Group on Innovation and Technology Policy

The spanish contribution to the discussion of the National Innovation Systems: Overall Policy Implications.

Focus Group: Cluster Analysis

MAPPING KNOWLEDGE FLOWS
IN SECTORAL SYSTEMS OF INNOVATION:
THE CASE OF THE SPANISH ELECTRONICS
AND TELECOMMUNICATION CLUSTER

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Contents

1. Introduction

This research project started at the end of 1996. The aim of the whole project was to assess the knowledge transfer mechanisms between the different institutions of the Electronic and Telecommunication cluster in Spain, following the OECD guidelines.

The study is being developed in two steps. The aim of the first one is to collect all the available statistical data from secondary sources and develop all the possible indicators. During the second one, data is being collected through interviews and surveys so as to develop another set of relevant indicators that were hard to obtain throughout the first phase.

During the first phase of the project we realised that there was an overwhelming lack of statistical information about the system, both at national and sectoral level. Even the recent publications on the Spanish Innovation Survey (INE, 1998) or the Bridging Institutions in Spain (Fernandez de Lucio, 1996) are quite limited if we want to have more information about knowledge transfer between institutions.

Our purpose is to collect quantitative and qualitative data of the stock of knowledge, channels and instruments of knowledge transfer and existing obstacles to the diffusion of knowledge in the system.

Our starting point was the system of innovation approach at the sectoral level. In this sense we were considering not only the Information and Communication Technologies (ICT) industry but also all the institutions involved in Knowledge flows to and from the ICT sector. In this sense we came across the cluster concept.

In we understand a cluster as " *networks of production of strongly interdependent firms (including specialised suppliers), knowledge producing agents (universities, research institutes, engineering companies) and customers, linked to each other in a value adding production chain"* (ROEDLAND, Theo; HERTOG, Pim den (1998)) one could say that the notion of system of innovation at the sectoral level could fit with the cluster approach in a broad sense.

As our objective is to focus on the system of innovation in which the ICT industries are embedded, we used the Input/output analysis as a tool to identify the network of agents linked to the "core" ICT industry, including those who supply knowledge to the system. In this sense, we can say that our "cluster approach" has specific features related to the main objectives.

Once this has been established, we would like to make a distinction between the concept of sector and the notion of cluster used in this document. We mean by sector or industry, only the ICT manufacturers and service providers as they are defined by the Spanish Industrial Association of Telecommunication and Electronics (ANIEL), that is: Consumer electronics, electronic components, professional electronics, telematics and service providers. On the other hand, the cluster concept is used in a broader sense. It includes not only the ICT Industry but also users, suppliers (incl. Knowledge providers) and broker institutions.

The paper is divided into 6 sections. The first one is a brief review of some theoretical considerations, the second one consists of the identification of the cluster using I/O techniques and qualitative information. The third one gives information about the composition and some economic indicators of the ICT industry in Spain. Then, we analyse the knowledge flows within the cluster and the obstacles to collaborate with universities and research centres. Finally, we end up with some policy conclusions.

2. Main theoretical framework

Traditionally, the study of technological change has been clearly limited by the availability of valid indicators. First indicators, built on the Frascati manual, continue in use with certain improvements, however the theory which underpinned them has been largely subdued by later studies about the mechanisms of technological change and its links with other areas of the economy.

Thus, as several authors have pointed out, it is clearly necessary to concentrate a significant amount of scientific effort on the development of new indicators for technological change and innovation activity. This research is an attempt to develop new indicators for the systemic analysis of technology flows in the industries of new information technologies (NIT) in Spain.

Throughout history we can find two major theories on technological change (technology production and diffusion): the neo-classical theory and the newer alternatives which involve different needs in indicators and data collection.

Neo-classical production theory is based upon a more restricted knowledge concept than the one accepted at present. In the neo-classical approach mainly derived from the papers by Arrow (1962) and Nelson (1959), technological knowledge is generic, codified, costless accessible and context independent (Smith, 1994 :6) in contrast with the evolutive mainstream which considers technology as something firm-specific, accessible at a cost, with multiple expressions and with deep and strong links with the environment.

The Neo-classical model, as pointed out by Smith (1994: 8), considers the process of innovation as a " process of discovery in which new knowledge is transformed into new products via a set of fixed sequence of phases" . Thus, following this argument, it will be enough to concentrate all efforts on the first stages to obtain the technologically expected results.

Thus, the innovation indicators based on the neo-classical model were built to measure and study the first stage of the process, namely the discovery phase, not taking into account the other phases of the technological process. As pointed out by Smith (1990 ;16) this model has been largely criticised both in terms of the idea of the innovation process as a progression between different and separated stages as well as the overemphasis placed on the R&D expenditure as the almost exclusive indicator of the innovation activity, which is just the empirical evidence of the so-called linear model of innovation.

In contrast with the neo-classical model, the so-called evolutive theory of technological change derived from the papers by Nelson and Winter (1974 and 1982 mainly) emerges. The aim of this theory based on the Schumpeterian ideas is to study the foundations of technological change in terms of its interactions between different agents. Therefore one of the main elements in the evolutive mainstream is the interaction and selection processes between agents.

Among the new theories of innovation we can find the theories of systems of innovation. We may distinguish three different approaches. All of them have in common the emphasis on the systemic approach to the innovation process and its attention to the relationshipsbetween different agents. Very briefly these approaches are (Smith 1994 : 3): technological system approach, in which the works of Gille (1978), Hughes (1983), Dosi (1982), Bijker et al. (1992) and Rosenberg (1982) are included, the industrial cluster approach, were we can find the works by Porter (1992), Dahmen (1970) and Hirschman (1958), and finally the national systems approach based, mainly on the works by Lundvall (1992), Nelson (1993), Soete & Arundel (1993), David & Foray (1994) and Smith (1994).

The latter also includes recent works on technological change fostered by the OECD. The aim of the OECD Member countries is to get to understand the NIS performance and its policy implications.

As pointed out by Freeman (1994: 466) several empirical works show that one of the key elements for an innovation to succeed is the present and future interaction between users and producers. This fact is of such importance that it has become one of the key topics to be studied in the research on National Innovation Systems (NIS).

One of the common features to all the studies included in this theory is the emphasis on the institutional aspects of the innovation processes both in the generation of knowledge as well as its diffusion through the several connections between the different institutions that conform the NIS.

In 1994, David and Foray, in an attempt to design a conceptual framework for comparing national profiles in systems of learning and innovation, proposed the study of NIS through its distribution power (David & Foray, 1994: 7). The purpose of the report was to help policy-makers of the Member countries to get a better picture of their NIS performance with regard to the distribution of knowledge.

Until then, the diffusion of knowledge had not been studied from a NIS perspective. Thus, it was necessary, as was pointed out, to reconsider the available data and indicators on scientific and technological activities (David and Foray, 1994 : 7).

This proposal opened an important line of work namely the study of NIS through its distribution power in order to have a satisfinstitutiony understanding of technological process to develop efficient scientific and technological policies, relying on new innovation indicators.

As was emphasised by the OECD report (OECD, 1994a ; 5) “the effectiveness and efficiency of a NIS depends crucially on its ability to distribute technological information” . Thus a NIS must be measured both from its capacity to produce technology as well as its ability to transfer it, as was stated by the evolutive theorists.

The scientific and technological policy has not yet taken into account the relevance of the diffusion of knowledge in NIS and, as pointed out by several authors, it has relied on neither a suitable comprehension of the innovation process nor good statistical indicators.

