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# The evolution of research activity in Spain
# The impact of the National Commission for the Evaluation of Research Activity (CNEAI)

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**Abstract**

This article outlines the evolution of international scientific production in Spain over the last 25 years, a period characterised by steady growth in research production. The following stages in this process are identified in accordance with some of the factors that predominated at different times. From 1974 to 1982 production increased due to causes endogenous to the scientific system itself, as scientists brought their work into line with the patterns which characterised research in other industrialised countries. From 1982 to 1991 the prioritisation of R&D by government administrative bodies represented a constant stimulus, implemented through a set of legal measures, investments and the creation of posts for new researchers. From 1989 to the present the creation of the Comisión Nacional de Evaluación de la Actividad Investigadora (National Commission for the Evaluation of Research Activity, CNEAI) and the research incentive system have provided a further stimulus, which has led to the maintenance of, and an increase in, the rate of research production in spite of the net decrease in the monetary value of research grants awarded during the last period analysed. Other special characteristics of Spanish research, such as its dependence on the public sector and its essentially academic nature, are discussed.


*Keywords:* Research activity; Evolution; Productivity; Scientific assessment; Spain; CNEAI; Scientific publications

## 1. Introduction

During the last 25 years Spain has experienced unprecedented progress in its research capacity, measured in terms of the production of published work. A country in which scientific activity had traditionally been carried out by a minority, where the research infrastructure had been poor, and in which scientific activity had lacked social recognition, has apparently entered a new phase which has placed it, within a very short period, amongst the top ten producers in the scientific world. A remarkable degree of growth is evident when Spain's scientific position is measured in terms of the gross production of articles recorded in the Science Citation Index (SCI). From 32nd place in the 1963 world ranking, with a total production that represented 0.2% of the world-wide output, Spain had jumped by 1996 to ninth position, with a publication output that accounted for almost 2.5% of the total world production. In other words, Spain's proportional contribution increased more than tenfold.

These data, which correspond to the period from 1974 to 1997, accurately reflect the exponential

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distribution described by Price in his well-known study of scientific growth (Price, 1973). According to this author, such growth corresponds to the initial stages of the scientific process which, in the long run, tends to decelerate to logistic rather than logarithmic growth. Nevertheless, these growth processes take place within the context of what can be called 'free growth'. In the SCI, growth is limited by the inherent dimensions of the total population of published articles, which obviously does not grow indefinitely. This means that any growth which is faster than the baseline rate can only take place at the expense of other producers. This leads to the conclusion that, above a certain point, it becomes increasingly difficult to scale positions in the ranking. These circumstances, however, do not appear to have affected Spanish research production so far, and it is this factor which has aroused the interest of several authors (Kovach, 1978; Anderson, 1986; Garfield, 1994, 1995, 1998). This unusual rate of growth has also attracted the attention of journals such as *Nature*, which recently devoted an entire supplement to Spanish science (Nature, 1998). This scientific position is particularly outstanding in that surpasses Spain's position in 1996 in 12th place relative to other European countries according to Gross National Product (GNP). At that time Spain's GNP accounted for only 1.86% of the world total production (European Commission, 1997). This rapid growth in research output has been well documented in many articles, most published in the mid-1980s. Nevertheless, most of these reports referred to limited temporal settings (López-Piñero et al., 1984; Méndez and Gómez, 1986; Terrada and López-Piñero, 1990; Maltrás and Quintanilla, 1992; Maltrás et al., 1995; Gómez et al., 1997a) and to specific fields of knowledge, scientific disciplines or specialities (Vázquez, 1986; Méndez et al., 1987; Ferreiro Aláez et al., 1989; Guardiola and Camí, 1989; Gómez et al., 1990; Pestaña, 1992; Cano and Julián, 1992; Bordons and Barrigón, 1992; Bordons et al., 1992; Camí et al., 1993; Guardiola and Baños, 1993; Gómez et al., 1995; Rodríguez and Moreiro, 1996; Soriguer Escofet et al., 1996; Bordons et al., 1996; López-Muñoz et al., 1996; Méndez and Gómez, 1985). Other studies centred on a single institution (Méndez and Gómez, 1985; Pérez-Álverez Ossorio et al., 1994, 1991; Gómez Leal, 1993; Jiménez-Contreras, 1997; Bellavista et al., 1993; Pulgarín et al., 1992; Sánchez Ayuso, 1999). This list could be extended even further to include comparative studies of different countries (including Spain) or global analyses of scientific activity, but it seems appropriate draw the limit at work which refers exclusively to Spain.

