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ABSTRACT

This working document is based on a broad multivariate data analysis of the regions conforming the Spanish R&D system, with the purpose of establishing a typology o f the regional innovation systems. The paper consists of four parts: It begins with a brief introduction reviewing the main theoretical approaches. In the second part we use a factorial analysis, which allows us to differentiate between four main factors that have an impact on the regional innovation capacity: The Regional Production and Innovation Environment, the University, the Public Administration and Private Enterprise. In the third part we determine a typology of the Spanish R&D system using the clus ter analysis with the four factors detected before. The regions that stand out are Madrid (Public Administration), Catalonia (Environment), Basque Country (Enterprises) and Navarra (University), the rest of regions showing the heterogeneity of the regional R+D system in Spain. Finally, we use patents as a measure of the innovative capacity of the Spanish regions, calculating a regression with the four factors explained before. We confirm the importance of the Regional Production and Innovation Environment m ore than others factors on this kind of output.

Keywords: Regional Innovation Capacity, Regional Innovation System, Typology, Regional Production and Innovation Environment, University, Public Administration, Enterprise, Spain, Regions.

RESUMEN

El presente documento de trabajo se basa en la aplicación de un amplio análisis estadístico multivariante a las distintas regiones que configuran el sistema de I+D español, con el fin de establecer una tipología de sistemas regionales de innovación. Para ello se re aliza un análisis factorial que permite distinguir cuatro factores de impacto sobre las capacidades de innovación regionales, a saber, el entorno regional y productivo de la innovación, las universidades, la Administración Pública y el sector empresarial. Esto permite establecer una tipología de sistemas de innovación regionales, a través de la técnica estadística de clusters, destacando las regiones de Madrid (Administración Pública), Cataluña (Entorno), País Vasco (Empresa) y Navarra (Universidad), eviden ciándose en los demás casos la heterogeneidad del sistema regional de I+D español. Finalmente, los factores son empleados como variables explicativas del output tecnológico (patentes). Se confirma aquí la importancia del entorno regional y productivo de la innovación en el caso español sobre los demás factores empleados

Palabras clave: Sistema regional de innovación, capacidad innovadora regional, tipología regional, entorno regional y productivo de innovación, universidad, Administración Pública, empresa, España, Regiones.

1- INTRODUCTION

The evolutionary approach in economics, despite its limited diffusion in the academic world, already has a significant influence on science and technology planners in developed countries. The importance given by this approach to processes of technological change, development and the diffusion of knowledge, and to the variety of elements linked to these processes, gives rise to a dynamic view as well as acceptance of the idea that it is knowledge-based innovation which is the main source of economic development.

In this framework, the study of innovations systems- both from the resources and the results point of view- by means of the use of econometric techniques, can be considered as a useful tool for developing scientific and technological policy. A system of innovation can be defined as "the set of institutional and business organisations which, within a specific geographical area, interact with the aim of allotting resources to performing activities geared to generating and spreading knowledge which supports the innovations which are the basis of economic development" (Buesa, 2002).This concept, the development of which has taken place in the last decade, was first formulated in the seminal work by Freeman (1987) and soon showed marked development in works published by Lundvall (1992), Nelson (1993) and Edquist (1993). Among the most important traits of the approach are those pointed out by Edquist (1997); Innovation and learning make up the nucleus of this approach, which is holistic and interdisciplinary in character, where the idea of interdependence not linearity is an essential aspect of it, thus divorcing itself from the neoclassical economic tradition and the idea of the existence of an optimal point in the allocation of resources. Moreover, the approach underlines the importance of institutions and of aspects related to the historical path in the evolution and working of systems[1]. Thus it is an approach that encapsulates a wide variety of elements in the structure and grants high importance to the relationships among them to explain the development of knowledge, and thence, economic behaviour.

Initially, the study of innovation systems made reference to the national environment (Lundvall, 1992; Nelson, 1993; Edquist, 1997;) but in a short space of time various authors have applied the concept at a regional level (Braczyck, Cooke and Heidenreich, 1996; Cooke, Gómez Uranga and Etxebarría, 1997; Howells, 1999; Landabaso, Oughton, Morgan, 1999; Morgan and Nauwealears, 1999; Cooke, Boekholt, Todling, 2000; Koschatsky, Kulicke and Zenker, 2000; Cooke, 2000; Cooke, 2001; Doloreux, 2002). The reasoning behind this analysis is based on the extended idea that industries tend to concentrate in specific spaces, as well as on the existence of decentralising policies which can be applied at regional level (Porter, 1990) .The concept of the regional innovation system can be understood as a section of the *national* one, where its main, identifiable characteristics are still valid when studies are made of smaller areas. Thus, a regional innovation system (SRI) can be defined as a set of networks between public and private agents which interact and give mutual feedback in a specific territory by taking advantage of their own infrastructure, for the purposes of adapting, generating and extending knowledge and innovations. In general, the processes for absorbing foreign technology, for creating national technology, or spreading it within a particular space, are determined by various institutions, organisations and agents who

