Documento de Trabajo

9214

SPANISH INNOVATIVE PERFORMANCE. EVIDENCE FROM U.S. PATENTING.

José Molero Zayas

Jordi Molas-Gallart.

FACULTAD DE CIENCIAS ECONOMICAS Y EMPRESARIALES. UNIVERSIDAD COMPLUTENSE DE MADRID.

Campus de Somosaguas. 28.223 MADRID.

SPANISH INNOVATIVE PERFORMANCE. EVIDENCE FROM U.S. PATENTING.

Dr. José Molero. Facultad de Ciencias Económicas y Empresariales, Universidad Complutense de Madrid, Campus de Somosaguas, 28023 Madrid, SPAIN.

Dr. Jordi Molas-Gallart. Science Policy Research Unit, University of Sussex, Falmer, Brighton BN1 9RF, U.K.

ABSTRACT

In this article we combine the insights provided by the study of Spanish patenting performance in the United States with further evidence on sectoral innovative strengths. This analysis unveils an image of Spanish innovative strengths not revealed by the more common use of innovation input indicators, specially R&D. A possible explanation for this divergence may lie in the existence of two different structures of innovation in the Spanish industry.

1 Introduction.

1.1 Spanish Science and Technology

In a previous article [Molero, (1983)] one of us discussed the deficiencies of the Spanish innovation system. It was then shown that a situation characterized by a very low R&D effort and a strong reliance on the import of technology, persisted despite changes in the economic and political environment system during the seventies. Since the early eighties the Government has targeted science and technology policy as an area of high priority. Accordingly, Spanish R&D has grown significantly from 0.4% in 1970 and 0.53% in 1985 to almost 1% by 1990. A new legislative framework[1] and a "National Plan"[2] were set up. The National Plan aimed at coordinating the science and technology policies of the different ministries, improve the management of R&D funds and the channels of communication between industries, universities and State laboratories, and set up clear research priorities.

It is too early to assess the results of these later S&T policy actions[3] implemented only since 1988. Yet, the examination of new indicators will provide fresh evidence on the characteristics of Spanish innovation and will offer additional tools for the future assessment of the success of the present S&T policies.

---

[1] Above all the April 1986 "Act for the General Coordination of Scientific and Technical Research," popularly known as the "Science Act."

[2] "National Plan for Scientific Research and Technological Development."

[3] A review is currently underway, the results of which will be available towards the end of summer 1991.

1.2 Measuring innovation

The increasing effort in R&D investment in Spain is well known. Figure 1 displays the growth of public R&D over the early eighties, before the implementation of the "National Plan."

(Figure 1 around here)

Yet, this growth in R&D investment (an input to technological innovation) does not automatically guarantee an improvement in the technological capacity of the Spanish economy. The analysis of technological innovation in Spain has, to date, relied almost exclusively on R&D data leaving unattended the study of indicators of innovative performance. This paper is a step toward redressing the balance.[4]

The analysis presented here will revolve around the use of U.S. patents data.[5] Such approach will furnish two objectives. First, it will help identify sectors of relative innovative strength in the Spanish economy. Secondly, it will locate the firms in which these innovations have taken place. The data obtained will be shown to be congruent with the insights provided by other economic indicators and analyses.

The U.S. patents indicator only refers to international innovations and therefore technological progress through imitation or purchase of capital goods is not captured by it. It reflects innovative performance at the world technology frontier rather than the capacity of an economy to assimilate innovations. Patents reveal

---

[4] Other studies using output indicators for the study of Spanish technological performance are MOLERO, BUESA, FERNANDEZ (1990), CIRCULO DE EMPRESARIOS (1982) and BUESA (1991).

[5] This source has hardly been examined for the Spanish case. A brief reference to Spain can be found in PAVITT, PATEL (1991) within a wider aggregate study of the European case.

genuine innovations that point to the existence of a competitive advantage not based on cheaper factors of production but on technological ability. U.S. patenting provides a more discriminating indicator than R&D. The much higher cost and difficulty of patenting in the United States guarantees that only products for which an international market is envisaged are going to be considered. Recent research has further confirmed the value of U.S. patents as an indicator of technological innovation and change.[6]

Although the patentees might be Spanish branches of Transnational Corporations -and therefore we cannot equate directly patents with technological "independence"- they evidence the existence of local technological capacity.[7] Besides patents offer highly detailed information making possible analysis of trends and sectoral strengths both at the economy and firm level.

The limitations of patents as indicators are well known and have been discussed by those authors that have done most to popularize their use [see Pavitt (1985, 1987); Basberg (1987); Griliches (1990)]. An additional difficulty is posed by the very limited number of Spanish patents registered in the U.S. thus substantially constraining the possibilities for a statistical analysis. Yet, there are enough advantages to the use of U.S. patents as an indicator to justify its employment. Most important it enables comparison across different national patenting performances, thereby avoiding the

---

[6] See for instance, PAVITT,K., PATEL,P. (1991); SOETE,L., WYATT,(1983); SOETE (1987).

[7] By Spanish patentee in the United States we understand any individual, firm, firm branch or division, or institution domiciled in Spain.

confounding problems that arise from the use of data based on different national patent systems.

Spanish U.S. patenting will be compared with Spanish patenting in other countries to show that the evolution of the former parallels the development of Spanish patenting in Europe.

