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Spanish Research and Innovation in the International Context.
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Spanish Research and Innovation in the International Context

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If technology is defined as the techniques (ways of doing useful things) that have been understood, improved or created thanks to science, it can be said that our country has never played a role, not even a discrete one, in the history of science and that only at very certain times has it stood out in the history of technology. The hydraulic devices of Islamic Spain were the cause of one of these moments, and the same occurred more recently, when the powerful empire of Philip II had to equip itself with more modern techniques and technologies to administer very distant and very different territories. For the time period, it was especially skilful in the control of health problems, in the provisioning of armies, in communications and in the exploitation of natural resources. The interest in science of that Spain was, as Sánchez Ron (1999) points out, "too instrumentalised toward specific directions of material value to the State". We would say, in the language of today, that there was only concern for innovation of lower added value, that which limits itself to using scientific knowledge, forgetting about generating it. It is a lesson which Spain still has not learnt, as the occasion will repeatedly arise to state throughout this article.

This obsessive preoccupation of such a powerful State as Spain for "applied science", or better for the application of science, could explain the fact that during the whole 18th century the impressive scientific revolution that would unfold during that period would go unnoticed by it. The works of Galileo, Harvey and Newton only had some influence at the end of that century, when a few innovators realised how far behind the country had become. But, the consequences were not very different from those commented on already, because even when Spain was among the users of Newcomen's machine, as early as 1730, it was not able to attract, in that century nor the previous one, foreign scientists and innovators, as other European countries did (Mokyr, 1990). In fact, the steam engine did not "acquire naturalness in Spain until 1833" (Nadal, 1988).

The arrival of the Borbons was good for Spanish science and technology. The Enlightenment modernised Spain, introducing the scientific institutions that had been successful in other countries, although it is true that this occurred through the work of military men and religious

figures, who tried to give a solution to the preparation of technical personnel and the education of the elites. All in all, at the end of the 18th century, in Spain there existed a relatively large number of institutions that achieved a certain integration in the European scientific world, in participating in international co-operation projects such as botanical expeditions and astronomical or geodesic observations. The Enlightenment ended badly in Spain, and with it the boon time for science and technology. When Jovellanos ended his famous Report of the Economic Society of Madrid, in 1794, the Reign of Terror was being imposed on France and it spread fear in Spain, to the point that several theses of the Report became suspect. The next ten years, until the war against the French, were marked with uncertainty, and the war itself was an end point of a period of a certain hope, because the war not only disrupted the institutions but also materially destroyed the laboratories and cabinets that were called on to be emblematic.

The country began the 19th century in very bad conditions for embarking on the evolution that, from an incipient Industrial Revolution, has characterised scientific and technological development. Industry and science should walk together more and more in order to prosper, although this did not become clear until much more recent times. But, the fact is that since then science has only flourished in a sustainable way when Industry has offered it a field for the detection of problems and for experimentation on their solutions. At that time, our country and many others were not among the few that had a strong economy capable of stimulating scientific capacity in the search for knowledge that would make it possible to give attention to demands that were growing in an unknown way. One example will suffice to see this reality: between 1800 and 1900, production of cotton fabric in Great Britain multiplied by 34 (Nadal, 1988).

The evolution of Spanish science in the 19th century is a reflection of the country's situation. The end of the war that ushered in the century did not signify the return to normality, no matter how much this was tried during the first absolutist period of Ferdinand VII. There continued to be uprisings, wars and continuous Government crises, and with it half a century went by without anyone being able to talk of tranquility. The Restoration, which began in the last quarter of the century, marked the beginning of a certain continuity in attention to science. Although throughout the century there had been figures dedicated to science, this field could not find spaces in which to develop and ended up reduced to the teaching of it and to the dissemination of the results of foreign research.

The loss of Cuba signified a veritable commotion for Spanish consciousness, which saw in this the consequence of the country's backwardness. And this affected science. "Half-Science Cause of the Ruin" is the title of an article by Santiago Ramón y Cajal in *El Liberal* in 1898, in which he says "we must create original science in all of the orders of thought... We have fallen to the United States due to being ignorant and weak; we did not even knew anything about its science and strength. It is necessary for us to regenerate through work and study". And from this regeneration sprang a current of scientific modernisation, the principal consequence of which was the creation of the Council for the Extension of Studies and Scientific Research [Junta de Ampliación de Estudios, JAE] in 1907. Spain initiated for the first time in centuries, albeit timidly, a foreign presence of Spanish science and scientists. Thanks to this Council, Spanish scientists frequented research centres of worldwide prestige and were able to align their work with the trends of the time. On example of this change could be the interest that the Rockefeller Foundation showed for Spanish science, which allowed for the creation of a new National Institute of Physics and Chemistry, arising from the Council's Physical Research Laboratory in 1932. Reports by American experts, which stretched from 1919 to 1932, repeated their good impression of Spanish scientists, whom they described as "enthusiastic and fairly active researchers set up in an absolutely inadequate way" (Sánchez Ron, 1999), a reason which justified future aid.