As mentioned by the OECD (1994b:7) any policy aimed at enhancing the innovative capability of a system should know the way firms access their information sources. As above (David and Foray, 1994: 7) policy-making needs to have a better picture of country performance on the distribution of knowledge and, at the same time, of the magnitude of the loss of innovation potential due to the obstacles to the distribution of knowledge through the system.

In this context, conventional indicators become very limited. Main performance indicators of NIS (Lundvall, 1992: 6) should reflect both the production and diffusion of knowledge. It could be claimed that the development of new quantitative and qualitative indicators are required (OECD, 1994b: 4). Moreover, these indicators should help to compare national profiles in systems of learning and innovation.

To this effect, the OECD is now working on a plan for pilot case studies relying on the work by David and Foray, whose aim is to develop new indicators for measuring the innovation activity in NIS (OECD, 1994 b).

This research aims to contribute to that project by means of the development of new indicators of the distribution power in the NIT industries in Spain. Specific analysis is specially relevant to this according to Nelson and Winter (Freeman, 1994: 466) since the variation between industries demand industry-specific analysis which take into account the differences in the selection environment as well as specific trajectories of each industrial subsector.

It seems clear that Spain must be included in the picture described above, as the Spanish authorities on establishing the priorities of its technological policy have followed the guidelines established by the more advanced countries. First and second R&D National Plans (Plan Nacional de I+D) tried mainly to co-ordinate the economic agents of a system and were characterised by over-emphasis on the technology production rather than its distribution, following the so-called linear model of innovation.

The third Plan that became public in 1995 broke away from what was done before as it aims to promote diffusion and co-operation between agents in the NIS. It defends the interactive model (Kline & Rosenberg (1986)) which emphasises the importance of the interaction among agents and the interchange mechanisms, feedback and networks through which knowledge flows. One of the objectives followed by the programme is the diffusion and distribution of knowledge to and between the different industries and sectors (CICYT, 1995).

Hitherto, as mentioned by Buesa (1994), technological policy was a secondary objective for the industry policy -makers. As assessed by Buesa and Molero (Buesa, 1994 and Molero & Buesa (1995)) due to the low amount of R&D expenditure from which Spain started, our country would have to keep the rate of investment on R&D activities for four or five decades to reach the position that the advanced countries occupied in 1980, and would have to maintain it for eight decades or a century to concur with them.

If, as stated by David and Foray, the improvement of a scientific and technology based system can be obtained by means of both the increase of the stock of knowledge to be distributed as well as the improvement of the channels through which that knowledge is distributed, and if by concentrating efforts on the first, the convergence will not be reach till one century, it becomes clearly necessary to concentrate efforts on the second element, namely the improvement of the distribution channels as the authorities intend to do through their third R&D national Plan.

For that to occur, the first thing to do is to assess what the distribution channels and the obstacles to the distribution of knowledge are. Like other countries Spain does not have good indicators of the technological activity. Conventional indicators need to be complemented by new indicators to help the study of new realities.

It could be claimed that our country is in need of an efficient policy that promotes technology transfer between institutions in order to improve the competence of our NIS. Therefore it requires new indicators on the technological activity. This present research is based on the OECD pilot project in order to guarantee future comparison with the NIS of other Member countries of the OECD.

The purpose of the study is to analyse the NIT system of innovation. The unit of analysis will be the cluster of NIT industries. Everything that will be studied will lead to several policy conclusions and suggestions about the guidelines that Spanish policy-makers should follow in future, as well as provide the Administration and scientific community with a valuable instrument of work.

The research is focused on the Electronics and Telecommunication cluster in Spain. This cluster plays a significant double role in technology transfer. On one hand, due to the strength of its internal and external networks and, on the other, as the new information technologies developed within the industry, contribute to the progress of the rest of the industries and firms.

3. Composition of the cluster

3.1. I/O analysis

The first stage in the analysis is the definition of the cluster. For doing so, we have used both the input/output tables and qualitative information. The main limitation to the analysis using I/O tables has been the level of data aggregation: 56 sectors. We considered both Office Machinery and Computer and Telecommunications to be the two main categories in which the industries within the sector could fit. The methodology used is the one developed by Monfort and Duitailly (1983).

The main supplier of the Office Machinery and Computers is the Electrical Manufacturing, being the main users the health services (market and non-market oriented) and the Public services.

For the second one of the sectors considered, the Telecommunications, the main supplier is the broad group of services to enterprises, while the main users are the financial and banking services and Restoring.

The first conclusion to be drawn from the analysis is the weight of the public sector in the cluster structure. Nevertheless one should not forget that input output tables give information on trade flows and not on co-operative linkages. One could claim that the former might be a good indicator of the latter, but this has to be checked with complementary data.

3.2. Qualitative information

To complete the picture above described, we went through a small survey among different experts of the Industry to get more information about the main producers, suppliers and users of the Industry. Figure 1 gives more detailed information about who are the main users and suppliers of the industry and the internal linkages between the different subsectors.

Again, the public sector together with the financial sector appear to be the main partners, which bears out the results obtained from the I/O analysis.

4. The Electronic and Telecommunication Industry

4.1.Subsectors

The six subsectors considered in the ICT Industry (apart from suppliers and users) are the following:

1Consumer electronics
2Electronic components
3Professional electronics
4Computers
5Telematics (Telecommunication and Data processing)
6Service providers

1**Consumer electronics**: The composition of this industry is actually being redefined to include personal computers and telephones. Hitherto, it was made of the electronic goods for domestic use only, mainly, TV, video and hi-fi. In Spain this industry is characterised by the significant presence of multinationals like Sony, Samsung, Grundig, Panasonic, Sanyo, Philips, Keewood, Nokia, Pioneer, Sharp or Thomson.

Over half of the manufacturers included in this group have fewer than 50 employees, and this percentage goes up to 70 per cent if we consider enterprises with fewer than 100 employees. Manufacturers are highly concentrated in Catalonia.

1**Electronic components**: Includes all the electronic devices that are to be incorporated to the final products of other industries of the cluster. Nearly 80 per cent of the industries considered have fewer than 100 employees. As the consumer electronics manufacturers most of the enterprises are in Catalonia.

1**Professional electronics:** This industry comprises all the electronics systems and machinery for use in services, industry or infrastructures. In practice, this industry is normally separated in five groups: Industrial electronics, Instruments, Electromedical, Military electronics and Radiobroadcasting (some times this latter group may be considered as being part of the Telecommunication sector).

The **industrial electronics** subsector comprises the industrial robots, power electronics, process control and monitoring equipment, motor speed-control equipment, machine tool control equipment, remote control and measurement, alarm systems and scales. The great majority of the firms are fewer than 100 employees and only 5 percent of them have more than 500, and are located in Madrid area and Catalonia and some in the Basque Country and Valencia.

Instrumentation includes electronic devices for measuring and power supply. More then 90 per cent of the enterprises have fewer than 100 employees. Geographic localisation is similar to the industrial electronics.

Electromedical comprises all the electronic machinery for medical purposes. Over 85 per cent of the firms have fewer than 100 employees and are located in the Madrid area and Catalonia.

Defence electronics comprises avionics, communications, navigation and equipment, electronic warfare, radar, simulation, gun fire control systems and command and control systems among others. Most of the firms are located in Madrid and about 2 per cent have more than 500 employees.