1.3 Summary of results

The present paper highlights the negative evolution of Spanish patenting in the U.S. over the eighties. Interestingly this negative evolution is not unique to U.S. patenting but coincides with the discouraging performance of the other indicators that have been analyzed. This result dampens the usual optimism derived from the observation of R&D and suggests the need to assess other indicators when analyzing the result of S&T policy. This is not a banal point, since in Spain most analysis of S&T policies pivot around technology input variables.

The present research effort is just a first step in the use of "alternative" indicators and the following conclusions have to be approached with care. Yet, they are two main outstanding elements in the results achieved. In the first place, several sectors among the highest consumers of R&D funds in Spain display very poor patenting performance. Secondly, a positive trend in the amount of patenting in the

U.S. by Spanish residents[6] has been reversed in the eighties precisely when R&D investment has started to grow substantially.

2 Analysis of Spanish patenting in the U.S.

2.1 General Trends.

Significantly the number of U.S. patents by Spanish firms or individuals is very small: a total of 1561 patents for the period 1963-1988. For comparative purposes it could be noted that the number of U.K. patents in the U.S. for the period in the mid eighties oscillates between 2000 and 3000 patent per annum. Spanish share of European patenting in the United States has oscillated around 0.5% [see Pavitt and Patel, (1991)]. Also more than 20 companies have patented more in the U.S. that the whole Spanish economy. The most important firm in terms of its U.S. patenting (GEC) obtains over 10 times the total number of Spanish patents.

(Table I around here)

Spanish technological weakness is specially relevant in 9 out of 34 product groups where Spanish residents have obtained no more than 10 patents in the period 1963-1988. Table I reflects the evolution of Spanish and World patenting in the United States since 1963. There are two relevant aspects in this table. First, less than 1 in 1000 U.S. patents is of Spanish origin. This is far below the economic significance

---

[6] We use the terms "Spanish patentees" and "patents by Spanish residents" interchangeably. They denote patents by individuals, firms and institutions whose declared address is in Spain. These include foreign-owned firms or Spanish branches of MNCs. In any case, most firms among the Spanish patentees in the U.S. are domestically owned.

of the Spanish economy as measured by any other indicator.[9] Second, Spanish relative weight has declined during the eighties, after substantial growth, albeit within very low levels, during the sixties and seventies. In the eighties the decline of the weight of Spanish was so serious that the percentage of Spanish patents in the U.S. over total U.S. patents reached an all-time low. That this has happened while R&D was increasing, is indeed intriguing. A more detailed analysis of sectoral patenting patterns may throw some light on the possible reasons for this paradox.[10]

2.2 SECTORAL ANALYSIS

We will be using in our analysis the RTA index. The use of the index of Revealed Technological Advantage (RTA)[11] allows comparison of patenting levels across different groups of products with different proclivities to patent [Pavitt(1982), Pavitt(1985)].

(Table II around here)

---

[9] For instance, the ratio of U.S. imports from Spain over total U.S. imports is about 7 times higher than the weight of Spanish patenting in the U.S. over the total U.S. patents.

[10] It may be argued that the reduction of the percentage of Spanish patenting in the U.S. both in relative and absolute terms may accompany a decline in the weight of Spanish imports in the United States. Yet, this has kept remarkably stable over the years. During the 1964-68 period the percentage of imports from Spain over the total of U.S. imports was 0.73%. In the 1983-1987 period this percentage was exactly the same.

[11] This is based on the same idea as the index of Relative Comparative Advantage used in trade theory:

$$RTA_i = \frac{P^i / W^i}{P^t / W^t},$$

where RTA_i is the Relative Technological advantage for a certain country in sector i; P^i is the number of patents in a certain sector, i, by that country and W^i is the total number of patents in the same sector by all the World. P^t is the total number of patents by the specific country referred to and W^t is the total number of patents for all sectors and all countries

Table II displays the Spanish "Revealed Technological Advantage" (RTA) and total number of Spanish patents for 34 product groups following the classification used by the Science Policy Research Unit. We include the RTA for the 1963-1988 period and for the last five-year period (1984-1988) for which information is available. There are no critical differences between both periods. This suggests that the structure of sectoral strengths and weakenesses revealed by the RTA index remains stable.

Table II exposes substantial weakness in some important research intensive products; namely, "Nuclear Reactors and Systems," "Aircraft," "Telecommunications," "Semiconductors, Calculators, Computers and Other Office Equipment," "Image and Sound Equipment" and "Photography and Photocopy." In short, aerospace and information technologies appear as specially weak areas of Spanish technology.

The case of aerospace is specially significant. It concentrates near 10% of total Spanish Business Expenditure in R&D; incidentally, most of it by a single firm. Yet, it has only generated one patent in the United States in more than 25 years, and this single patent does not come from CASA, the Spanish aerospace firm performing most R&D in the Spanish aerospace sector.

In Table II we have highlighted with an asterisk the areas with a relative technological advantage (i.e., those with a Revealed Technological Advantage higher than 1). Spain shows a relative strength in areas of lower research intensity like "textiles, clothing, leather, wood products," "miscellaneous metal products" and "food and tobacco." Yet, there is also a high RTA in some areas of higher research intensity;

viz "road vehicles and engines," "inorganic chemicals," "drugs and bio-affecting agents," and "dentistry and surgery."

Significantly, a relative technological advantage is shown in product groups associated to the medical sciences and in mechanical engineering. In relation to the medical sciences, the highest RTA appears in "dentistry and surgery" and "Drugs and bio-affecting agents" also displays a very high RTA. The strength in these two product groups related to the medical sciences is specially relevant because they are conventionally considered as "high-tech."