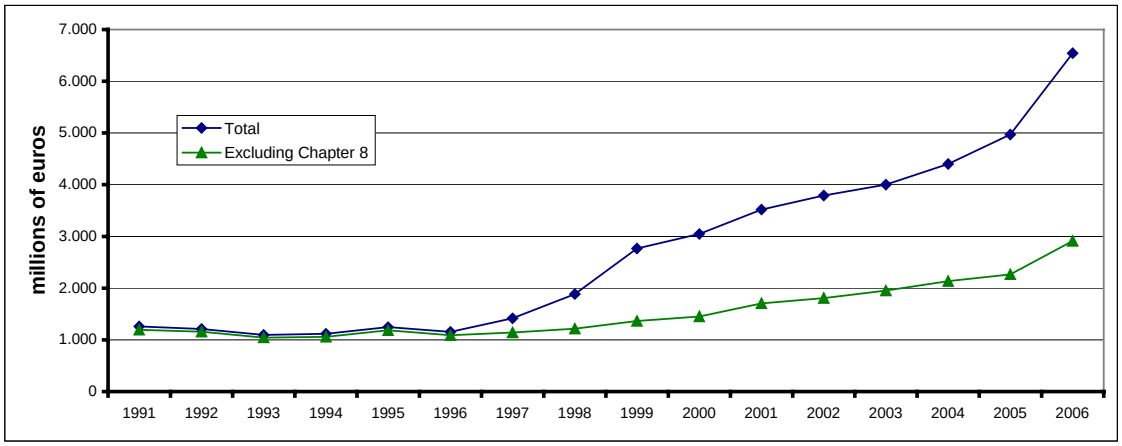
The Civil War was the next hindrance to the development of Spanish science. With it began a serious dispersion of Spanish scientists, who in many cases would never return and in other cases only did so in the last years of the dictatorship. The Spanish National Research Council (CSIC) and the University were the repositories of Spanish science and technology, but during this long period of time, there were no resources or initiatives that would take it again up to the international level.

The change caused by the 1986 Science Law

Following the tradition of centuries, the political transition begun in 1975 did not show any early concern for science and technology. Eleven years had to go by before an initial interest would emerge. After several attempts, in April 1986 the Science Law was passed, which signified a radical change in the way the Spanish Administration faced the issue of science and technology. The principal merit of this Law has been to achieve that, since its passage,

year after year, the General Budget of the State has allocated funds for the generating of science and technology. They are not large sums yet, but they have been maintained throughout these years, with growth rates that reflect not only the economic situation but also the interest that the Government has manifested in technological issues, as seen in Figure 1.

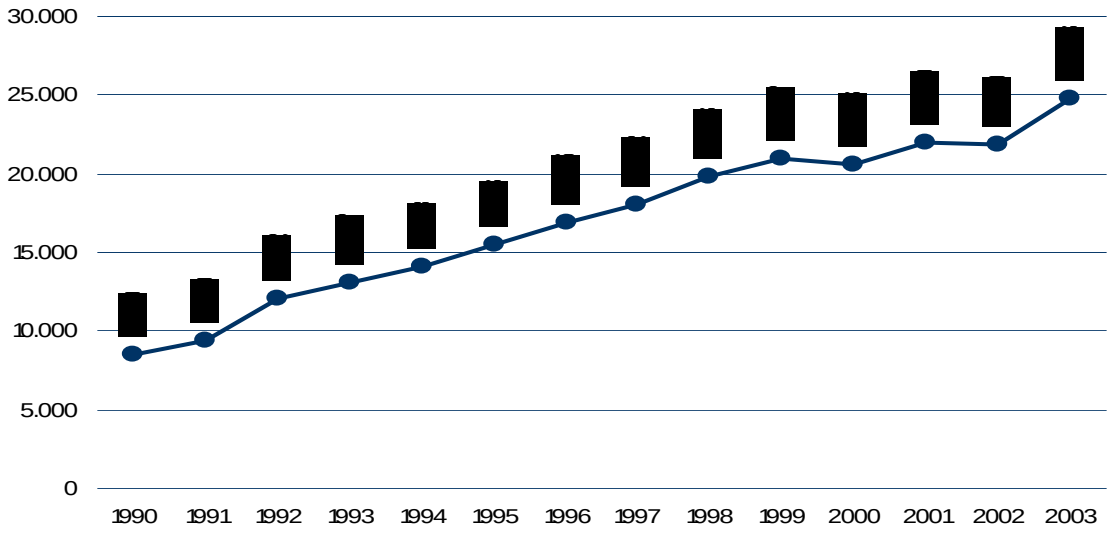
Figure 1.- Evolution of the amounts allocated to Science, Technology and Innovation in the General Budget of the State.



Source: Author's own elaboration based on the General Budget of the State (several years)

The Law also made it possible to create what is called the National Agency for Evaluation and Forecasting (ANEP), which established a system for evaluating research project proposals that competed for these funds. Without a doubt, the work of this agency has been a determining factor in the favourable evolution that Spanish scientific production has had. Currently, Spanish articles represent 3% of those published in scientific journals of worldwide prestige. This percentage is one point higher than our GDP in the global context, as can be seen in Figure 2.

Figure 2.- Evolution of Spanish scientific production (SCI) in international journals (number of documents), 1999-2003.