Although none of this research has outlined the process from a global perspective and within a wider timeframe (specifically the last 25 years), the majority of these studies identified a number of factors that might help explain this evolution. Most of them attributed this progress to the increase in R&D investment and the application of an evaluation policy aimed at stimulating scientific production and its international diffusion. Some of this research has analysed the effects of these government measures as independent factors responsible for the progress in Spain's science productivity (Ricoy, 1990; Dorado et al., 1991; González Blasco, 1992; Marín León, 1993; Sanz Menéndez, 1995; Rey et al., 1998; Millán Barbany, 1998).

Nevertheless, the present article proposes that this phenomenon has still not been adequately explained, in that previous work failed to accurately determine the importance of each of these factors. Specifically, insufficient attention has been given to the importance of the establishment, for the first time in Spain, of an evaluation policy administered by the *Comisión Nacional de Evaluación de la Actividad Investigadora* (National Commission for the Evaluation of Research Activity, CNEAI), whose activities have been the subject in recent years of controversy within Spanish universities and public research organisations. This controversy has been reflected in articles in the national press and items on national television news broadcasts.

The general approach of the CNEAI falls within the Mertonian scheme of scientific functioning, according to which one of the main driving forces behind scientists' academic behaviour is the motivation to achieve recognition by one's peers. According to some authors, this approach not only explains scientists' academic behaviour, but also foments the general coherence and functioning of the system from an economic perspective. In other words, this approach ensures, although with certain limitations, that scientific progress is advantageous for society as a whole, and at the same time is economically viable (Dasgupta and David, 1994).

Despite the differences between the ways in which different governments finance and evaluate research, the system used in the Spanish national research evaluation is fairly similar to that used in other industrialised countries (Research Evaluation, 2000, special number devoted to scientific evaluation). Moreover, there are clear similarities between the Spanish system and the Research Assessment Exercises used in the UK since the beginning of the 1990s (Research Assessment Exercise, 2001).

This article will consider some of the specific features of the Spanish system, in an attempt to shed light on the following issues:

1. The growth of Spanish scientific research, in terms of its international diffusion, during the period 1974–1998.
2. The different circumstances which have given rise to this change, especially during the 1990s.
3. The relationship between this change and the creation of a national organisation responsible for the evaluation of Spanish researchers: the CNEAI. It is hypothesised that the growth of research activity and its international diffusion can be attributed, to a great extent, to this agency's evaluation policy. A further objective of this analysis is to evaluate the impact and the efficiency of evaluation policies which were designed for the express purpose of stimulating scientific production and increasing the international dissemination of Spanish science.
4. The evolution of Spanish science in distinct stages during the period from about 1975 to the present.

## 2. Materials and methods

We used data recorded by the Institute for Scientific Information (ISI) as an indicator of Spanish international scientific production. These data were obtained by searching the SCI-search on-line data base. A simple strategy was used to retrieve all items containing the term 'Spain' in the corporate source field. As in similar studies, and despite its well-known biases (Seglen, 1997), this data base was chosen because of its multidisciplinary nature and the fact that it is accepted as the most representative source available for analysing the international dissemination of scientific literature. Moreover, it is the only source which systematically compiles the addresses of the authors of each item registered. Information about the productivity per author is also provided as the quotient obtained by dividing the number of researchers by the number of items. Information about the average cost of the articles was provided by the *Instituto Nacional de Estadística* (National Statistics Institute, INE).

To measure the levels of investment in the R&D system, the following commonly used indicators were chosen: the percentage of the GNP assigned to R&D, the budget allocated to research measured in terms of constant pesetas, and the number of researchers. These data were obtained from the INE, the European Commission, the *Comisión Interministerial para la Ciencia y la Tecnología* (Interministerial Commission for Science and Technology, CICYT), the CNEAI itself (for data regarding salary increases based on publications—the so-called *sexenios*), or from the sources which are identified in the notes to the tables.