The relative strength in those products related to mechanical engineering is also significant. Almost half the product groups displaying a relative technological advantage are in areas related to mechanical engineering, and most of the mechanical engineering articles have a RTA higher than 1.

A further important fact to note lies in the sectoral evolution of Spanish patenting in the U.S.A.. In the 69-73 period, Spain increased its share of world patenting in 19 out of the 34 product groups in relation to the previous five years. Even more groups (25) showed an improvement over the following five years (1974-1978). Yet, this positive tendency is then abruptly and somehow surprisingly truncated. In the 79-83 period only 11 groups improved their share of world patenting in the U.S., and in the following five years, the number of improving product groups decreased even furhter to only 9. The same change of trend is apparent in the total number of patents. Where Spanish share of U.S. patenting increased until 1974, a sharp decrease followed in the next ten years.

This reversing of an improving trend is concurrent with the increase in Spanish R&D expenditure. In fact, there is further evidence pointing at a lack of correlation between R&D expenditures and patenting performance. Instead, the areas with strong patenting performance appear significantly correlated with those sectors in which Spain shows a relative commercial strength.

(Table III around here)

Table III displays the correlations between patenting, commercial advantage and R&D effort. There have been several problems in the compilation of data required to calculate the coefficient presented in Table III. First, the different sources utilised use different sectoral and product classifications. Therefore we have had to adapt the data to a purpose-built 16 sectors classification, recalculated the statistis on this base and applied the Spearman's rank correlation coefficient to the resulting data. Second, for most data there are no homogenous long series of data; for instance the only sectoral R&D data at the time of writing was for the period 1982-1987. That is the reason why we have had to use slightly different periods for the different data. Yet, the results obtained do not seem to be sensitive to using different time periods. This reaffirms the expected stability of the sectoral rankings used to calculate Spearman's coefficient.

Table III reflects the lack of relationship between those areas with a good patenting performance and high R&D expenditure. The correlation coefficient are negative but non-significant in both cases. This indicates that there is no clear relationship between those sectors in which Spain is investing most of her R&D effort

and those areas in which it shows a relative technological advantage. The lack of strong correlation between sectors with high R&D and sectors with good patenting performance have also been revealed by other studies which have used data on Spanish patenting in Spain [BUESA (1991)].[12] Also, a similar lack of correlation between R&D efforts and patenting performance is shown in the analysis of patentees presented below.

In comparison there is a clear relationship, albeit of negative sign, between the sectors with high R&D investment and those with a revealed commercial advantage. In other words, Spain's commercial advantage lies in sectors with low R&D investment. Besides, there is further evidence of Spanish commercial weakeness in areas that our study has revealed as having a low RTA [ALONSO (1991)].

Finally, there seems to be a positive relationship between revealed comercial and technological advantages. Table III shows that despite the lack of relationship between R&D and patenting performance, the latter shows a positive relationship with the pattern of Spain's commercial advantage. In most cases, the product groups with a relative technological advantage display a commercial advantage as well. That both elements coincide in product groups with a very low R&D activity points to the importance of other elements rather than formal research activity in keeping Spanish international competitiveness. Natural endowment may be key in some areas like the food industry, and low wages may also provide a partial explanation for success, above

[12] See also Alfonso Bravo' data on patenting in Spain [BRAVO (1991)]. This shows that the sectors in which Spain has a higher RTA do not coincede with the sectors with the highest R&D expenditure.

all in labor-intensive area like textiles and clothing. Yet, learning-by-doing and prolonged industrial effort have also played a role as important factors bringing on the structure of Spanish exports [see ALONSO (1988)] and the technological ascent of certain Spanish firms [BUESA,MOLERO (1988),(1991)]. These latter elements may become more important while wage differentials between Spain and other European countries rapidly close.

2.3 ANALYSIS OF PATENTEES

The lack of correlation between R&D and patenting performance is not only found in global and sectoral aggregates but also takes place at the firm level. Table VI presents a list of the most important firms in Spain for its declared volume of R&D activities.

(Table VI around here)

Although R&D expenditure may vary from year to year the above table includes the most important R&D performers in Spain. The seven most important Spanish firms in terms of their R&D effort have not produced a single patent in the United States for the 1968-1986 period. Of the 13 firms listed only two companies (mostly pharmaceutical firms) have managed to obtain a few U.S. patents.

Other studies of patenting in Spain have disclosed similar evidence. A study on State-owned firms [BUESA, MOLERO (1989)] reveals that a group of State firms concentrating more than one third of Spanish R&D is responsible for 1% of all patents registered in Spain. Similarly, Buesa has shown [Buesa (1991)] that 72.7% of firms

with R&D activities in the province of Madrid (the most "R&D intensive" Spanish region) have not registered any patent within Spain. Likewise, 83.2% of Madrid firms registering one or more patents in Spain declare not to carry any formal R&D activity.

Therefore, all the evidence available confirms again the lack of correlation between research activities and patenting performance. It also suggests a possible key for the partial explanation of this fact. The firms in Table VI are big, mostly foreign or State-owned companies. Only a few private, domestic firms are listed, most of them pharmaceutical companies. Instead Spanish patentees are usually small to medium Spanish companies, many of them in "traditional" sectors with low research intensity.[13] The higher role of individuals in Spanish patenting also points towards the same conclusion.