Source: CINDOC (2004)

The Science Law also put the Spanish scientific panorama in order. Thanks to it, methods were established for planning and co-ordinating scientific activity. The National R+D Plan became the principal instrument of science and technology policy, which had to be managed by the Inter-Ministerial Commission on Science and Technology (CICYT), both of which were created by this Law. Article 11 of the 1983 University Reform Law and the later Regulation on Salaries of University Professors, of 1989, made it possible, for the first time, to achieve a certain stabilisation of Spanish university researchers as a group. Thus, Spain now has a structured system of science and technology comparable with those of the countries around it, although, as will be seen further on, it is of an excessively small dimension. Nevertheless, the ideas in fashion at that time and on which the writing of the Science Law was based, would lose credibility very few years later. The year 1982 saw the publication of the article by Nathan Rosenberg entitled *How Exogenous is Science?*, which began to erode the faith that was professed in what we now call the linear model of technological innovation, which that Law supported.

Following what was orthodox at that time, its main concern was to give impetus to the existence of a scientific system, an obvious need for the Spain of that period, but it forgot the

whole process of conversion of scientific knowledge into products or services that could be created or assimilated in Spanish laboratories. The Law did not pay attention to more that one part, undoubtedly a very important one, of the process of technological innovation: according to that model, it sufficed to create scientific knowledge, since confidence was placed in productive sector being able to take advantage of it. What Rosenberg had revealed was that in an effective technological innovation system, it was necessary to stimulate the presentation of the technological problems of businesses to researchers and to translate science into technology capable of solving those problems within the business context itself, frequently of a low technological level. In consequence, the Law had not foreseen, in a specific way, the need to stimulate technology transfer nor any of the mechanisms and instruments that later, and with a certain difficulty, have gradually been created.

Technology centres, science parks and many other innovation-support infrastructures were not considered in the Law, nor was consideration given to awarding merit in the career of public researchers for the difficult task of transferring technological knowledge to a traditional production system and with competitive advantages, which only very recently have begun to be based also on technology. The Science Law has been able to create, for the first time in the history of Spain, a scientific system with weight in the world, a fundamental step but one which is insufficient for it to be able to contribute to an increase in wealth and welfare for Spaniards.

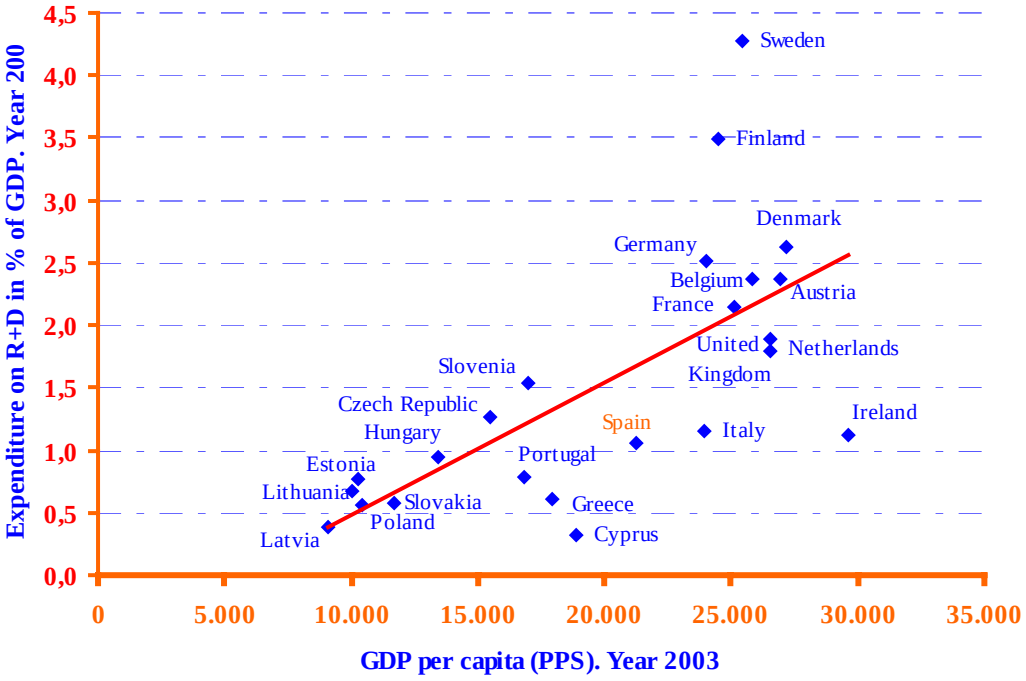
Current figures and the challenge of the immediate future

In international comparisons, the indicator most utilised for synthesising the scientific and technological capacity of countries is their spending on R+D, expressed in percentage of their GDP. This is only one of the indicators of contributions to national innovation systems (inputs), but their use is backed up by their extraordinary correlation with results in science and technology and with the degree of welfare as well as by the fact that they are the fruit of statistics which, for over thirty years, the countries of the OEDC carry out. Figure 3 shows value of this indicator in 2003 for the countries in the Europe of the 25 (EU-25), and it relates this with their per capita GDP.