The statistical analysis was straightforward. The data in Figs. 3 and 5 were adjusted by minimum squares regression, and the projections from the data in Fig. 3 were calculated from parameters previously obtained from those adjustments.

One last methodological question emerged from a discrepancy between the data for the percentage of investment allocated to the R&D in Spain during the last few years of the study period, depending on whether the source was the INE or the EC Report on S&T Indicators (European Commission, 1997). Although these differences are important, they did not affect the issues analysed here. When there were discrepancies, the source is clearly indicated in a footnote to the appropriate table.

## 3. Results and discussion

### 3.1. 1970–1980: history

The recent history of Spanish science and scientific policy has been outlined by Sanz Menéndez (Sanz Menéndez, 1997). It is nonetheless worth recalling that during Franco's regime, no specific scientific policy was established until the 1970s, and that until that time scientific activity received little if any attention from politicians. The first public funds for research were made available 1964 (Decree Law 3199/1964, 16 October, 1964, which established the National Fund for the Development of Scientific Research; BOE, 21 October). The funds allocated to R&D were equivalent to approximately 0.2–0.3% of the GNP during the 1960s and the 1970s. At this time the universities, which are now where most basic scientific research in Spain is done, were mostly neglected. A short study published in 1963 and signed by the then Minister of Education and Science, Manuel Lora Tamayo (Lora Tamayo, 1963) sets out the National State Scientific Policy. In this text the role of the university is completely ignored, and the achievement of the country's scientific goals is based on the development of the *Consejo Superior de Investigaciones Científicas* (Higher Council for Scientific Research, CSIC) and other, more specific organisations such as the Council for Nuclear Energy or the National Institutes of Aeronautical Technology or Agricultural Research. The total number of researchers (including all institutions), according to this policy paper, was only 400, which gives us some idea of how modest the goals were. In the light of these circumstances, Spanish economic development can be said to have taken place despite the lack of public investment in science and technology based on the idea, repeatedly expressed since the 1940s, that funds allocated to science represent a long-term investment. (Even today some authors maintain the 'miraculous' nature of recent Spanish economic development in view of the present expenditure on R&D by the government) (Luque López, 1998).

During the second half of the 1970s, i.e. during the transitional period from dictatorship to democracy, scientific policy remained absent from the government's agenda, as other political and social priorities monopolised the attention of successive Central Democratic Union (UCD) governments. Despite this continued neglect, the proportion of the GNP devoted to R&D rose during these years by approximately 0.1%. Considering the amounts of money available to the government at that time, this was a considerable increase (Sanz Menéndez, 1997).

Nevertheless, few authors (Ferreiro Aláez et al., 1989) appear to have suggested that the first signs of the marked increase in scientific production first became evident during the mid- and late 1970s. The eloquent figures in Table 1 suggest that this increase might reflect the consolidation of a trend which had in fact begun to appear in the 1960s.

The figures show that Spanish scientific production increased by 133% during the 8-year period from 1974 to 1981. It should, however, be borne in mind that these figures represent the averages of marked peaks and troughs which were probably due to the fragility of the scientific and political systems in Spain at that time. During this period there was no significant increase in the total number of journals included in the ISI database, or in the number of Spanish scientific journals. The small rise in GNP during this period would not have been translated into any detectable increase in productivity, because of the logical lag period between investment and publication. The only significant event that might have influenced research activity was the prolonged general university strike from 1976 to 1977. We speculate that, freed from their teaching duties, university professors might have devoted their extra time to research.

Table 1
Number of items in the SCI published by Spanish authors between 1974 and 1998

| Year | Papers | Year | Papers |
|---|---|---|---|
| 1974 | 1738 | 1987 | 8788 |
| 1975 | 1106 | 1988 | 9392 |
| 1976 | 1682 | 1989 | 10007 |
| 1977 | 3479 | 1990 | 10723 |
| 1978 | 3633 | 1991 | 11943 |
| 1979 | 3296 | 1992 | 13864 |
| 1980 | 3872 | 1993 | 15348 |
| 1981 | 4059 | 1994 | 16245 |
| 1982 | 4891 | 1995 | 18361 |
| 1983 | 5719 | 1996 | 20055 |
| 1984 | 6198 | 1997 | 22077 |
| 1985 | 6913 | 1998 | 23461 |
| 1986 | 8011 | | |

Source: SCI search.