Finally, **Radiobroadcasting and TV** consists basically of radiobroadcasting transmitters, TV transmitters, TV and Fm transposers, Closed circuit TV, Audio/video professional equipment materials, Hertzian links ...etc. As mentioned before, according to the criteria used these industries might be included within professional electronics or within telecommunications. The geographical distribution is similar to the industrial electronics and 80 per cent of the firms have fewer than 100 employees.

1 **Telecommunications**: herewith we may include all the equipment for diffusing and treating information images and sound. We can distinguish between telecommunication equipment and services. Most of the firms are located in Madrid and Catalonia. More than 40 per cent of them have more than 100 employees.

1**Information processing:** Includes equipment, software and services related to the edition, storage and information retrieval. Traditionally this industry is subdivided into two groups: hardware and software. They are mainly located in Madrid and Barcelona, and the majority are small and medium enterprises. Few of them have more than 500 employees. That is the case of some multinationals like IBM, AT&T (actually Lucent Technologies), Ericsson, Fujitsu, Hewlett Packard, Siemens or Sony.

1 Service Providers: Includes Cable, mobile and satellite communications services, data transmission, networks and value added services. They are mainly located in Madrid and the average size of the firms is higher than in any other group.

We analysed the economic indicators of the industry as a whole compared to the Spanish economy. We found that the ICT industry has significant weight in the economy in terms of production and demand. Also, the average growth rate of the main economic magnitudes of the sector is clearly above the average growth rate of the Spanish economy.

4.2. Size and geographical distribution

As is shown in figure 2 the vast majority of the firms have fewer than 50 employees which is well below the European average. Only telecommunications, some electromedical, a few industrial electronics and clearly service providers have more than 100 employees.

The average size of the firms is going to have a very strong effect on the propensity of the firms to collaborate with other institutions within the system and on the existing barriers for innovation.

The great majority of the enterprises are concentrated in Madrid and Catalonia as is shown in Figure 3. This means that the regional system of innovation is quite important. When they collaborate with other institutions they do so, in most of the cases, within their own region.

4.3. Multinationals

A common feature of the ICT industries all over the world is the high proportion of multinationals. Whether they interact with the local system of innovation or not has important effects on the efficiency of the system of innovation as a whole. In the case of Spain, 35 per cent of the firms surveyed were multinationals (11% Spanish and 24% from other countries).

Most of the multinationals with their head office from abroad had their R&D centres outside Spain. They usually interact with users and suppliers but seldom with other R&D institutions like universities or research centres.

4.4. Innovation

The main data sources on innovation in the sector are the Spanish Industrial Association of Electronics and Telecommunications (ANIEL) and the National Statistical Institute (INE). Chart 1 shows the evolution of the main R&D indicators for all the subsectors of the industry considered.

Most of the R&D expenditures are devoted to technological development. Only a small part of the resources are assigned to basic research and applied research, as is shown in figure 4.

In figure 5 one can see that the majority of R&D expenditures of the industry are self-financed (84 per cent). The other 16 per cent comes from the Spanish Public Sector (9,3 %) and abroad (4,8).

Related to the output of the innovative process, nearly 75 per cent of the innovative firms within the cluster develops both product and process innovation, 25 per cent just product innovation and only 5 per cent develops only process innovation (INE, 1998).

According to the proportion of sales due to new products, about 35 per cent of the sales are due to brand new products while 20 per cent are related to products with incremental changes (INE, 1998). On average, 34,5 per cent of the sales are due to products new to the firm and 20,3 are related to product innovations new to the industry.

1 Knowledge flows

Despite the value of the input/output analysis to identify the main institutions of the cluster, one should not forget that they are about trade flows and not knowledge flows, which is the aim of the study. In order to better identify the cluster in terms of knowledge flows we need more qualitative information on the knowledge flows between the different agents.

For doing so, a survey was conducted to collect information on the stock of knowledge, the external relationships of the firms and the obstacles to collaborate with research centres as University Departments and Technology institutes.

In this paper we will focus on the results of part two and three of the questionnaire, that is, the external relationships of the firm and the obstacles to collaborate with the academic and technological institutions.

We asked not only the significance of different institutions and mechanisms of knowledge acquisition but also the frequency of interactions with each of them. The institutions and mechanisms considered for the analysis are compiled in Chart 2.

5.1. Main results

Suppliers and users are considered to be the main source of knowledge employed during the innovative process, as is shown in figure 6. Firms collaborate rather frequently with suppliers and users. Trade fairs seem to be one of the main mechanisms of interactions and, in general, one could say that personal contacts and publications are the main means of acquiring the required knowledge to innovate.

Related to that, when asked about the main obstacles to innovation, a high proportion of firms pointed out the lack of a qualified demanding customer as we will see in more detail in section 6. That is, even being the user one of the main institutions, firms seem to be very unsatisfied with the information they get from them.

On the other hand, the results reveal the weaknesses of the relationships with universities, technological centres and bridging institutions. In this sense one could say that the economic system has evolved apart from the academic system, being that, from our point of view, one of the main constraints for the development of the sectoral system of innovation.

There is one main explanation for this mismatch: policy-makers, through their various National R&D Plans have largely promoted basic research in Universities and Public Research Centres. Thus, there was no need to collaborate with firms in their R&D projects. In this sense we could claim that the academic innovation has evolved apart from the firms needs. Although this is slightly changing through political programmes that demand the presence of the users of the invention (more market oriented policy), it will be a very slow process as we are talking about two different cultures (as is stressed by the surveyed firms).

5.2. Multinational versus local firms

One interesting exercise to be carried out is to compare the behaviour of national versus multinational firms. Multinational firms are one important source of knowledge for any system of innovation and this is specially relevant for the ITC cluster in which nearly 35% of the firms are multinationals.

Figures 7 and 8 indicate the importance given by national and multinational firms to each of the institutions and mechanisms considered and the frequency of their interactions. With the only exception of suppliers and other units of the same enterprise, multinationals find their external linkages with the local system of innovation less important than national firms do. Despite that, they co-operate more often with consultants, other units of the firm, and universities (through training programmes) than national firms do. On the other hand, it seems clear that, for the vast majority of the items considered, local firms have more interactions with the national system of innovation.

1`1 Innovators versus non-innovators

Firms rarely innovate in isolation. They need to interact with their environments, acquiring knowledge from external sources and commercialising the results of their innovative processes. It is believed that the greater amount of external networks the firm has, the better it will perform in its innovative activity.

On the other hand, one could think that the higher the innovative level of the firm is, the more conscious one is about the advantages of accessing to external sources of knowledge and the easier it will be to select the knowledge the firm needs.

No matter which one of the relationships we consider, it is a fact that there are significant differences between the frequency of interactions of the innovative firms[1] and the non-innovators, as figures 9 and 10 show.

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[1]In this particular case, we consider a firm to be innovative if it has introduced into the market a new product, process or service during 1996.

It seems clear that innovative firms do interact much more with their system of innovation than non-innovators do. This facts seem to confirm the hypothesis that the frequency of interactions with the external sources of knowledge have a very positive strong impact on the innovative performance of the firms in terms of more new products, processes or services being commercialised in the market.

These differences apply also for the firms that undertake R&D projects and those that do not. Both the importance and the frequency of interactions are higher among the R&D firms than non R&D firms, as can be seen in figures 11 and 12.