An initial conclusion that is drawn from Figure 3 is that Spain spends noticeably less on R+D than what would correspond with its income level. This can reflect that its development has

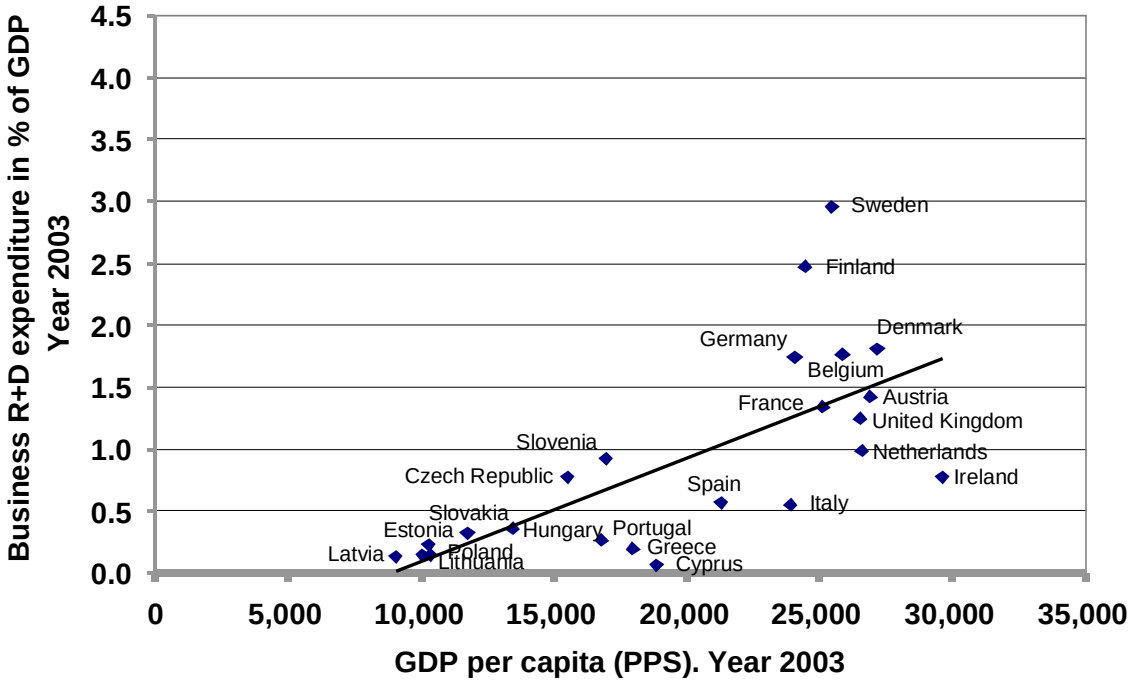
been based on economic models that have resorted to science and technology with less intensity than others, but what it clearly expresses is that our innovation system is proportionately smaller than what could be expected from our economic situation. The business contribution to R+D expenditure should give a clearer idea of the economic importance of this activity, because it is logical to suppose that the application of these resources will be aimed at obtaining products or services. Figure 4 shows its international comparison also.

Figure 3.- R+D expenditure and per capita GDP in the EU-25 countries (2003)



Note: Data for Luxembourg and Malta unavailable.
Source: Author's own elaboration based on Eurostat (2005)

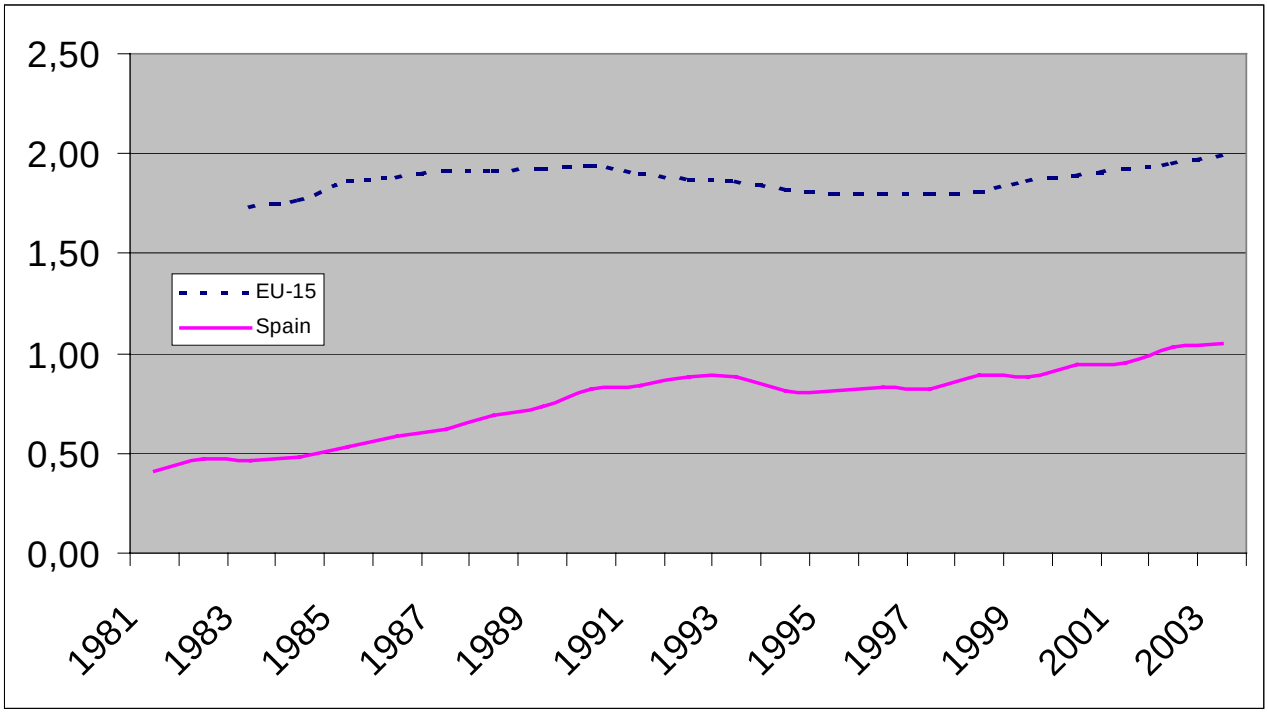
Figure 4.- Business expenditure on R+D and per capita GDP in the EU-25 countries (2003)