In the absence of significant investment or political guidelines, the only explanation for this early growth in scientific production is the change in publication behaviour on the part of academic researchers in both the CSIC and the universities. This change occurred, independently of other intervening factors, by researchers' adapting their work to the requirements of the rest of the Western world, with which they now found themselves increasingly in contact. They perceived the need to integrate their research within the international scientific community, a goal which in fact appears to have been claimed as an achievement in the 1960s in the study published by the then Minister of Education and Science.

Sanz Menéndez (1997) described the situation thus:

> Interaction increased and the patterns of behaviour that were habitual in international science were accepted; thus the Spanish system of scientific research, as an institutional organisation, is the result of the learning process and of the competence acquired through the international diffusion of the results. These elements were the determining factors in the legitimisation of both the disciplines and the scientific careers of the agents responsible for those disciplines.

Several sources of evidence support the hypothesis that Spanish scientists had already started to accept international publication practices (i.e. to export their articles to foreign journals) by the late 1970s. A number of studies carried out by universities and their corresponding research centres show a gradual move away from national scientific journals in favour of international journals published in English (at least in the disciplines of physical sciences, the experimental sciences and biomedicine).

Fig. 1 provides an example of this change in attitude, which is clearly evident in the University of Granada as a steady increase in the number of articles published in international journals included in the SCI. It also provides evidence of a change in the publishing trend with respect to national journals: an initial increase followed by a decline, with minimum publication rates throughout the 1980s. This case is particularly significant in that it also includes citations to national journals which are not included in the SCI database (Jiménez-Contreras, 1997).

Similar developments have been reported for other universities, such as the University of Barcelona, where work published in Spanish throughout the 1980s fell from 10% to less than 2% of the items from this centre in the SCI (Bellavista et al., 1993). A similar process can also be observed in the 1960s and 1970s in research centres belonging to the CSIC (Ferreiro Aláez et al., 1989), in chemistry articles published between 1975 and 1990 (Pérez-Álverez Ossorio et al., 1994), and in agronomy articles from the 1980s onwards (Rey et al., 1998). In all cases scientific production published in foreign journals increased while articles appearing in national journals decreased.

The result is that increasing numbers of articles began to appear in basic research fields—the type of research best covered in the SCI—even though there had been no significant increase in public investment or