[1] A more detailed examination of the literature can be seen in Navarro (2001), Heijs (2001b) and Martínez Pellitero (2002).

influence the region's interactive learning capacity. In this way, effort and sufficient development of local and regional infrastructure is needed, taking the concrete form of interfirm relationships, and relationships between the latter and the rest of the physical and support infrastructure, in training suitable human capital, in accumulating and transferring knowledge and in shaping the production structures (Buesa, Martínez Pellitero, Heijs and Baumert, 2003).

For countries like Spain a view must be given at this level of breakdown, due to the variety of regions with different modes of behaviour, where the capacities of systems, resources and results in the innovation field vary from one region to another (Acosta, Coronado, 1999; Baumert, Heijs, 2002). The Spanish case is not unique. In nearly all countries high geographical concentrations of innovatory activities have been detected, with regions with a very high share of the whole of national innovation (European Commission, 2002).That means that when we speak of a national innovation system, what is usually being described is based on the most advanced regions (Heijs, 2001b). Thus, there is an important loss of information

Starting from this approach, in this article we tackle the drawing up of an empirical methodology, which is statistical and econometric in character, to study the makeup of regional innovation systems and their knowledge generating capacity. That methodology is adapted to the case of Spanish regions, defined according to their political and administrative nature. Thus, reference is made to Autonomous Communities, which means undoubted advantages in obtaining the necessary information, even if its specification does not necessarily have to coincide with that which would stem from the use of economic geography criteria. The article is structured in three sections. In the first, after a brief description of those variables included in the study, by using multivariate techniques, an analysis is made of the main components which enable those factors to be identified which define the innovative structure of regions (economic and productive environment, university, innovatory firms and Civil Service) and which, also serve to define a typology of regional innovation systems after using for this purpose the multivariate statistical technique of conglomerates. In the second part, using information on patents as a tangible output indicator of innovation processes, those factors are modelled as determining elements of regional innovation capacity, with their importance estimated by means of a regression analysis. Finally, there is a presentation of the conclusions of the econometric analysis of the case presented .

2- MAKEUP OF THE SPANISH REGIONAL INNOVATION SYSTEMS

Bearing in mind the theoretical proposals mentioned in the previous section, to study the case of Spain we have based our work on the use of existing information on variables and indicators related to science, technology and innovation, from the viewpoint of resources and results, as well as certain aspects of an institutional nature and the productive structure. (Buesa, Navarro, et. Al. 2001). The years studied range from 1994 to 1998, both inclusive[2]

[2] The indicators and variables used in the research are found on an existing database in the Instituto de Análisis Industrial y Financiero of the Universidad Complutense in Madrid . This was created as a result of research being carried out there, particularly the Programa de Indicadores de la Ciencia y la Tecnología de la Comunidad de Madrid (Program of Science and Technology Indicators of the Community of Madrid). To create this database data have been used which were provided by the Instituto Nacional de Estadística (INE). In some cases it has been necessary for INE to draw up "ad hoc" uses. In other cases, we had to apply some estimation model-for example the stock of technological and scientific capital-and, finally, others have been directly obtained from

and as a regional study unit we have worked with the 17 Autonomous Ccommunities[3], corresponding to the level II NUTS according to the European nomenclature.

2.1 Variables and indicators

According to the outline presented by Heijs (2001), the variables we have worked with stand for the following aspects: firms and their relationship with the regional innovation system; support infrastructure for innovation; public innovation-linked performance; and the regional and national environment for innovation[4]. It should be noted that the border between these subsystems is at times not very clearcut and there is a certain overlap between the different areas, so it is not always easy to classify each of the factors, actors or elements according to the four subsystems. Nonetheless, this classification is useful as an analytical outline to establish the indicators, and point out the aspects they represent within this study, as well as to indicate the influence of the evolutionary viewpoint which propounds the existence of interdependence relationships between the parts or elements of the system

In the case of *firms*, we start from the hypothesis that these are the most important elements in innovation systems, not just as instruments for generating knowledge, which materialises in products and processes, but also as sources of internal learning, and as linking elements between the productive system and that of innovation in the case of *innovating firms*. Therefore, in the research several variables have been included relating to human and financial resources devoted to R&D, as well as the stock of firms' technological capital in Spanish regions.