Note: Data for Luxembourg and Malta unavailable.
Source: Author's own elaboration based on Eurostat (2005)

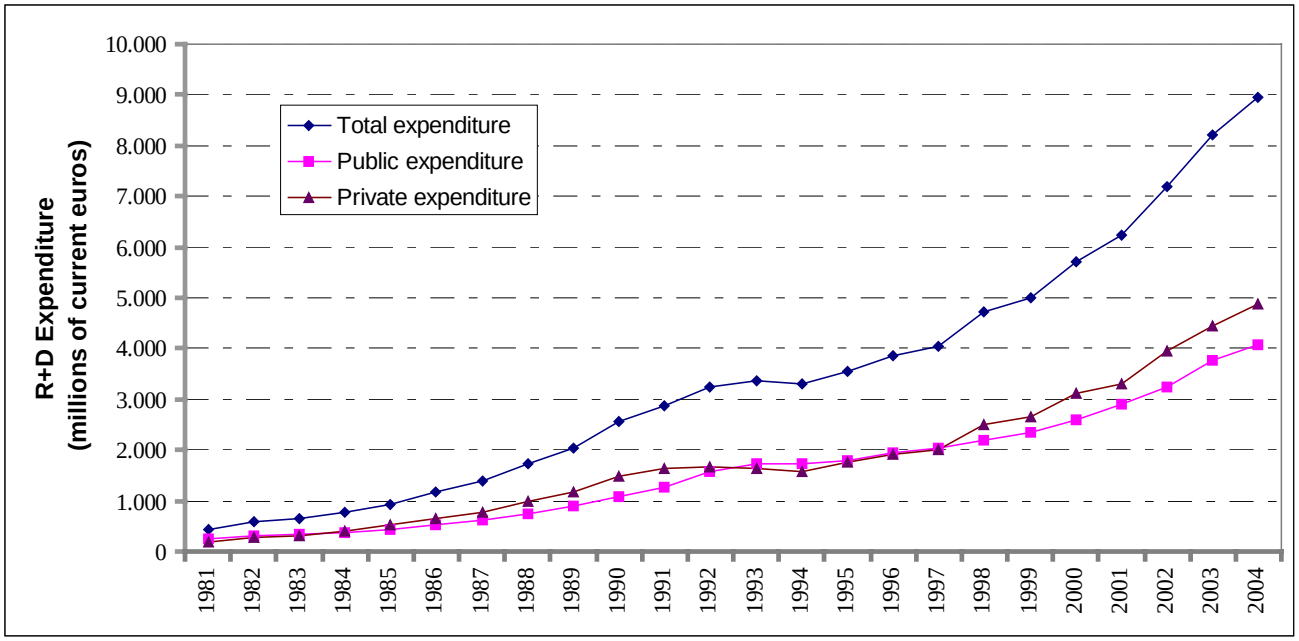
On the part of Spain, the evolution of the dedication of resources in terms of the GDP demonstrates a convergence with the European Union, although it is still far from achieving this, as seen in Figure 5. But, due to the fact that the growth of the Spanish GDP has been greater than that of Europe in the last few years, a better idea of the effort made by Spain is given by the expenditure curve in current money, found in Figure 6.

Figure 5.- Evolution of total expenditure on R+D in terms of per capita GDP for Spain and for the average of the EU-15 countries.



Source: Economic Office of the President (2005)

Figure 6.- Evolution of Spanish R+D expenditure in current money, according to its agents.