6. Obstacles to collaborate with Universities and Research Centres. Barriers to innovation.

6.1. Main results

Regarding the apparent mismatch between the manufacturing and academic system mentioned in point 5.1, we asked the firms about the main obstacles to collaborate with Universities and Technological Centres. The first conclusion that emerges from the analysis is that there are not significant differences between Universities and Public Research Centres. As is shown in figure 13, Timing, Financial Constraints and Lack of agreement in the design of the project are considered to be the main obstacles for collaboration.

From a policy point of view it is difficult to avoid the first and the third obstacles in order of importance as they have much to do with those *culture gaps* than with any other element. However policy makers can remove a significant part of the financial constraints through a more market oriented R&D policy. For policy purposes not only the obstacles to collaboration but also the more general barriers for innovation are important.

Figure 14 shows the main obstacles to innovation. The most important constraints have to do both with public intervention and demand conditions. If we consider that the public sector is also the main user, we can see the outstanding role played by the public administration in the development of the sectoral system of innovation.

6.2. Innovators versus non-innovators

When asked about the main obstacles to collaborate with Universities, innovators give more importance to timing and difficulties of finding a partner while non-innovators stress the lack of interest, absence of tradition in co-operation and difficulties in finding a partner as is shown in figure 15.

6.3. R&D versus non-R&D

In relation to the R&D firms, figure 16 points out clearly that R&D firms consider all kinds of obstacles to be more important than non-R&D firms do. The main explanation for this fact could be that as R&D firms collaborate more frequently with universities and research centres, they are also aware of the difficulties of collaborating with other institutions in R&D projects. In this case, the main obstacles are the absence of appropriate infrastructures , lack of specific demand and again, timing, which is just a result of two different cultures, in the sense that basic research is not usually subject to terms or deadlines, while applied research and development usually conducted by firms is.

Some of the difficulties described above could be clearly overcome if there was an efficient network of bridging institutions that provide information of both ways on the results of the innovative process in universities and research centres and on firms' needs to researchers in academic institutions. One of the most complete studies on the bridging institutions in Spain is the one directed by Ignacio Fernandez de Lucio. He analyses the bridging institutions in Spain, collecting information directly on the number, type, objectives, activities, and instruments of interaction most frequently used. He distinguishes between four different environments and then, four basic types of institutions:

a) **Scientific environment,** whose main activity is the creation of new knowledge for the system. The main institutions are the Universities and the Public Research Institutes. The bridge institutions are of three kinds: OTRIS (Transfer Office for Research Results), Fundación Universidad-empresa (Enterprise-University Foundation) and specialised bridging institutions from the scientific environment.

b) **Technological environment** made of the technological institutes, engineering services and entrepreneurial R&D units. Its bridging institutions are mainly four: Technical Centres for Training and Consultancy, Technical services, Consultants and Technological institutes.

c) **Producer environment**, producing value added goods and services. Its main bridge institutions are the Technological Parks and a variety of entrepreneurial bridging institutions (like sectoral associations).

d) **Financial environment**, generating the financial resources needed for all the innovative activities carried out by different agents within the system. The main bridge institutions are of two kind: Venture capital institutions and the Public administration.

One of the most interesting conclusions of the study directed by Fernandez de Lucio is that bridging institutions are responsible for only a 15 per cent of the whole technology diffusion in Spain. Technology flows between the scientific, the technological and the producer environment are very low, and this is mainly due to the existing rivalry between the bridging institutions of the scientific (SBI) and the technological environment (TBI). That has led to a situation in which TBI, instead of being nearer the firms needs have tried to render the same services as the SBI do. So, there is no specialisation and there is an overwhelming lack of bridging institutions serving the enterprise's needs.

7. Main policy conclusions

The cluster of the ICT industries in Spain is a very complex network of producers, users and suppliers but with very weak links which could be considered as the suppliers of knowledge. Suppliers and users are considered to be the main source of knowledge used by firms in their innovative processes.

Related to the technology users, the Spanish demand is characterised by its low technological content. In other words, consumers are not very concerned about the technological features of the goods and services. This is a heavy obstacle to innovation and thus, transfer of technology. The public sector is the main user of the ICT industries.

The weaknesses of the relationships between the productive and the academic side of the system is, without any doubt, one obstacle for the development of the system of innovation. If firms, for whatever reasons, do not access the public knowledge-base, this is one fact that should be considered in any policy towards the sector as is an important barrier for the innovative system. This is specially important in a sector where innovation is the key factor for competitiveness.

Innovation and R&D seem to have very positive effects on the external relationships of the firm or, may be if we look at the results the other way round, one could say that the stronger the links with the external sources of knowledge, the better they will perform in their innovative activities.

Policy measures should aim at removing the existing obstacles to firms' access to the public knowledge, to improve its role as the main user of ICT technologies being more pro-active and to promote the integration of multinationals in the local system of innovation.

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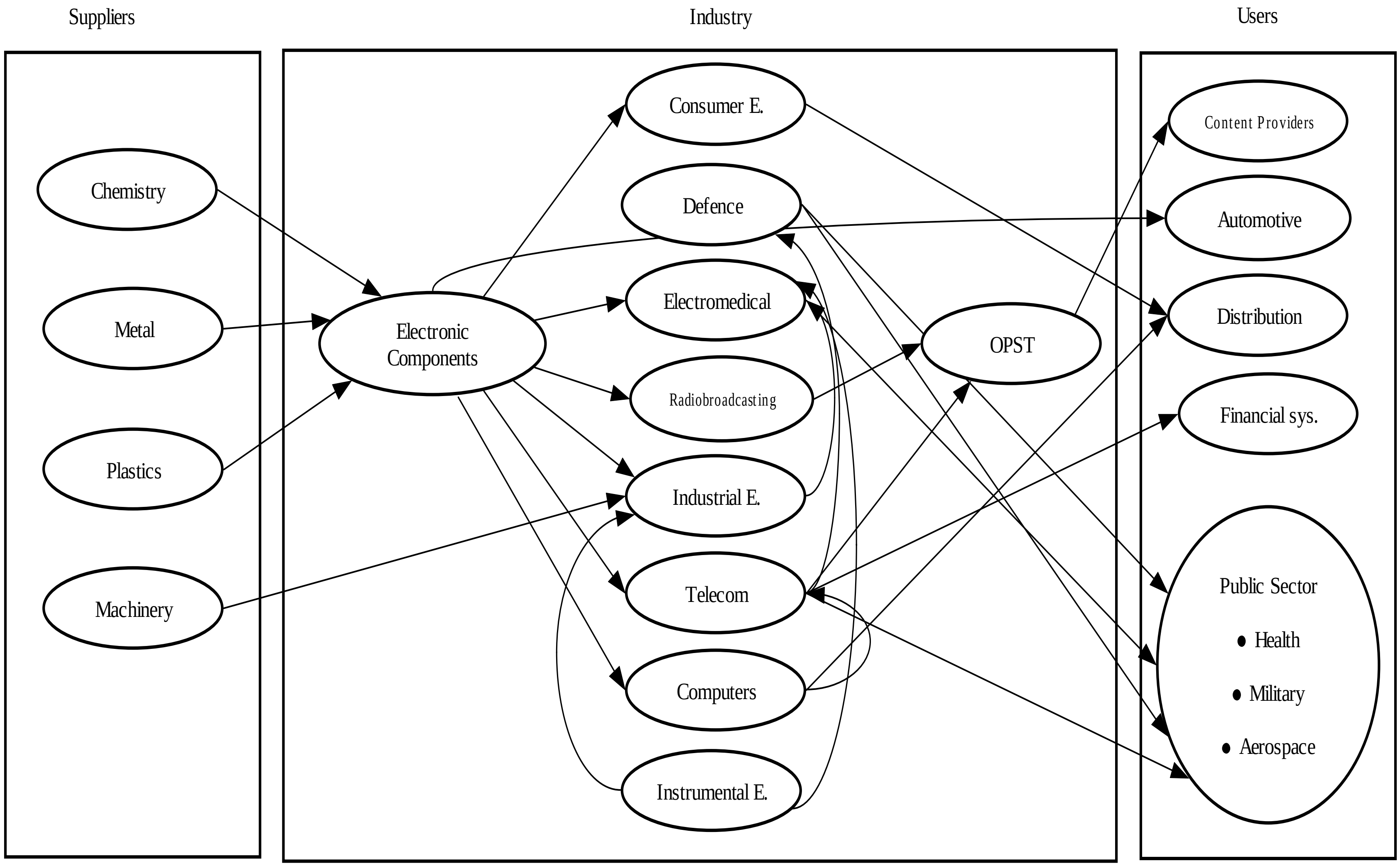
ANEX 1. FIGURES