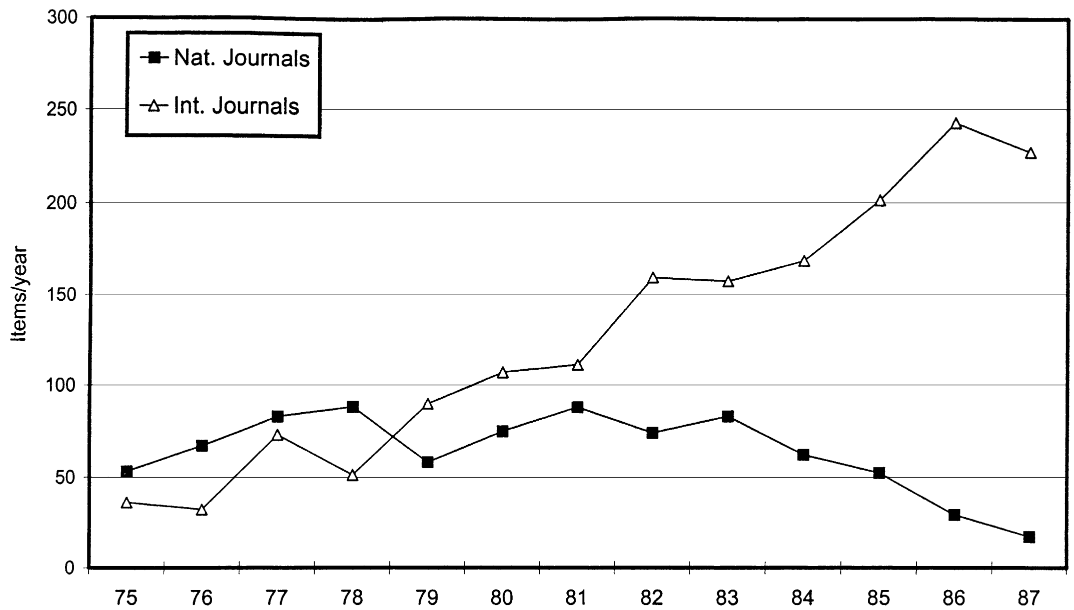


Fig. 1. Research articles by authors from the University of Granada published in national and international journals between 1975 and 1987.

human resources. On the other hand, the small volume of work which constituted the starting point for this expansion explains how this change in attitude, which the Spanish scientific community seemed to have been mature enough to accept since the mid-1970s, came about so quickly and successfully.

### 3.2. *The 1980s: political change*

An analysis of the increase in Spanish research productivity during the late twentieth century must also consider the political impulse discernible since the beginning of the first Socialist administration in 1982. With the Socialist government, science + technology became a specific item on the agenda for reform for the first time. This was manifested, above all, as a more open attitude towards the sciences, and towards the universities in particular. The change was due in part to the fact that various Socialist ministers, senior officials and members of parliament were university professors, and that the imbalance between investment figures and scientific production in Spain and other countries in Europe had been recognised for some time (Quintanilla, 1992).

The new objectives of the Ministry of Education and Science in this decade can be summarised as (1) the co-ordination of publicly-funded scientific endeavours, (2) a general increase in the magnitude of the scientific and technological system in terms of resources such as human capital, and (3) the establishment of a policy of prioritisation. This meant, in other words, the establishment of an authentic science policy in line with the technical, industrial, economic, and social needs of Spain. The most noteworthy specific objectives were the proposals to double public expenditure in R&D, to strengthen postgraduate training, to reform the laws regulating employment of research personnel by the civil service in order to stabilise their employment status. A further goal of the Ministry of Education and Science was (4) to introduce incentives in the different fields of research.

To put the new policies in practice, a series of laws were promulgated, the most important being the University Reform Law in 1983 (11/1983, BOE 25 August 1983), the so called Science Law in 1986 (13/1986, 14 April, BOE, 18 April 1986, officially designated as the Law for the Fomentation of Science and Technology), Royal Decree 1164/1986, 6 June, which regulated the application of the National Fund for the Development of Scientific and Technical Research and its administration (BOE, 23 June and BOE, 21 July), and finally the National Plan for Scientific Research and Technological Development, in effect since 1987, which established the objectives, programs and priority areas of Spanish scientific activity. These laws put in place the legal framework of publicly-funded scientific activity, and represented the first of a set of measures aimed at creating a specific scientific policy with clear objectives and mechanisms of internal oversight.

The University Reform Law (*Ley de Reforma Universitaria*, LRU) regulated the administration of Spain's public universities, previously considered to play a relatively small part in national research activities. In the 1980s the universities started to gain recognition for their research capacity, and they soon became one of the protagonists. Two factors underpinned this rapid ascent: the majority of the country's scientists were to be found within these institutions, and the disciplines university-affiliated researchers were most experienced in, i.e. the basic sciences, were now considered by the government to be fundamental and worthy objectives. From this point onwards, university funding increased considerably within the context of general policies in support of expansion of the public sector. Indeed, the increase in the number of public sector posts in the university system, although somewhat slower than in the 1980s, continues to this day.