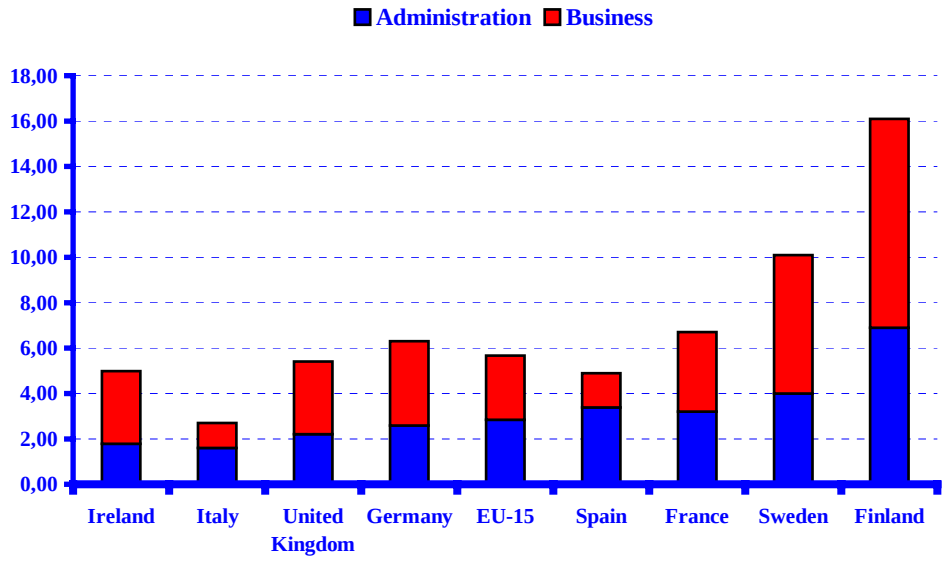


Source: Author's own elaboration based on INE (several years)

The increase in Spanish expenditure on R+D has been important since the middle of the last decade, both that made by businesses and that made by universities and public centres, as Figure 6 shows. The growth rate is over 10% annually accumulative, surpassing what has been habitual in Europe, North America and Japan. According to a recent report by the consulting firm, Booz, Allen and Hamilton (Jaruzelski et al., 2005), based on a worldwide survey of 1000 companies, which could signify between 60 and 80% of world expenditure, the rate of growth in these companies' R+D spending between the years 1999 and 2004 has been a world average of 6.5%, which should be compared with Spain's 14%. It is true that the growth of the companies in the sample is very disparate by region. The American ones grew at an annual rate of 6.6%, the European ones at 6.2% and the Japanese at 4.8%. Those of China and India have grown at 21.1% and those of the rest of the world at the high rate of 36.7%. These figures do not cease to give evidence for the idea that concern for generating science and technology is great throughout the world and that Spain is acting in accordance, although in order to reach the European average, it should still do so with greater intensity, as can be deduced from Figure 5.

The country's scientific and technological potential is really measured by its research personnel and by the resources they have at their disposal. In relative terms, the Spanish situation can not be distinct from that which the above-cited data has been demonstrating. Figure 7 presents the number of researchers per 1000 people employed in some European Union countries, separated according to whether they work in the public or private sector.

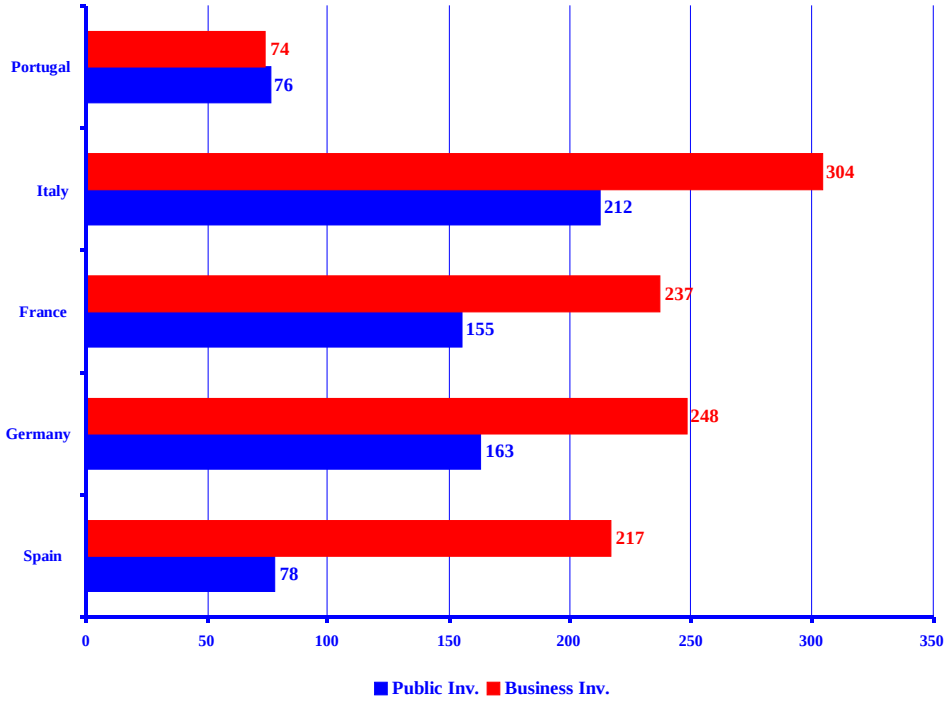
Figure 7.- Researchers in FDE (full dedication equivalencies) for every 1000 employees by sector in various EU countries.



Source: Author's own elaboration based on OECD (2005) and Eurostat (2005)

Spain has a total number of researchers somewhat under the European average, but a great deal lower than countries like Germany, Finland and Sweden. However, the great difference is that the majority of Spanish researchers (69%) are working in the public sector, when this ratio is inverted in the most advance countries. And the situation is much worse, because, as Figure 8 shows, the Spanish public researchers have much less resources than their European counterparts, although it is true that the Spanish business researcher is reasonably well equipped.