In the case of the *Civil Service* we also use as a base the idea that this institution plays a very important part in the development of systems. On the one hand, the public sector manages an important part of regions' scientific apparatus, while exerting an important role as a financing agent for innovation. On the other, it also has an outstanding role as an agent linked to the development of technological policies. The research has tried to include those aspects via the indicators which reflect the human and financial resources used in R&D, the stock of scientific capital deriving from the latter, as well as part of technological policy, by means of the projects approved by the Centre for Industrial and Technological Development (CDTI)[5] in the different Autonomous Communities,
.Regarding the *support infrastructure for innovation*, understood as the group of bodies conceived to facilitate firms' innovatory activity, we make a distinction between a private part and a public one. The private part refers to the wide range of services among which are found technological centres and parks. Within the public domain, we consider the Public Research Bodies (OPI) and the universities with their resources and findings. To these are added human resources in science and technology[6]

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prime sources-technological patents or centres-. The methodological problems which arise in the use of different statistical sources are studied in Buesa, Casado, Heijs, Martínez Pellitero and Gutiérrez-Gandarilla (2002). See, also for these matters Buesa, Navarro et al (2001).

[3] Due to an important dearth of data in the case of Ceuta and Melilla, these two autonomous cities have been eliminated from the analysis.

[4] A more detailed analysis of the variable can be found in Martínez Pelletero (2002).

[5] The CDTI is a public institution managing credit funding of business projects involving technological innovation. It is probably one of the most important instruments of Spanish technological policy. See Molero and Buesa (1998) and Buesa (1998), Heijs (2001a).

[6] Human resources in science and technology have been measured in accordance with the methodology proposed by the OECD (1994).

Finally the *regional innovation environment* is a broad concept including aspects which indirectly impinge on regions' technological and innovation capacities. Five aspects have been included in this research: the productive structure as quantified via VAB, employment and exports in industries with varying technological content; accessibility to venture capital systems; accumulated knowledge[7], as quantified by means of an indicator of the quality of the universities; the size of the regional market represented by GDP value; and representative social indicators of the population's cultural preferences and traits, specifically, one relating to the information society and another stressing reading habits.

2.2. Factorial analysis of main components

From the above-mentioned variables and indicators, a multivariate technique of the factorial analysis has been applied with the object of determining implicit factors in Spanish regional innovation systems. This technique, from a set of quantitative variables, allows us to determine a lower set of non-observable hypothetical variables, called factors, which summarise practically all the information contained in the original set[8]

In this study we have started out from a total of 35 variables in determining the implicit factors of the Spanish regional innovation systems. Using as a base the concept of *community quality of a variable*- which is defined as the proportion of the total variable recorded by the factors preserved- the variables and indicators have been established which form part of the final model via a process of trial and error; if the variable is found to be associated with a small community it will be reasonable to include another factor, provided that it is of better use to explain the model, or, rather, to eliminate it, if, on the contrary, it did not provide it with a significant value. The factorial method of data reduction that we have worked with is that of *main components*, and the final solution chosen was that made up of four factors, where 85% of the variance of the model was preserved, and where the communities take satisfactory values.[9]

Before beginning to interpret the factors obtained in the exercise by means of the *factorial components matrix*, it is worth pointing out that during this process a series of variables have been eliminated, specifically the three related to human resources in science and technology, those of a more social nature (population of people who normally read newspapers and

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[7] In previous studies (Martínez Pellitero, 2002, Buesa, Martínez Pellitero, Heijs, Baumert, 2003) patents were also used as an indicator of accumulated knowhow. However, given that in the following section they are used as a measure of output-in statistical terms as a dependent variable of regression-they are omitted from this first part of the analysis.

[8] In this analysis we have worked with the SPSS 10A statistical program .From *Barlett's Sphericity Test and the KMO Measurement of Sample Suitability* the possibility has been verified of carrying out a factorial analysis on the basis of existing data. In the analysis no more than 20 or 25% of the original variability has to be lost, and the *autovalue* concept is used to represent the part of the total variability that a factor is able to record. The program's criterion by default- *Kaiser's criterion,*- preserves all factors with autovalues of one or more. Nevertheless, it is obvious that the lower the number of variables in an analysis, the greater is the proportion of variability rejected when eliminating factors with autovalues close to one. When this technique is used, variables could be obtained for each factor present in the analysis, though that would lead to a non-valid solution since dimensionality or the volume of data remains constant. Moreover, it should not be understood in the initial solution that each component extracted is associated with the same variable, that is 1st factor with 1st variable, 2nd factor with 2nd variable, and so on, since the interpretation and, thus the significance of the factors, is obtained by analysing the so-called *factorial components matrix.*

[9] After the extraction of the four factors 73% of the variables show communality qualities over 0.800.

population of people who use Internet), and one related to technological centres (staff on the payroll of technological centres). This exclusion is due to the fact that, in the specific case studied, and in the time period analysed, these indicators have been rejected as explanatory variables in the analysis[10]. Regarding the variables linked to human resources in science and technology, a possible explanation could be that these indicators reflect concepts which, in part, are already included in others on R&D, so to a certain extent they may be redundant .And the same can be said for the people working in technological centres .As for the indicators of a more social nature, exclusion could mean that at the present time the regional differences are not clearly significant.