Charts

Figure 1.



Suppliers
Industry
Users
Chemistry
Metal
Plastics
Machinery
Electronic Components
Consumer E.
Defence
Electromedical
Radiobroadcasting
Industrial E.
Telecom
Computers
Instrumental E.
OPST
Content Providers
Automotive
Distribution
Financial sys.
Public Sector
Health
Military
Aerospace

Figure 2. Size of the firms in the ICT sector

Figure 3. Geografical distribution of companies

Figure 4. R&D Expenditures by type

Figure 5. Financial sources. NITC 1994

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Figure 6. External relationships of the NIT industry in Spain

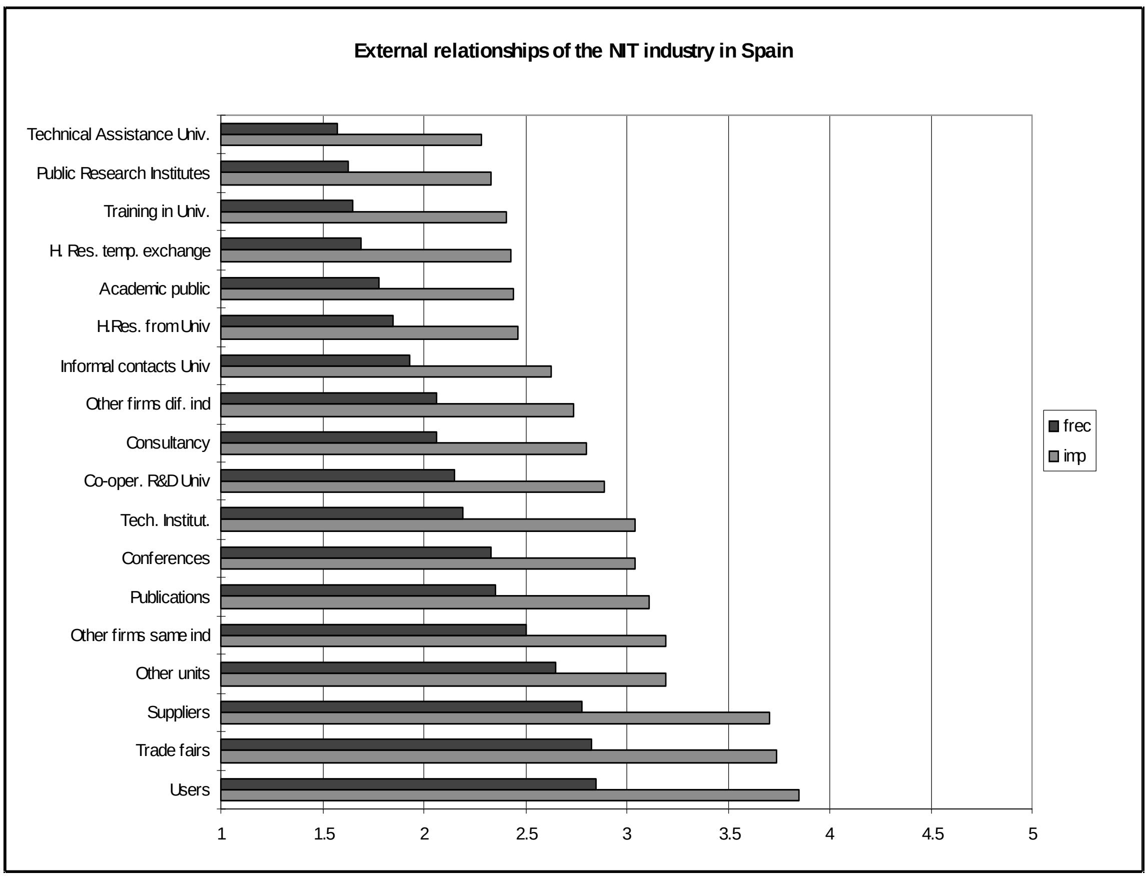

Figure 7. Significance of the external relationships. Multinational vs. National firms

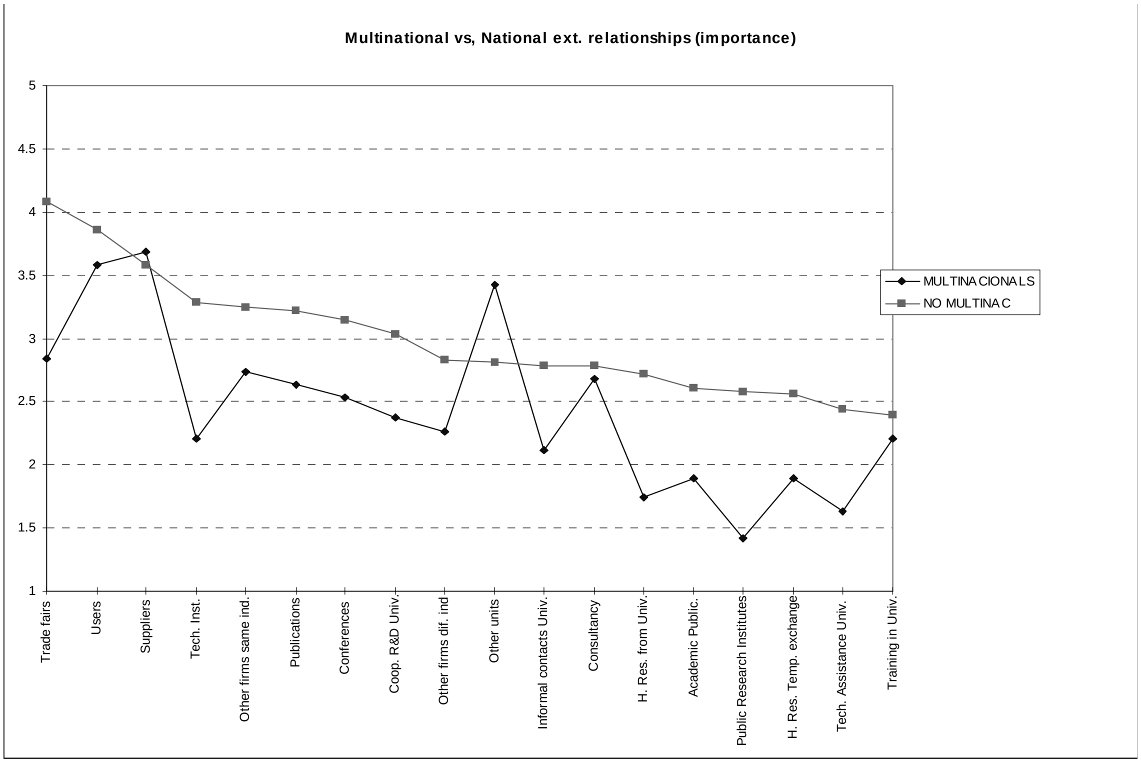

Figure 8. Frequency of interactions. Multinational vs. National firms.