The role of individuals

Given the complexity involved in patenting in the United States big firms seem, a priori, the best endowed to attempt it. Still, out of the 1802 Spanish patents, 1012 are from private individuals;[14] less than half the patentees are firms. This is a low percentage if compared with other OECD countries.

(Table IV around here)

---

[13] With the noticeable exception of pharmaceutical companies.

[14] Often private individuals may represent small firms. These small companies and/or individuals do not usually conduct formal R&D activities. Yet, they are the more important source of Spanish patenting in the United States. This further confirms that patenting reflects a form of innovative performance that is not gathered by R&D indicators. It also suggests that patents may be more adequate to reflect innovation in small companies.

The strong presence of private individuals may indicate a lower level of sophistication and economic potential in the patents granted. In fact, individuals usually patent less in areas where the complexity of the technological base requires complex research structures (e.g.: telecommunications, chemical, semiconductors,. . .). Yet, in the Spanish case, individual patenting is important in other "heavy" and "high-tech" areas like fertilizers, hydrocarbons and even nuclear reactors and power plants. This would indicate that the already the very low number of patents in these products are often the result of individual or small groups "ideas" rather than the outcome of research carried out by big corporations. A relevant exception is in "drugs and bio-affecting agents." This area has a very low percentage of patenting by individuals and is also one of the very few research intensive sectors where Spain shows a relative technological advantage. The lower proportion of individual patenting can suggest that the technological level of Spanish patents in drugs is higher than the Spanish average.

3 OTHER INDICATORS OF INNOVATIVE STRENGTH

3.1 Domestic and European Patenting

It could be argued that the decline of Spanish patenting in the U.S. may not reflect any deterioration in "innovativeness." There may be other reasons behind such a decline; namely, a greater reliance on the comparatively new European patenting system, or the possible increase in the costs of U.S. patenting. Yet available information on other innovation indicators confirms the declining trend revealed by U.S. patenting.

Table V reveals the evolution of Spanish patenting in countries other than the United States and in the European Patent Organization. Although the data available covers a shorter period than our information on Spanish U.S. patenting, it remains clear that Spanish patenting abroad has deteriorated during the first half of the eighties. This is coherent with the negative trend appreciated in Spanish patenting in the United States during the same period.

(Table V around here)

The reduction of the relative weight of Spanish patenting in the United States cannot be attributed to the launching of the European Patent Office (EPO). Spanish patenting through the EPO system has been very low both in relative and absolute terms. In relative terms the weight of Spanish over total "European" patenting is slightly lower than the Spanish share of U.S. patenting. In absolute terms there were only 8 Spanish patents in the EPO between 1979 and 1982, and 36 between 1983 and 1985. It is by all accounts a small occurrence; therefore, one cannot attribute the poor performance of Spanish patenting in the U.S. to a possible deviation of Spanish patenting away from the United States toward other areas like the European Patent Office.

(Figure 2 around here)

The evidence from patenting <u>in</u> Spain also points to the poor innovative performance of Spanish nationals. Figure 2 shows that total applications[15] for patents in Spain hit bottom in 1983. Up to then, a slow but constant downward trend

[15] There is no data available on patents granted in Spain for such a long period of time.

had mainly been caused by the reduction in domestic applications. From 1983 the number of patent applications increased very markedly, due to the growth in applications by foreigners. Domestic applications have followed a slow decline for the whole of the period for which data is available, with the only exception of a short recovery in 1984-85.

Applicants for patents in Spain are predominantly foreign, and the gap between foreign and domestic applicants is widening. In 1979 there were 2.98 applications by foreigners for every application by a Spanish national. In 1988 this ratio had grown to 13.1. Between 1979 and 1988, there was not a single wholly Spanish-owned firm among the 80 companies leading the ranking of patent applicants. None of the leading Spanish patentees in the U.S. were among this 80 companies.

The evolution of patenting in Spain reaffirms the results of the study of the Spanish patenting performance in the United States: the very low patenting activity by Spanish nationals, firms or branches of MNCs has worsened over the eighties.

3.2 The technological balance of payments

The changes in other indicators seem to confirm the negative evolution presented by Spansish patenting. The deficit of the technological balance of payments is among the biggest in the OECD area. Its coverage rate felt to a 13% in 1988 after having reached a peak of 31% in 1981 [Avila and Minguez (1989)]. In 1988 and 1989 the coverage rate oscillated between 18 and 19 per cent, hence signalling a slight

recovery. The trade balance for most of the technology intensive products has also worsened over the last years.[16]

4. CONCLUSIONS.

The empirical evidence presented here strongly suggests that Spanish performance in worldwide innovation (which is the kind gathered by U.S. patenting) does not stem from its effort in R&D. On the other hand, relatively high R&D investment in some sectors denotes some sort of action in either introducing, adapting or developing new products and processes.

The poor patenting performance by those companies and sectors more active in R&D activities seems to suggest that most of these activities must be geared to the introduction and adaptation of products and processes developed somewhere else, most probably abroad. Significantly, previous studies have revealed that Spanish branches of Multinational Corporations (MNCs) figure among the higher R&D investors in Spain [MINER (1990), MOLERO, BUESA (1991)] as well as being the largest technology importers measured both by number of technology transfer contracts [MOLERO (1983)] and volume of payments [SANCHEZ (1988)].[17] MNCs' branches are also the most active in the introduction of new products and processes [CIRCULO DE EMPRESARIOS (1988)]. The role of MNCs partially explains the concentration of R&D and technology imports in a few sectors with a high presence

---

[16] See OECD. Main Science and Technology Indicators 1982-88. Paris 1989.