In Table 1 a synthesis of the information provided by the *rotated components matrix*[11], is presented,, aimed at facilitating a correct view of the indicators classified by factors. Moreover, arrows have been included, to show the relationships between the variables and indicators linked to more than one factor[12]. Each factor records a series of indicators with a high degree of saturation in them. The allocation of a name has been based on their composition, and corresponds to the elements considered essential by theory in innovation systems .

2.3. Factors determining Regional Innovation Systems

The first factor-*regional and productive environment of innovation*- registers a 28.67% variability, and is organised around three aspects: the productive structure-production, employment and exports linked to the industrial sector-support institutions for innovation and the size of the regional market. All the variables are found to be highly saturated, with values higher than 0.8, except for the one representing medium-low technology exports. This variable was in turn also found to be correlated with the fourth factor which registers elements linked to the area of innovating firms.

The second factor clearly reflects *the role of the universities*. It records a 21.58% variability. Particularly noteworthy is the fact that the variables with a higher degree of saturation are those referring to the research environment in its strictest sense-postgraduate students, staff and researchers-. Regarding the indicators related to university results in the first and final part of the degree course, there is a lower degree of correlation.

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[10] In similar studies, where a lower time series was analysed, the extraction of the same variables has taken place See Martínez Pellitero (2002).

[11] *The components or factorial matrix* contains the linear correlations between the different variables of the analysis and the preserved factors. These correlations are also called *saturations of the variables in different factors*. It is convenient to have a matrix in such a form that the variables are saturated in the factors, or what amounts to the same thing, they should have an important correlation .If the different variables are saturated in different factors, the solution is clearer and simpler to solve. A *rotation technique,* specifically the *Varimax*, has been used to improve the solution. The rotation of the factors is aimed at achieving a components matrix which has the greatest likelihood of being interpreted, that is, it fits in with the *simple structure principle,* under which each variable is saturated in a different factor. It may occur, however, that certain variables, even after rotation, are correlated to several factors, and that can be assumable because the variable participates from the significance of all of them .As has already been indicated, with four factors the model preserves 85% of the original total variance, so it can be stated that it is right to reduce the 35 initial variables to four factors .But, it is also important to interpret the meaning of the factors after the rotation. This will be done bearing in mind the saturation of the variables in them.

[12] The exclusion barrier for variables has been placed in saturations below 0.5.

The third factorial axis registers 18.19% variability and basically records variables referring to *the Civil service role* regarding innovation. To these can be added the variable referring to the venture capital system.

Finally, the fourth and ultimate factor, which records 16.89% variability, shows those elements alluding to knowledge creation activity in *innovating firms*. Moreover, variables referring to technological centres are saturated in the factor, due to being support units for firms in research, absorption and diffusion of technology activities.

Table 1: Factors of Spanish Regional Innovation systems

FACTOR 1: REGIONAL AND PRODUCTIVE ENVIRONMENT FOR INNOVATION

1) Productive Structure

- NAV High and medium technology industry in million € 1999 **(0.859)**
- NAV Low technology industry in million. € 1999 **(0.968)**
- Employees high and medium technology industry **(0.890)**
- Employees in low technology industry **(0.975)**
- Export. High and medium-high technology industry in million € 1999 **(0.870)**
- Export. Medium-low technology industry in million € 1999 **(0.666)**
- Export. Low technology industry in million .€ 1999 **(0.978)**

2) Support institutions for innovation

- National projects approved by the CDTI in million.€ 1999 **(0.882)**

3) Size of the region

- GDP in million € 1999 **(0.860)**

FACTOR 2: PAPEL DE LAS UNIVERSIDADES

- Internal university R&D expenditure, % of GDP **(0.686)**
- Internal university staff (FTE) in R&D, % of active population **(0.931)**
- University researchers (FTE) in R&D, % of active population **(0.917)**
- Students enrolled in first and/or second part of degree course compared to population aged 16 and over (each 100.000 inhabitants) **(0.631)**
- Students who have finished 1st and /or 2nd part of degree course compared to population aged 16 and over (each 100.000 inhabitants) **(0.694)**
- Students registered in postgraduate courses compared to population (each 100.000 inhabitants) **(0.892)**
- Students who have read their thesis compared to population aged 16 and over (each 100.000 inhabitants) **(0.916)**
- Research quality indicator of un iversity **(0.854)**