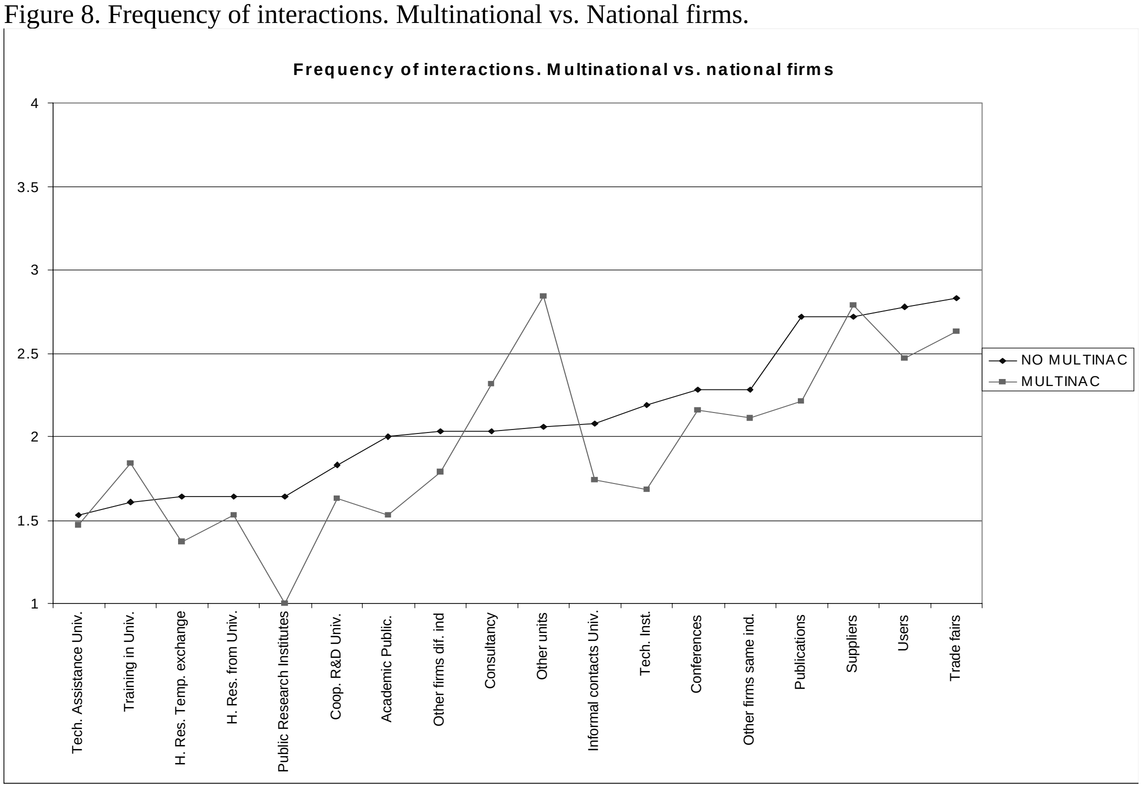

Figure 9. Significance of the external relationships. Innovators vs. Non-innovators