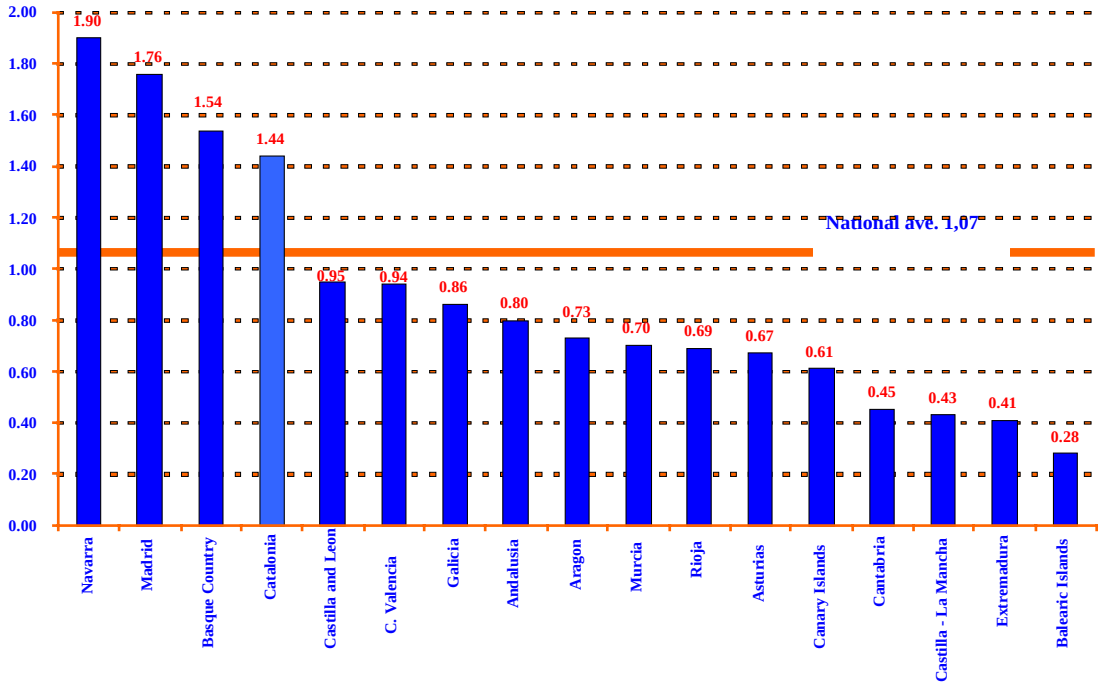
Figure 8.- Expenditure in thousands of $PPC per researcher in the public and private sectors in different EU countries.



Source: Author's own elaboration based on OECD (2005) and Eurostat (2005)

Another non-positive characteristic of the Spanish innovation system is its very low degree of geographic homogeneity, which is shown in Figure 9. Only four communities are over the average expenditure in R+D measured in percentage of GDP, which matches the same dispersion pattern in the rest of the indicators of their regional systems.

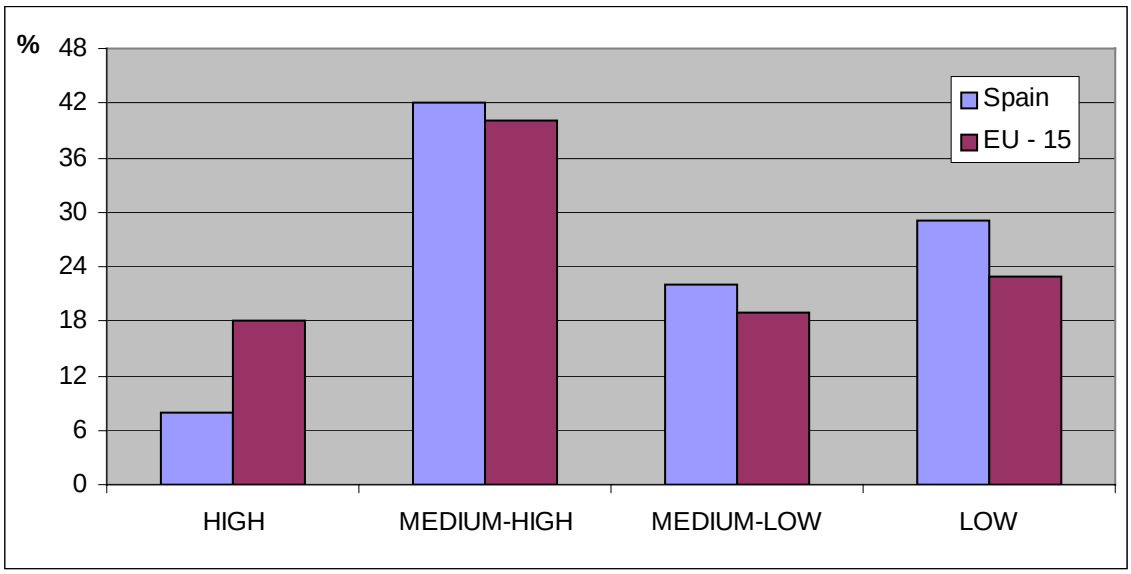
Figure 9.- Total regional expenditure on R+D measured in terms of GDP, and their comparison with the national average.