FACTOR 3: ROLE OF THE CIVIL SERVIVE

1) Civil Service

- Internal Civil Service expenditure on R&D, % of GDP **(0.908)**
- Internal Civil Service staff (FTE) in R&D, % of active population **(0.899)**
- Civil Service R&D Researchers, % of active population **(0.928)**
- Scientific capital stock in R&D (1999 € per inhabitant) **(0.791)**

2) Others

- Venture Capital investment (million € of 1999) **(0.533)**

0.500

FACTOR 4: ROLE OF INNOVATING FIRMS

0.533

- Firms internal R&D expenditure (percentage of GDP) **(0.809)**
- Internal staff (FTE) of firms in R&D, %o of active population **(0.801)**
- R&D researchers (FTE) of firms, %o of active population **(0.755)**
- Firms` technological capital stock in R&D (1999 € per inhabitant).**(0.693)**
- Regional distribution of technological centres
- Annual income of technological centres **(0.701)**

Source: own elaboration

2.4 Typology of Regional Innovation Systems

Identification of the factors mentioned has been used in building up a typology of regional innovation systems. The technique used for this purpose has been the cluster or conglomerate analysis from the values adopted by the factors in each of the cases. The cluster analysis is a multivariate technique which enables "individuals" to be classified in groups, without the sets constituting them or their number being known a priori. In this case the individuals are the selfsame Autonomous Communities in the different years of study and the grouping methods are both the one considering the proximity between units of each group and the one constructed from the separation between those units[13].
Bearing in mind the findings, and on examining the variables closely, the solution chosen is the one which establishes five clusters or groups. This result coincides in the two procedures carried out, which adds an element of confidence regarding the choice opted for. Consequently, the SRI typology set up on the basis of the factors identified in the previous section defines five systems types, four of which comprise just one Autonomous Community- Madrid, Catalonia, Basque Country and Navarre- and another the remaining regions, regardless of the year of study[14].

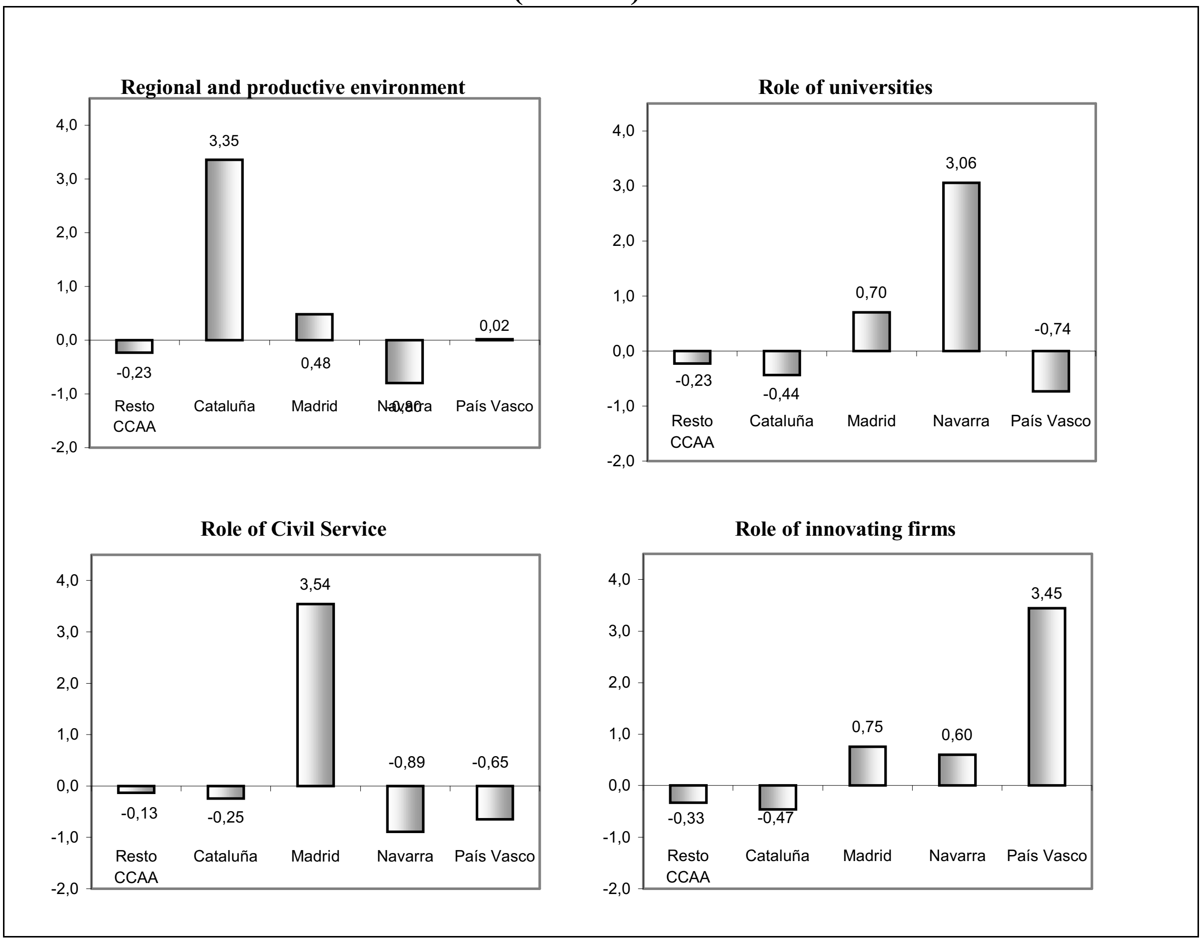
In order to show that there exists a significant differentiation among the five previously defined groups, as well as to highlight the factors which, in each case, characterise innovating activities, a variance analysis has been made via the factor classifying the Autonomous Communities in each of those systems. Given a quantitative dependent variable (four identified latent factors) and a qualitative independent variable (a variable or factor identifying each CCAA with a relevance cluster), the variance analysis with a factor consists of determining the behaviour of the dependent variable in the established groups by the values of the independent one. With a 99 per 100 level of significance the equal means null hypothesis has been rejected, so it can be stated that the types of regional innovation systems that have been detected register different behaviour in the four factors. Graph 1 shows the solution obtained by means of the factorial scores of the variables charged with summarising the statistical information regarding the mean.