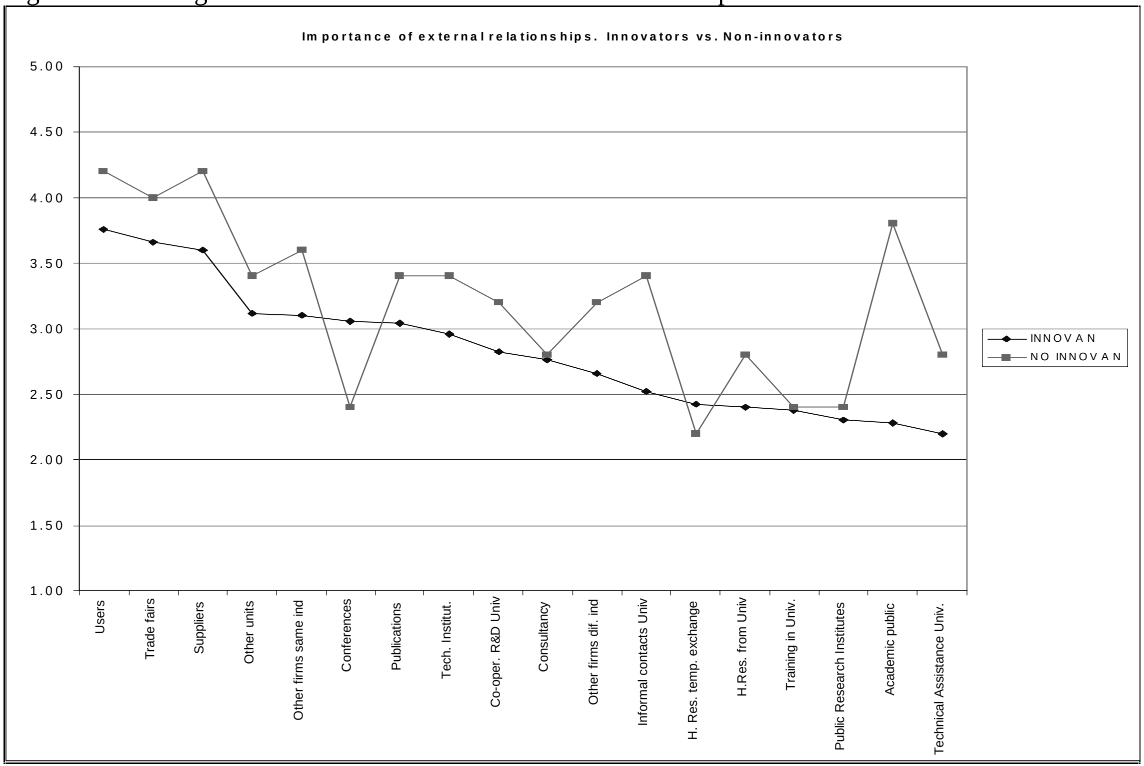

Figure 10. Frequency of interactions. Innovators vs. Non-innovators

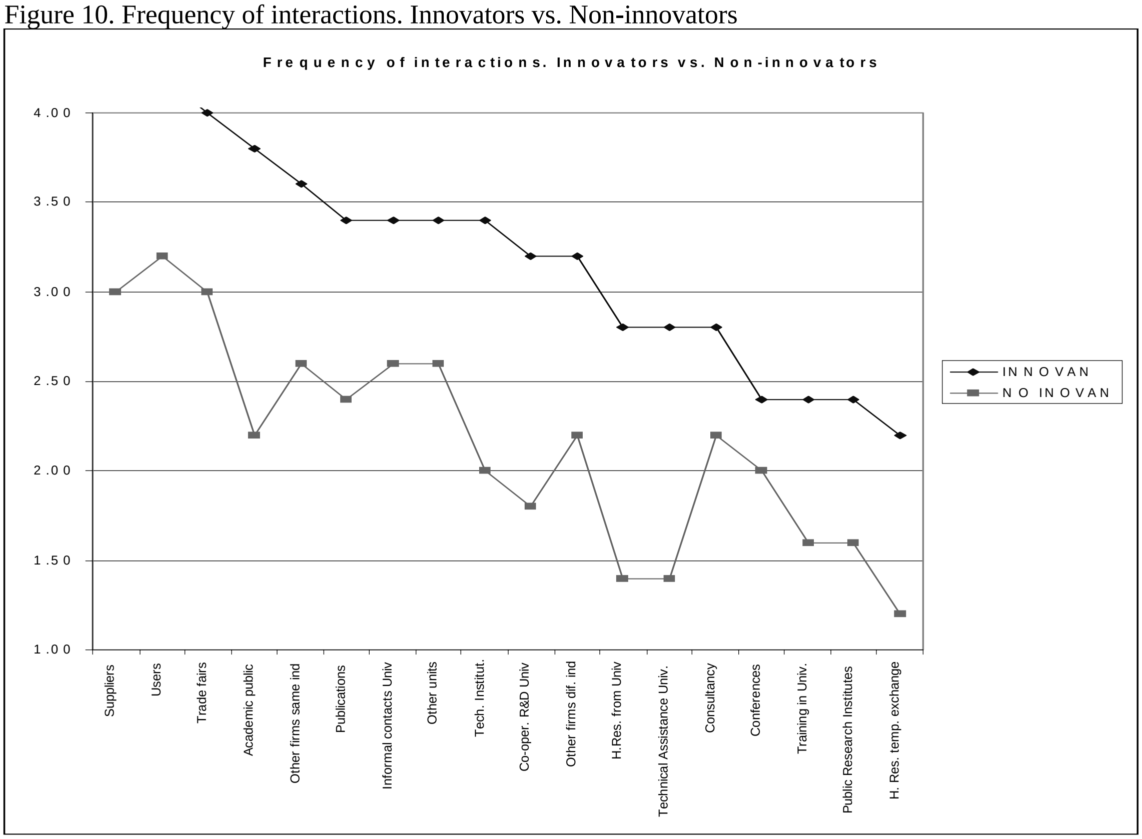

Figure 11. Significance of the external relationships. R&D vs. Non-R&D

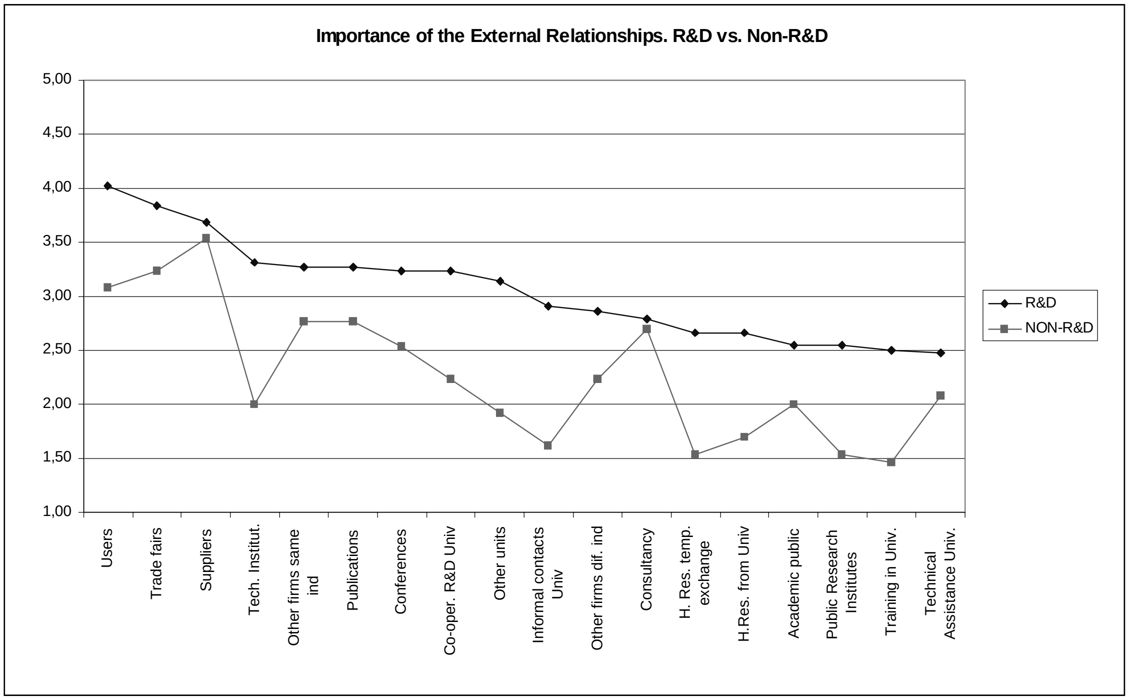

Figure 12. Frequency of interactions. R&D vs. Non-R&D

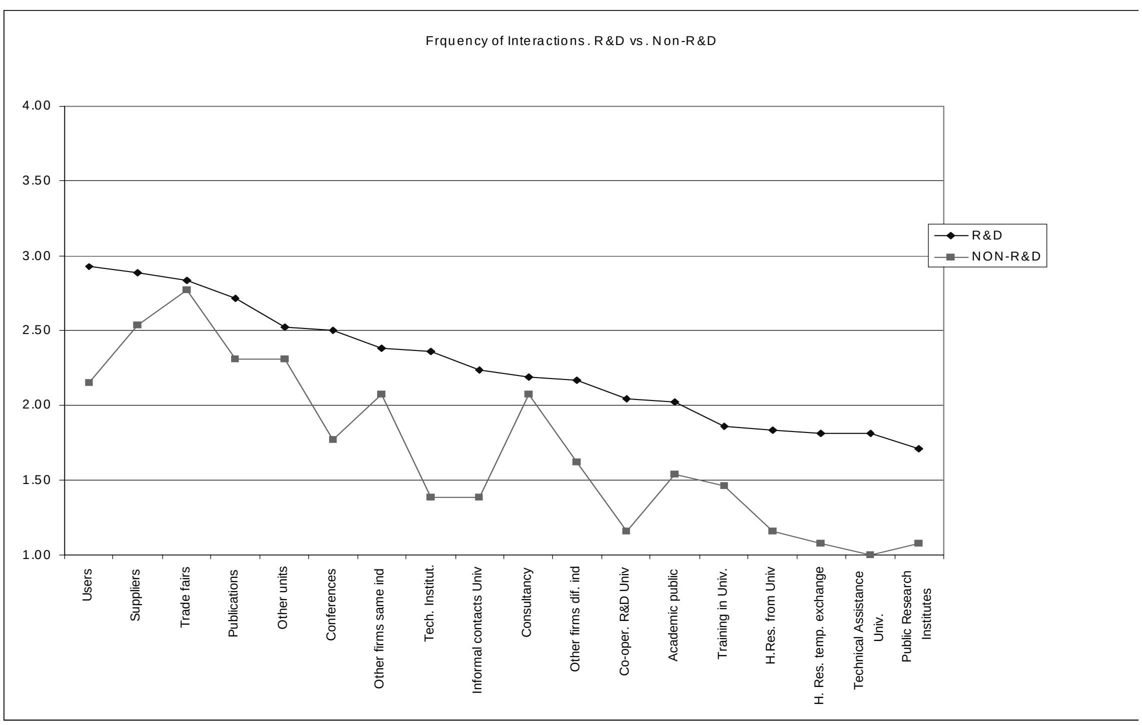

Figure 13. Obstacles to collaborate with Universities and Technological Centres

14. Obstacles to innovation

Figure 15. Obstacles to collaborate with Universities and Research Centres. Innovators vs. Non-innovators