Source: INE (2004)

Whereas the resources devoted to R+D activities are used as an indicator that synthesises the concern that an economic system feels for science, technology and its conversion into a tool of competitiveness, it is habitual to compare the performance of this concern, also in a synthetic way and as a first indication, through the composition of the exports of the economy in question. Those economies that export high-technology products in a greater proportion will supposedly be those that dedicate more resources to R+D and obtain greater advantages with them. In comparison with the EU, the behaviour of Spain would be reflected in Figure 10. Spanish exports would surpass the proportions of the set of 15 old members of the Union in low, medium-low and medium-high technology, at the expense of a significant negative difference in those of high technology, a result that would be in agreement with all that has been said up until this point.

Figure 10.- Structure of exportations according to their technological intensity.



Source: Economic Office of the President (2005)

Another frequently used indicator of results (output) of the innovation system is the number of patents applied for annually. Spain, with less than three thousand applications per year, is one of the least efficient countries in this respect. To the small size of the system itself is added a production structure that, as has already been seen, is composed of companies dedicated to low- and medium-technology sectors, which, in addition, are of a small size, where the protection provided by a patent has less value.

Spain also fares no better in the indicators that aim to measure its capacity for innovation. These are still experimental indicators and are based on data that is much less reliable than that cited before for research activity. In the European sphere, the so-called *European Innovation Scoreboard* (EIS) has been repeated for the fifth time, which generates a synthetic index on the basis of 22 partial indicators grouped into four categories, which aim to reflect for each country the availability of human resources for innovation, the production of new knowledge, the transmission and application of knowledge and, finally, the financial situation of the innovation, of the results and of the markets in each country. Year after year, this index demonstrates that Spain is slightly behind in innovation with respect to the European average and its tendency in evolution has been considered in the majority of cases to be positive, although the predictive capability of this index is quite doubtful for estimating evolution,

because it does not use values of the indicators always corresponding to the year of evaluation.

By way of conclusion, it can be said that the principal defect of the Spanish innovation system, when it is subjected to an international comparison, is its small size, and its principal dysfunction is the small weight of business in research activities. But, this demands a more detailed analysis. On the one hand, as has already been commented on, Spanish scientific production is reasonably good, and this coincides with an acceptable number of researchers in the public sector, who have scant resources, but which must be sufficient for financing scientific production, on the whole much cheaper than the production of technology. When the figures of exportation of high-technology products are scaled with expenditure on R+D, there do not exist large differences among the results per euro spent with what other European countries obtain, and in some cases the balance is even clearly favourable to Spain. Something similar occurs with the exportations of capital goods, which are always demanding in terms of technology. All of this, together with the known existence of Spanish companies that successfully compete in technological markets allows one to have the hope that the Spanish innovation system, within its small size, will be efficient. Certainly it is true that during the years that have transpired since the Science Law came into effect, the country has achieved creating a small system that involves very few businesses, a reasonable number of public researchers with little dedication to knowledge transfer and an Administration that manages the resources its allocates to public research with a certain effectiveness. But, this system has not been capable of creating an environment that manages to stimulate the innovative activity of a significant part of the productive fabric. If this were so, the country would be prepared for an expansion of its innovation system, because it would have already acquired the ability to manage this resource which is important for all modern economies.

Bibliographic references

COTEC (2004) *El sistema español de innovación. Situación en 2004.* Cotec.

COTEC (2005) *Informe Cotec 2005. Tecnología e innovación en España.* Cotec.

EUROPEAN COMMISSION (2005) *European Innovation Scoreboard 2005. Comparative analysis of innovation performance.* http://trendchart.cordis.lu/scoreboards/scoreboard2005/pdf/EIS%202005.pdf

INE (2005) *Estadísticas sobre actividades de I+D.* http://www.ine.es/inebase/cgi/um?M=%2Ft14%2Fp057&O=inebase&N=&L=

INE (2005b) *Encuesta sobre innovación tecnológica en las empresas.* http://www.ine.es/inebase/cgi/um?M=%2Ft14%2Fp061&O=inebase&N=&L=

JARUZELSKI, Barry et al. (2005) The Booz Allen Hamilton Global Innovation 1.000: Money isn't every thing. *Strategy + business* 41.

MOKYR, Joel (1990) *The lever of riches. Technological Creativity and Economic Progress.* Oxford University Press.

NADAL, Jordi et al. (1988) *España, 200 años de tecnología.* MINER

OFICINA ECONÓMICA DEL PRESIDENTE (2005) *Convergencia y empleo. Programa Nacional de Reformas de España.* Ministerio de la Presidencia.

ROSENBERG, Nathan (1982) *Inside the black box: technology and economics.* Syndicate of the Press of the University of Cambridge.

SÁNCHEZ-RON, José Manuel (1999) *Cincel, martillo y piedra. Historia de la ciencia en España (siglos XIX y XX*). Taurus.