[17] Some sectoral studies have shown the same traits for specific sectors. See for instance ABAD (1985) for the food industry.

of foreign companies [MINER (1990)], and the strong correlation between R&D expenditure and technology imports [MINER (1990), SANCHEZ (1988)].

As a provisional hypothesis supported by the evidence presented here we can postulate the existence of a two-tier system for technological innovation in Spain. On one level we find mainly big firms in technologically intensive sectors, spending relatively important amounts in R&D, most of it geared to follow or "catch up" with the state of the art technologies developed in the leading countries.[18] On the other level we could find small to medium companies in "traditional" sectors, carrying out very little formal R&D activities but with a relatively high patenting performance. This degree of innovativeness may derive from the firms' attempts to solve specific engineering and production problems or be the result of the ingenuity of a small team or single individual developing new products without the support of a formally established R&D team.

This duality may help explain why Spanish patenting performance has deteriorated together while R&D expenditure was growing. The traditional sectors with a relative technological advantage have been long suffering a profound crisis that may have impeded its ability -financial and otherwise- to patent. Meanwhile the growth of R&D expenditure has concentrated in sectors which in Spain have extremely low patenting capacity (aerospace, information technologies, . . .).

---

[18] See for instance the evidence on the character of R&D carried out by German MNCs in Spain [MOLERO, BUESA (1991)]. This study reveals that most of their R&D is geared to accompany the implementation of foreign technologies in the Spanish branches while "original" research is very low. There is also further evidence presented in CIRCULO DE EMPRESARIOS (1988), that reveals that R&D conducted by Spanish companies is of a reactive character and attempts to defend the internal market.

It stands to reason that this possible duality of Spanish innovative structure has profound implications for the design of Science and Technology policies. Any policy or assessment of past policies that concentrates on R&D strategies and the evolution of R&D expenditure will be inherently biased as it leaves outside an important element of the Spanish innovation system. At the beginning of this article we mentioned the almost exclusive attention paid in Spain to R&D figures as an indicator of technological performance. After the evidence presented here, the deficiencies of this practice have become apparent.

In any case, Spanish Science and Technology Policy revolves around the need to increase R&D expenditure, above all in key research intensive sectors like electronics and information technologies. This inclination can be detected in the "National Plan for Scientific Research and Technological Development." This "National Plan" is the most serious attempt by the Spanish central authorities at coordinating and establishing a clear set of priorities for the Spanish Science and Technology Policy (STP). It was approved for a period of four years (1988-1991)[19] and has become the main tool for the government's STP. In the analysis of the Spanish Science and Technology System that accompanies -and justifies- the National Plan [Comisión Nacional de Ciencia y Tecnología (1988)] one can identify two intertwined lines of argument that are relevant here. First, there is almost exclusive attention to -and faith in- the role of R&D within the Science and Technology Policy. R&D is defined as the key factor in insuring the future growth of the Spanish economy. This may not

[19] The Plan is subjected to a yearly revision.

be surprising as the Plan is, after all, a R&D plan. Yet, it is significant that the most important STP tool in Spain completely overlooks elements like learning processes or know-how as a source of technological performance in areas where an important pool of technological knowledge has already been amassed by the Spanish economy.

Closely linked with the above is the notion underlying the plan that we are witnessing a technological revolution that will break the patterns of technological development that characterized the old "phase" of industrial growth. These will be substituted with new patterns of technological development revolving around new core, "enabling" technologies (electronics and IT, biotechnology, new materials, . . .).

Consequently, the programs in these areas (Photonics, Space, Microelectronics, New Materials, Information and Communication Technologies and Biotechnology) account for half the total planned expenditure "National Plan." This faith in the possibilities of "technology push" in high-technology sectors and a comparative neglect of the scientific and technological opportunities in the "mature" areas is not unique to the Spanish policies: British approach to innovation is similar [Pavitt (1980), page 11].

It should not come as a surprise then, that in the near future, Spanish patenting performance keeps declining while R&D expenditure enjoys considerable growth. The patent analysis has provided much needed additional information on the sectors in which Spain displays aa technological advantage. If one considers that the design of Science and Technology policies has to be based on a proper consideration of present productive capacity and of accumulated experience, then the results of the

present study become relevant and the reduction in Spanish patenting performance appears as a negative development. Then, attention should be paid to the existence of domestic skills in traditional areas like mechanical engineering, where a possibility of endogenous technological development seems to exist. It is under this perspective that the analysis of patents in the United States provides a useful tool of analysis for the Spanish case.

The evidence presented here is not conclusive, but confirms again the usefulness of patent statistics as indicators of technological performance. It also proves the need for further research of patenting by Spanish residents as a way of complementing the study of Spanish R&D data.

APPENDIX

Table III Spearman's Rank Correlation coefficients are calculated on the basis of the present indexes. The diversity of classifications used in the different statistical sources used have compelled us to devise a new product classification that could be used to recalculate the statistics that provide the basis for the indexes presented here.