Figure 16. Obstacles to collaborate with Universities and Research Centres. R&D vs non-R&D

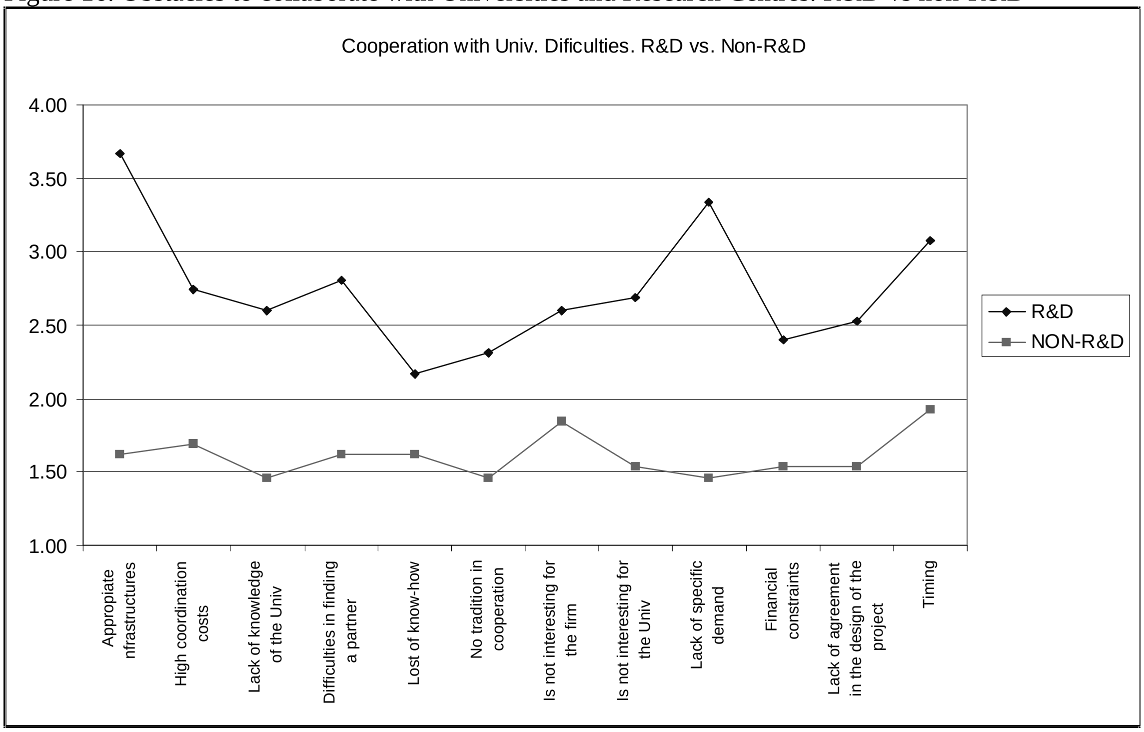

Chart 1.

		1995	1994	1993	1992	1991
Total	**R&D expenditures**					
	in relation to its GDP	8%	7%	8%	8%	7%
	Total R&D expenditures	63647	47000	45000	50000	50000
	Salaries	n.d.	61%	60%	57%	57%
	Equipment	n.d.	24%	25%	29%	29%
	Other	n.d.	15%	15%	14%	14%
	R&D total employment					
	in relation to total staff	10%	n.d.	9%	8%	8%
	Total employment	3769	n.d.	3800	3924	3965
Consumers	**R&D expenditures**					
	in relation to its GDP	3%	3%	4%	4%	4%
	Total R&D expenditures	3800	3600	4200	4952	5217
	Salaries	60%	60%	62%	n.d.	n.d.
	Equipment	15%	11%	12%	n.d.	n.d.
	Other	25%	29%	26%	n.d.	n.d.
	R&D total employment					
	in relation to total staff	5	n.d.	4,5	5	5
	Total employment	220	n.d.	194	310	330
Components	**R&D expenditures**					
	in relation to its GDP	5,0%	4,2%	4,9%	6,3%	6,1%
	Total R&D expenditures	6000	4370	4200	5100	5350
	Salaries	65,00%	63,10%	61,30%	57,20%	56,00%
	Equipment	28,00%	23,80%	28,20%	31,10%	35,60%
	Other	7,00%	9,10%	11,70%	11,70%	13,40%
	R&D total employment					
	in relation to total staff	7,50%	7,10%	6,90%	7,30%	6,90%
	Total employment	451	418	410	460	480
Professional	**R&D expenditures**					
	in relation to its GDP	11%	10%	9%	9%	10%
	Total R&D expenditures	9700	8537	8070	8235	9842
	Salaries	57%	6%	59%	59%	50%
	Equipment	15%	14%	11%	13%	25%
	Other	28%	80%	30%	28%	25%
	R&D total employment					
	in relation to total staff	15%	15%	13%	14%	12%
	Total employment		825	859	1204	999
Telematics	**R&D expenditures**					
	in relation to its GDP	10%	12%	9%	8%	7%
	Total R&D expenditures	44169	47400	36450	25895	28537
	Salaries	n.d.	n.d.	n.d.	50,00%	57,20%
	Equipment	n.d.	n.d.	n.d.	12,50%	14,30%
	Other	n.d.	n.d.	n.d.	27,50%	28,70%
	R&D total employment					
	in relation to total staff	10,50%	9,50%	9,50%	9,40%	7,00%
	Total employment		2351	2415	2595	2154

Absolutely amount are in millions pesetas
* Ratios are refered to the total amount of the subsector

Chart 2

EXTERNAL RELATIONSHIPS OF THE FIRM		DIFFICULTIES COOPERATING WITH UNIVERSITYES AND TECHNICAL INSTITUTES	
A	Tech. Assistance Univ.		
B	Training in Univ.		
C	H. Res. Temp. exchange	A	Timing
D	H. Res. from Univ.	I	Financial constraints
E	Public Research Institutes	L	Lack of agreement in the design of the project
F	Coop. R&D Univ.	D	Lack of specific demand
G	Academic Public.	H	Is not interesting for the firm
H	Other firms dif. ind	B	Is not interesting for the Univ
I	Consultancy	G	No tradition in cooperation
J	Other units	J	Lack of knowledge of the Univ
K	Informal contacts Univ.	K	Difficulties in finding a partner
L	Tech. Inst.	C	Lost of know-how
M	Conferences	F	Appropiate nfrastructures
N	Other firms same ind.	E	High coordination costs
O	Publications		
P	Suppliers		
Q	Users		
R	Trade fairs		
	IMPORTANCE		FREQUENCY
	1 NO IMPORTANT		1 NEVER
	2 OF LITTLE INTEREST		2 SELDOM
	3 NORMAL		3 FREQUENTLY
	4 SIGNIFICANT		4 ALWAYS
	5 VERY SIGNIFICANT		