Apart from economic and human resource data, which will be considered later, these legislative measures created a more favourable setting for research activity, at least insofar as the central government became more directly involved. On the other hand, for a number of reasons the subsequent evolution of science policy meant that of all the political objectives initially proposed by the government, it was the goal of strengthening basic research which gained the most importance, at least within the national policy-making organ created by the National Plan for research and development: the CICYT. Responsible for co-ordinating research activities at a national level, the CICYT was controlled mainly by researchers with an academic background (Sanz Menéndez, 1997). It is significant that of the 20 sectorial programs for that were approved for funding by the National Plan, at least 16 of them were clearly

Table 2
Percentage of Spanish GNP invested in R&D between 1974 and 1996

| Year | GNP (%) for R&D | Year | GNP (%) for R&D |
|---|---|---|---|
| 1973 | 0.32 | 1985 | 0.55 |
| 1974 | 0.33 | 1986 | 0.62 |
| 1975 | 0.37 | 1987 | 0.64 |
| 1976 | 0.37 | 1988 | 0.72 |
| 1977 | 0.37 | 1989 | 0.75 |
| 1978 | 0.37 | 1990 | 0.85 |
| 1979 | 0.37 | 1991 | 0.87 |
| 1980 | 0.43 | 1992 | 0.91 |
| 1981 | 0.41 | 1993 | 0.91 |
| 1982 | 0.48 | 1994 | 0.85 |
| 1983 | 0.48 | 1995 | 0.80[a] |
| 1984 | 0.50 | 1996 | 0.76[a] |

Source: Sanz Menéndez, 1997 (data prior to 1980), INE, 1999 and European Commission, 1997.
[a] European Commission data.

Table 3
Number of publicly employed researchers in Spain between 1980 and 1998

| Year | University researchers | Researchers in other public centres |
|---|---|---|
| 1980 | 11793 | 3536 |
| 1981 | 12410 | 3632 |
| 1982 | 12022 | 3351 |
| 1983 | 13053 | 2872 |
| 1984 | 13570 | 2917 |
| 1985 | 13763 | 2839 |
| 1986 | 14305 | 4060 |
| 1987 | 15100 | 4528 |
| 1988 | 16912 | 5706 |
| 1989 | 17554 | 5864 |
| 1990 | 18904 | 7623 |
| 1991 | 20775 | 8079 |
| 1992 | 22167 | 7660 |
| 1993 | 24006 | 7737 |
| 1994 | 28591 | 7820 |
| 1995 | 27666 | 8359 |
| 1996 | 30858 | 9126 |
| 1997 | 30648 | 10490 |
| 1998 | 34524 | 11021 |

Source: INE, Investigación científica y desarrollo tecnológico, 1999.

devoted to quantitative, experimental sciences and technologies.

In economic terms the new policies that resulted from measures taken by the Socialist government led to increases in the investment in R&D (Table 2) and in the numbers of research staff employed by the State in the universities and other *Organismos Públicos de Investigación* (Public Research Organisms, OPIS) (Table 3). These increases go a long way toward explaining the growth in Spanish international research production, which trebled in the SCI between 1982 and 1991 (Table 1).

During the 1980s, as we have seen, many new sources of support for R&D appeared that made the large increases in research production during this decade quite predictable. Human resources and funding available to the universities both increased, as did the involvement of the universities in research. Increased funding also became available from the recently created autonomous communities, whose contribution between 1987 and 1991 rose from 17.6 billion pesetas to 45.4 billion pesetas (Fernández de Lucio et al., 1994). Funding from the European Union during this period is estimated to have covered approximately 5 to 7% of the total cost of R&D in Spain. Funding for R&D rose from 0.48 to 0.85% of the GNP during this period, and reached its highest point in 1992 (0.91% of the GNP), an increase which was accompanied by proportional increases in personnel both in the universities and in other OPISs (Table 3). Furthermore, as has been widely assumed, the increase in staff meant an increase in researchers working in academic science, and as such, it was to a certain extent inevitable that scientific production should increase steadily as a result.

### 3.3. The 1990s

The economic crisis in the early part of the 1990s meant the end of the cycle of growth of resources allocated by the state to R&D, and a period of recession then ensued. Even if the figures given by the INE are accepted (despite the discrepancies between these and the figures presented in the European Commission's 1997 S&T Indicators, see Fig. 2), it is clear that investment levelled off. To be precise, however, and given that expressing investment as a percentage of the GNP might camouflage increases in investment given an overall increase of GNP, it is informative to analyse the evolution of Spanish R&D investment in terms of constant pesetas. This analysis, using the value of the peseta in 1986 as the reference, shows only a slight