The first factor identified- the regional and productive environment of innovation-shows different behaviour in the regional systems defined via the cluster technique. The Autonomous Community with a higher value than the rest of the regions for this hypothetical variable is Catalonia. In second and third place, with quite lower, albeit positive values[15], are Madrid and the Basque Country. The lowest, and negative mark is for Navarre. Also negative is the score for the group registering the rest of the regions of Spain. Thus we can see how important

[13] To use the technique it is necessary to fix a difference and a method of group building. Distance is an index reflecting the greater or lesser similarity among individuals, so the greater it is the lesser the similarity between the defined systems of innovation. The distance used here, *Euclid squared***,** can be seen to be affected by the type of units being handled, so this problem has been corrected by standardising the variables according to the Z scores method. With regard to the group-forming method, two *agglomeration* procedures have been used **-** *the nearest neighbour and the most distant neighbour*- that is, all the individuals are considered to belong to isolated groups and they become members of the cluster consecutively. In the case of the *nearest neighbour method* the groups are formed on the basis of lesser distance, and in that of the *most distant neighbour,* the nearest groups of individuals join together within the most distant ones.
[14] This same solution had already been achieved in previous studies where a similar list of variables was used for the average of 1996, 1997, 1998. (Buesa, Martínez Pellitero, Heijs, Baumert, (2003).
[15] Positive values denote a certain intensity of the higher-than-average factor of the group of Autonomous communities; and the negative ones the opposite.

within the Catalonian innovation system are the elements linked to environment and support infrastructures, such as the productive structure, aid to innovation in firms, accumulated knowledge and regional size. And it also shows the lesser importance of these variables in the remaining cases, among which Madrid and the Basque Country score positive, as we have already mentioned.

Graph 1.Value of the factors in regional clusters (mean=0)



Moreover, the factor referring to the university system has a clearly more outstanding relative role in the case of Navarre than in the other regions. Madrid, with a positive score, fills second place, though some way behind the former region. Whereas, on the opposite side, and with negative results which leave them in a position of the greatest disadvantage, we find the Basque Country. Catalonia and the other Autonomous communities also have negative factorial scores.

In the case of the factor recording elements linked to the Civil Service, the situation is also striking. Here we find a region, Madrid, where the average is way above those obtained by the remaining Communities. The importance of the Civil Service axis can be seen in this region, which gives it different characteristics to the others. Conversely, and most markedly in the Basque Country and in Navarre, the other regions are characterised by having negative scores in this factor, which is not strange if we take into account that Civil Service institutions dealing with science and technology are more likely to be sited in the Spanish capital.

Finally, in the case of the factor representing aspects most linked to the area of innovating firms, noticeable differences appear once more. The average of this hypothetical variable is very high in the case of the Basque country, which highlights the importance of this subsystem within the regional innovation itself. In second and third place, with positive values, we find respectively, Madrid and Navarre, with Catalonia and the other Communities achieving negative scores.

By way of conclusion, it can be mentioned that Madrid is the region with the most complete innovation system, as verified by its factorial scores which are always positive, and thus above average. The Basque Country and Navarre take what could be considered as an *assymetrical system*, since only one of the four factors is found in a developed form. The remaining regions have weak innovation systems, and have not achieved important development in any of its components.