	TR&D 1982/87	RR&D 1982/87	RTA 1981/86	RCA 1985/87
I.Chemicals	8.20	1.52	0.72	-5.31
II.Refined oil products	2.61	0.28	0.00	3.72
III. Pharmaceuticals	8.26	5.90	1.66	-0.10
IV. Rubber products	1.44	0.46	0.95	1.31
V. Non-metal. minerals	1.21	0.30	0.70	1.25
VI. Foodstuffs and drinks	3.22	0.14	1.19	3.35
VII. Metallurgical Products	3.53	0.40	0.86	0.81
VIII. Non-ellectrical Machinery	3.43	0.88	1.38	-6.52
IX. Electrical Machinery	8.19	2.48	0.74	-1.13
X. Vehicles	8.81	0.97	1.81	5.81
XI. Aeronautics	8.19	16.39	0.00	-0.22
XII. Other Transport equipment	3.75	1.88	1.33	1.04
XIII. Electronic goods	10.43	3.72	0.15	-2.82
XIV. Office Machinery	3.69	2.17	0.54	-5.83
XV. Metal Products	2.23	0.34	2.48	1.30
XVI. Textiles, Clothing, Wood	1.30	0.13	3.05	5.53

Source: Own ellaboration of data from the Spanish National Statistics Institute, Ministry of Industry and Energy and SPRU/OTA patent data base.

TR&D=R&D for each product group divided by total R&D for the 1982-87 period.

RR&D=TR&D for each sector divided by its share of industrial production in 1987.

RTA=RTA for the 1981-86 period.

RCA=Revealed Commercial Advantage for the 1985-87 period. Each sector's RCA is calculated on the basis of its Rate of Contribution to the Trade Balance (RCTB)

$$RCTB_i=[\{(X_i-M_i)/(X_i+M_i)\}-\{(X_t-M_t)/(X_t+M_t)\}]*\{(X_i+M_i)/2(X_t+M_t)\}*100$$

where, , i = product group i;
t = total.

We are indebted to Pari Patel at the Science Policy Research Unit for his assistance in providing us with the data on Spanish patenting in the U.S., and to Puay Tang - School of Advanced International Studies-The Johns Hopkins University- for her comments and editing of this article.

REFERENCES

ABAD, C. (1985), "La industria alimentaria española. Caracterización de la concentración y internacionalización de las mayores empresas" Estudios sobre Consumo, no. 6. December.

ALONSO, J.A. (1988), "El sector exterior" in GARCIA DELGADO,J.L. España Económica. Espasa Calpe, Madrid.

ALONSO, J.A. (1991), "Economía Española: Especialización Comercial y Factores de Competitividad." Mimeo. Madrid: Departamento de Economía Aplicada, Universidad Complutense de Madrid.

AVILA, P., MINGUEZ, R. (1989), "La Balanza de Pagos Tecnológica en 1988" Boletín del ICE. Semana 17-23. April.

BASBERG, B. (1987), "Patents and the Measurement of Technological Change. A Survey of the Literature." Research Policy, 16, August.

BRAVO, A. (1991), "Cuadros y Gráficos de la Ponencia 'I+D en las empresas'." Presented to the "Conferencia EPOC: Análisis del Sistema Español de Ciencia y Tecnología y Evaluación de la Política Científica," Salamanca, 24-25 September.

BUESA, M. (1991), "Patentes e Innovación Tecnológica en la Industria Española (1967-1986)." Mimeo. Madrid: Departamento de Estructura Económica y Economía Industrial, Universidad Complutense de Madrid.

BUESA, M., MOLERO, J. (1988), Estructura Industrial de España. Fondo de Cultura Económica, Madrid.

BUESA, M., MOLERO, J. (1989), "La empresa pública en la estructura industrial de España." In La empresa pública estatal no financiera en España, 1978-1988. Un estado de la cuestión. By J. BRAÑA (Chairman). Report to the Instituto de Estudios Fiscales, Madrid.

CIRCULO DE EMPRESARIOS. (1988), Actitud y Comportamiento de las Grandes Empresas Españolas ante la Innovación. Círculo de Empresarios, Madrid.

COMISION NACIONAL DE CIENCIA Y TECNOLOGIA (1988), Plan Nacional de Investigación Científica y Desarrollo Tecnológico. Ministerio de Educación y Ciencia, Madrid.

GRILICHES, Z. (1990), "Patent Statistics as Economic Indicators: A Survey." Journal of Economic Literature 28 (December).

MINISTERIO DE INDUSTRIA Y ENERGIA (MINER). (1990), Informe sobre la Industria Española, 1989. Ministerio de Industria y Energía, Madrid.

MOLERO, J. (1983), "Foreign Technology in the Spanish Economy: An Analysis of the Recent Evolution". Research Policy, 5, 269-286.

MOLERO, J., BUESA, M. (1991), "Proyecto GERDISE. Informe Final/Final Report" Mimeo. Fundación IESA, Madrid.

MOLERO, J., BUESA, M., FERNANDEZ, J. (1990), Demandas del Sistema Productivo y Adaptación de la Oferta Educativa. CIDE-Ministerio de Educación y Ciencia, Madrid.

PAVITT, K. (Ed.) (1980), Technological Innovation and British Economic Performance. MacMillan, London.

PAVITT, K. (1982), "R&D, Patenting and Innovative Activities: A Statistical Exploration." Research Policy, 11.

PAVITT, K. (1985), "Patent Statistics as Indicators of Innovative Activities: Possibilities and Problems." Scientometrics, 1-2, 77-95.

