D expenditure executed by Universities -	

Environments	Input/Output	Productive Environment		Technology Environment		Scientific Environment		Interface (intermedium) structures and Institutional indicators	
		Input	Output	Input	Output	Input	Output	Input	Output
Technology Environment	Input			- Number of Technology Centres - Technology Centres' expenditure on R&D - Technology Centres' expenditure on Innovation - Income from privately financed contract research at RTOs			- University funded R&D expenditure executed by Technology Centres - Percentage of RTOs with R&D cooperation with Univs - Mobility of R&D personnel from Univs towards RTOs - Employment of Univs members as regular consultants - Nº of students from the university involved in firms (projects) -		- Corporation funded R&D expenditure executed by Technology Centres
	Output					- Mobility of R&D personnel from RTOs towards Univs - Employment of RTOvs members as regular consultants - Technology Centres funded R&D expenditure executed by Universities			

Environments	Input/Output	Productive Environment		Technology Environment		Scientific Environment		Interface (intermedium) structures and Institutional indicators	
		Input	Output	Input	Output	Input	Output	Input	Output
Scientific Environment	Input					- Number of HEIs - Income from privately financed contract research at universities - Number of foreign students within the territory with inland funds - University expenditure on R&D - University expenditure on Innovation -			- Corporation funded R&D expenditure executed by Universities
	Output						- Number of students outside the territory with inland funds	- Number of joint publications	

Environments	Input/Output	Productive Environment		Technology Environment		Scientific Environment		Interface (intermedium) structures and Institutional indicators	
		Input	Output	Input	Output	Input	Output	Input	Output
Interface (intermedium) structures and Institutional indicators	Input							- Number of Interface Structures (or clusters) - Corporative expenditure on R&D - Corporative expenditure on Innovation	
	Output								- Number of jobs had by an employee - Cualification of the personnel - Number of Project contracts developed with other entities - Relation between the age of co-operations and the type of co-operation - Do exist differences in the type of co-operation among environments? - Distance (km) among the organizations co-operating with - Distribution between co-operation with local, national or international partners - Is co-operation a well

									established phenomenon or a one-time experience? - Do the legal conditions required to stablish innovations – co-operations facilitate the process? (public funding projects) - Rate of external R&D expenditure (share of externally used R&D expenditure in proportion to the total R&D expenditure) - Rate of external R&D financing (share of external order-related R&D financing in proportion to the total R&D expenditure) – Governmental promotion is not considered - Degree of exclusiviness of interactions - Degree of economic growth