3. THE INNOVATION SYSTEM AND KNOWLEDGE GENERATING PROCESSES

Once the factors implicit in regional innovation systems have been detected, we went on to make a multiple regression least squares analysis, to determine what is the combination of them which enables the calculation of innovation flow, by means of the *number of patents* to be estimated[16].

There is a broad range of empirical studies indicating the existence of a high correlation between a measurement of innovatory input-such as R&D costs- and measurement of output, such as the number of patents (see among others Griliches, 1990; Trajtenberg, 1990; Patel and Pavitt 1994). Moreover, compared to other measurements of innovation output, patents guarantee a minimum level of originality, as well as being highly likely to become an innovatory product. (Buesa et al.2001). Undoubtedly, the use of patents as a measurement of technological innovation also has some disadvantages which were already pointed out by Griliches in 1990. Firstly, not all innovations materialise in the form of a patent, since firms may opt for other ways of protecting their inventions, such as, for example, the industrial secret in itself. Secondly, even though the patents-by their own definition-guarantee a certain level of newness and originality, it is also true that the value of the patents is heterogeneous, that is, they do not reflect differences of quality between them. Moreover, not all of them reflect technology used in productive activity. However, as pointed out by Buesa et al, (2001), it is a restriction the effects of which are minimised due to the fact that, if data are used for a large number of patents, their quality should be expected to be distributed in a similar manner for any type of aggregation, probably following a normal pattern.

The output indicator takes into account the patents requested and published by the Spanish and European Patents Offices. We have deemed it necessary to reflect the greater value of

[16] This type of analysis fits in with the line of empirical studies which have investigated the presence of spillovers in their respective areas of analysis. Basically a distinction can be made between two types of models: those which analyse national innovation systems (Stern, Porter and Furman, 1999, 2000, 2002) and those which do the same for regional systems. Among the latter can be distinguished those which study the American regional innovation system (Jaffe, 1989, Acs et al, 1992, Feldman, 1994; Anselin et al, 1997; and those who have done it for Spain Gumbau, 1996; Coronado and Acosta, 1997; García Quevedo, 1999).

European patents, which have higher registration costs both in time and money, using a factor of five to weight them in comparison with the Spanish ones, since European patents are registered on average for five countries, so that :

$$PAT_{r,t} = PAT_{r,t}^{ESP} + 5 \times PAT_{r,t}^{EUR}$$

Where $PAT_{r,t}$ is the weighted sum of the patents of region r in year t and $PAT_{r,t}^{ESP}$ y $PAT_{r,t}^{EUR}$ are respectively, Spanish and European patents for each region:

As our aim is to detect which of the above-mentioned factors enable innovation flow to be estimated and to what extent, the generation of fresh knowledge function is fixed by the following equation:

$$PAT_{r,t} = \delta_{ENT} W_{r,t}^{ENT} + \delta_{ADM} X_{r,t}^{ADM} + \delta_{EMP} Y_{r,t}^{EMP} + \delta_{UNI} Z_{r,t}^{UNI}$$

Where W^{ENT} designates the *environment* factor, X^{ADM} measures the *Civil Service* factor, Y^{EMP} indicates the *innovating firms* factor and Z^{UNI} records the value of the *university* factor, and in which the subindices r and t designate, respectively, the region and the year. Note that we have done without a lag between *input* and *output,* considering that, as pointed out by Buesa and Molero (1992), in Spain the relationship between R&D and patents is almost simultaneous.

In Table 2, there is a presentation of the findings obtained by applying an ordinary least squares procedure by the stepwise method. The necessary validation steps[17] have been carried out on this model.

Table 2

	Non-standardised coefficients	*Standardised coefficients*	*Parametric contrasts*	
	B	*BETA*	*t*	*Sig.*
(Constant)	201,506		28,428	.000
ENVIRONMENT	267,463	,874	37,510	.000
CIVIL SERVICE	106,291	,347	14,907	.000
FIRMS	68,356	,223	9,587	.000
UNIVERSITY	45,104	,147	6,326	.000
R	R^2	Durbin Watson*		
0,978	0,957	2,02		

a Dependent variable : Weighted sum patents
*Values obtained after randomising the residuals

[17] To validate the model we have carried out the usual tests on residuals, comparing their normality, lack of statistically significant correlation among the forecast values and the residuals and, finally checking their homocedasticity ,which ensures the model's robustness and, thus, the validity of the coefficients calculated .In a complimentary way a colinearity diagnosis was carried out, producing a lesser condition index of 15, and this, along with the regression procedure used, avoids any multicolinearity problem that might restrict the validity of the findings.