PAVITT, K. (1987), "Uses and Abuses of Patent Statistics." DRC Occasional Paper Nr.:41, Science Policy Research Unit, Brighton.

PAVITT, K., PATEL, P. (1991), "Europe's Technological Performance." In FREEMAN, C., SHARP, M., WALKER, W. (Eds.) Technology and the Future of Europe. Global Competition and the Environment in the 1990s. Pinter Publishers, London and New York.

SANCHEZ, P. (1988), La Empresa Española y la Exportación de Tecnología. Instituto Español de Comercio Exterior, Madrid.

SOETE, L. (1987), "The Impact of Technological Advantage on International Trade Patterns: The Evidence Reconsidered." Research Policy, 4, 101-130.

SOETE, L., WYATT, S., (1983), "The use of foreign patenting as an internationally comparable science and technology output indicator." Scientometrics, 5, 1.

TABLES & FIGURES

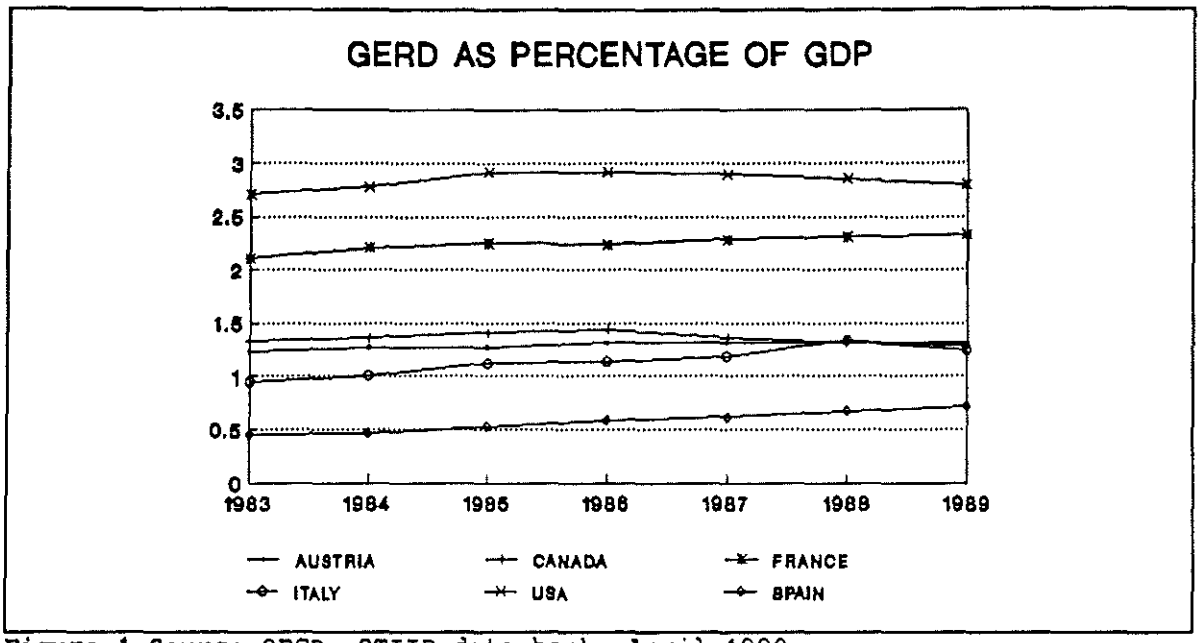

Figure 1 Source OECD, STIID data bank, April 1990.

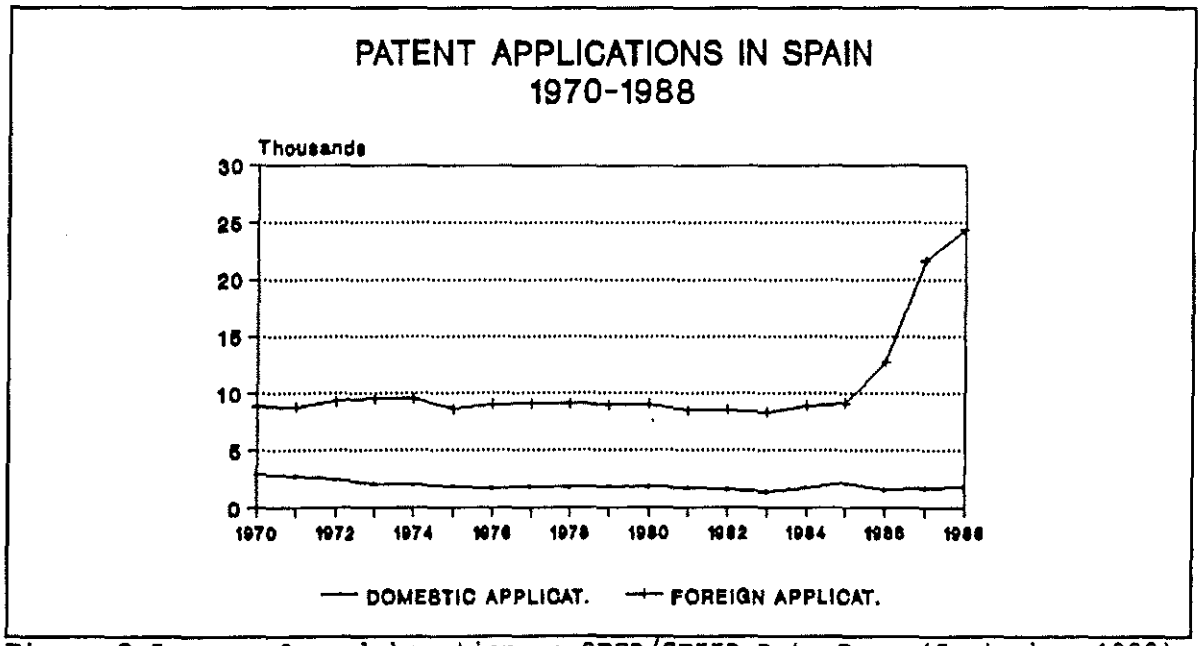

Figure 2 Source: Own elaboration on OECD/STIID Data Base (September 1988)