From the findings it is confirmed that the four factors turn out to be statistically significant and also have a positive sign, which confirms the validity of the evolutionary approach in arguing that knowledge creation is the result of the interaction of different elements considered to be under the concept of Regional Innovation System. Now, it is also of interest to interpret the relative weight of those factors in the model. That will be done by taking into account the values of the standard BETA coefficients[18], which enables us to compare the importance of the factors in the model. As can be seen, it is the factor related to *regional and productive environment* which has a greater prominence in the model, specifically with a 0.874 Beta value. Secondly, and at an important distance, we find *Civil Service* (Beta 0.347), followed by the role of *innovating firms* (Beta 0.223), and finally, with a relatively lower weight in the model we have the *university* (Beta 0.147).

Within the economic interpretation, we will be able to highlight that for the Spanish case there is a strong influence of *environment* variables in the quantified innovation flows across the weighted sum of patents. Specifically, a larger-sized productive structure plays a key role in achieving results related to technological innovation, which ratifies the importance of a certain critical mass and a minimum market size. In this way, the hypothesis which states the importance of the business segment within innovation systems is verified. If we also bear in mind the relative weight of the factor related to innovating firms, this hypothesis is reinforced. Moreover, the Civil Service and the university, albeit with a significant, positive role, are reduced to a secondary role, which is not an obstacle to their interaction with the other factors contributing to obtaining greater innovation results.

The findings obtained via the use of factors corresponding to regional innovation systems are in accordance with those of preceding studies where the work was carried out with a set of non-hypothetical indicators- as is the case with factors-but real ones (Buesa, Baumert, Heijs Martínez Pellitero 2003), for the same time period and using the same dependent variable (weighted sum of patents) and, at the same time, they are in keeping with those that have been highlighted in international literature, both for regional and national cases[19].

4. CONCLUSIONS

As indicated at the beginning of this article, the economy is giving merited attention to the relationships existing between innovation and the regional geographic environment. Various authors have underlined the importance of the evolutionary approach in the design and implementation of policies, especially those related to scientific and technological aspects. What is more, the importance of carrying out empirical studies to serve as a basis for *policy making* exercises is highlighted.

Bearing these aspects in mind, in this article the findings have been presented for the study of the Spanish case on the capacities of regional innovation systems, through the use of different

[18] This coefficient represents, in terms of elasticity, the increase in the dependent variable-in typical deviations- produced when the typical deviation increases by one unit the value of the dependent variable under the *ceteris paribus* hypothesis.
[19] See the works quoted in note 16.

econometric analyses. In the first place, the research started from a database comprising a wide range of indicators referring to the elements making up innovation systems. From this starting point and for a time period ranging from 1994 to 1998, by applying the multivariate technique of main components analysis, four essential factors have been identified in them: the regional and productive environment, the university, the Civil Service and innovating firms. These factors, the denomination of which synthesises the variables of which they are made up, as well as showing us the axes making up the Spanish innovation systems, have been used in a double exercise: on the one hand, they have been used to identify a typology of regional innovation systems; and, on the other, they have been used as explanatory variables of the flow of knowledge obtained by means of patents.

As far as the typology of the regional systems is concerned, the findings obtained show the existence of five groups with very significant differences, four of them made up of a single region (Madrid, Catalonia, the Basque Country and Navarre) and the fifth grouping together the rest. Of those systems the Madrid one is the most balanced, since all the factors score positive, which corresponds to a position of advantage in all elements which are important in the generation and diffusion of knowledge. The cases of Catalonia, the Basque Country and Navarre show systems in which only one or two of the four factors stand out. Thus, Catalonia boasts an extensive market and important productive activity. The Basque country reflects a strong segment of firms engaging in R&D. Navarre stands out through the special role of the universities located there whilst having an above-average place in innovating firms' activity. Finally, the other regions are located in the technological periphery and do not stand out in any of the factors identified. This fact is proved by observing how factorial scores always have a negative value. They are, therefore, regions which still have important weaknesses which should receive preferential treatment in comparison with the other above-mentioned ones as far as scientific and technological policies are concerned.

Regarding the findings obtained through the linear regression analysis, verification has been given to the fact that in the Spanish case, the *regional and productive environment* is the factor having the greatest impact on the generation of technological knowledge, as evidenced by patents If we also take into account the relationship existing between the *productive environment* and *firms of an innovatory nature,* the weight of this union is much higher than that exerted by the *Civil Service* and, especially, by the *university.*

From all the above two important conclusions can be drawn. On the one hand the differences between the various Spanish regions when designing scientific and technological policies must be borne in mind, since their innovation systems show important inequalities and shortfalls in developing the factors which shape them. Thus, an attempt should be made to resolve in time the specific weaknesses of each region by applying policies of a regional nature. Also, it must not be forgotten which factors carry the greatest weight in knowledge generation. In this way those policies geared to growth in regional innovation will have to target their effort preferably to developing a diversified productive structure, as well as strengthening and extending the number of innovating firms capable of developing fresh knowledge.

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