TABLES/ii

TABLE I
EVOLUTION OF SPANISH PATENTING IN THE U.S. COMPARED WITH TOTAL WORLD PATENTING

	1963-68	1969-73	1974-78	1979-83	1984-88	TOTAL
SPAIN PATENTS (1)	238	336	472	271	244	1561
WORLD PATENTS (2)	347852	357801	349257	290967	368570	1714447
[(1)/(2)]*100	0.068	0.094	0.135	0.094	0.066	0.091

Source: Own elaboration on SPRU U.S. Patent Data Base.

TABLE II
SPANISH REVEALED TECHNOLOGICAL ADVANTAGE(RTA)[a].

	1984-88	1963-88
• Inorganic Chemicals	1.76	1.69
Organic Chemicals	0.69	0.73
Agricultural Chemicals	0.00	0.49
Chemical Processes	0.75	0.68
Hydrocarbons, Mineral Oils, Fuels and Ignition Devices	0.00	0.10
• Bleaching, Dyeing and Disinfecting Agents	1.40	1.18
• Drugs and Bioengineering	1.64	1.72
Plastic and Rubber Products	0.46	1.06
Materials (including glass and ceramics)	0.15	0.44
Food and Tobacco (processes and products)	0.52	1.43
Metallurgical and Metal Treatment Processes	1.45	0.96
• Apparatus for Chemicals, Food, Glass, etc.	1.22	1.41
• General Non-electrical Industrial Equipment	1.95	1.21
General Electrical Industrial Apparatus	0.51	0.59
• Non-electrical Specialized Industrial Equipment	2.08	2.19
Metallurgical and Metal Working Equipment	1.04	0.66
Assembling and Material Handling Apparatus	0.31	0.83
Nuclear Reactors and Systems	0.00	0.41
Power Plants	3.27	0.99
• Road Vehicles and Engines	2.81	1.98
Other Transport Equipment (excluding aircraft)	0.75	1.24
Aircraft	0.00	0.16
Mining and Wells Machinery and Processes	0.00	0.29
Telecommunications	0.34	0.57
Semiconductors	0.00	0.22
Electrical Devices and Systems	0.35	0.47
Calculators, Computers, and Other Office Equipment	0.09	0.12
Image and Sound Equipment	0.00	0.47
Photography and Photocopy	0.18	0.09
Instruments and Controls	0.49	0.50
• Miscellaneous Metal Products	1.31	1.59
• Textile, Clothing, Leather, Wood Products	3.63	2.65
• Dentistry and Surgery	3.22	3.54
• Other-(weapons,road structures,animal & plant husbandry)	2.09	1.55

Source: Own ellaboration on SPRU-OTA U.S. Patent Data Base.

[a] See Page 4 for RTA definition. A RTA index superior to 1 indicates a (positive) revealed technological advantage.

TABLE III

Relation between Trade and Patenting Performance and R&D Activity.
Spearman's Rank Correlation Coefficient

	RTA	RCA
TR&D	-0.088	-0.415*
RR&D	-0.121	-0.498**
RTA		0.407*

Where,

TR&D=R&D for each sector divided by total R&D for the 1982-87 period.
RR&D=TR&D for each sector divided by its share of industrial production in 1987.
RTA=RTA for the 1981-86 period.
RCA=Revealed Commercial Advantage for the 1985-87 period. Two asteriks indicate a statistically significant coefficient with 95% reliability, while one asterisk indicates a statistical singnificance very near to 95%.

TABLE IV

Spanish Patenting in the U.S.
Percentage of Patents by Individuals.

1969-72	1973-76	1977-80	1981-84	1985-88
73.1	57.7	49.3	54.4	40.4

TABLE V
SPANISH PATENTING ABROAD
Percentage of Spanish patenting over total patents in selected countries.

	1975-1978	1979-1982	1983-1985
UNITED KINGDOM	0.28	0.22	0.21
FRANCE	0.45	0.42	0.33
F.R.GERMANY	0.16	0.11	0.10
JAPAN	0.03	0.03	0.02
EUR.PATENT.OFF.	-	0.08	0.09

Source: Own elaboration of data from Registro de la Propiedad Industrial, 20 años de patentes en España, Madrid 1987.

TABLE VI

Spanish firms with the highest R&D Investment 1984-86

Firm	R&D Million Pta.	Number of U.S. Patents 1969-86
CASA	15154	0
Standard Eléctrica	8745	0
IBM España	6201	0
Teléfonica	5347	0
Motor Ibérica	5170	0
E.N. Petróleo	2862	0
ENDESA	2684	0
Nestle	2180	0
CEPSA	2021	1
Iberduero	1838	0
Lámparas Z	1832	0
Antonio Gallardo	1789	2
Seat	1700	0