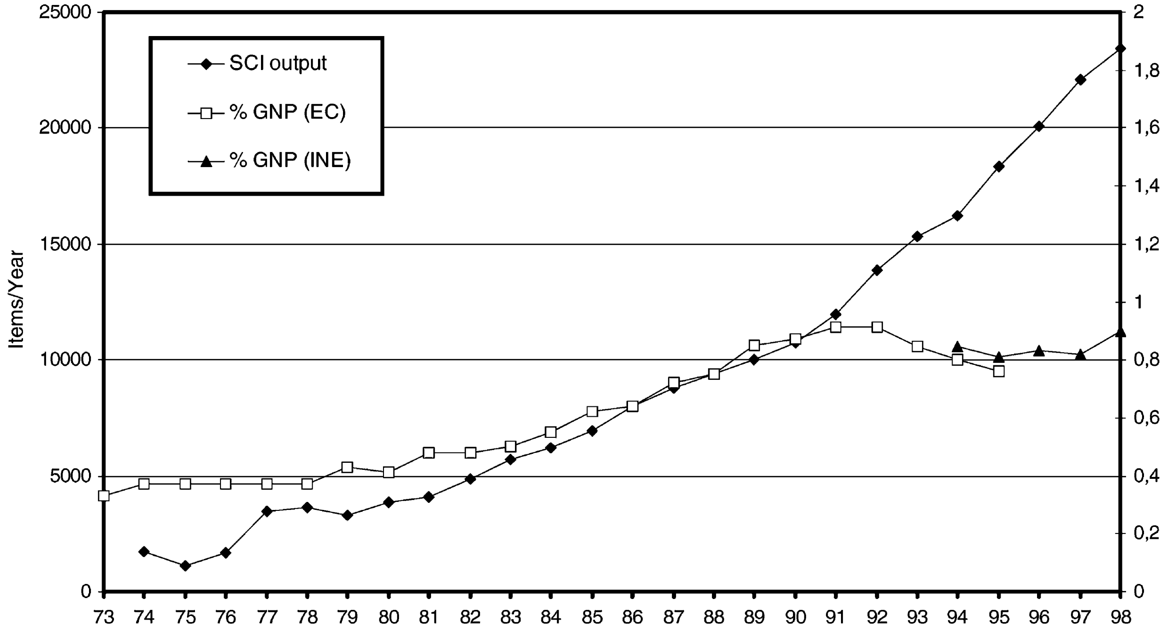


Fig. 2. The evolution of scientific production with respect to public investment in R&D between 1973 and 1998.

increase from 176 to 193 pesetas between 1991 and 1997, a net increase of approximately 10% compared to the 140% growth in funding between 1982 and 1991 (Table 4). Translated into cost per published article (on the basis of data supplied by the INE), this represents a decrease from 12 989 000 pesetas to 8 705 000 pesetas, reversing a historical tendency which dated back to the 1980s (the earliest period for which these data are available) (Fig. 5).

At the same time, the hiring of researchers by the government was also halted, and there was a decrease in the growth of the number of university posts. These changes can be seen as symptoms of the loss of priority which R&D and higher education had enjoyed throughout the preceding decade. Considering these conditions, it would seem logical to expect a parallel deceleration in Spanish scientific production. Nevertheless, this was not the case. In fact, Spanish scientific production accelerated even more (Table 1).

Although the 1980s were a period of important growth, the profile of this increase in Spain's capacity to produce research, albeit intense, was linear. The period beginning at the end of the 1980s, when the steady increases in the government's investment in

Table 4
Investment in R&D in constant pesetas (1986 = 100)

| Year | Pesetas |
|---|---|
| 1980 | 63 |
| 1981 | 63 |
| 1982 | 72 |
| 1983 | 73 |
| 1984 | 76 |
| 1985 | 87 |
| 1986 | 100 |
| 1987 | 110 |
| 1988 | 130 |
| 1989 | 144 |
| 1990 | 168 |
| 1991 | 176 |
| 1992 | 186 |
| 1993 | 184 |
| 1994 | 174 |
| 1995 | 178 |
| 1996 | 188 |
| 1997 | 193 |
| 1998 | 205 |

Source: INE, Investigación científica y desarrollo tecnológico, 1999.

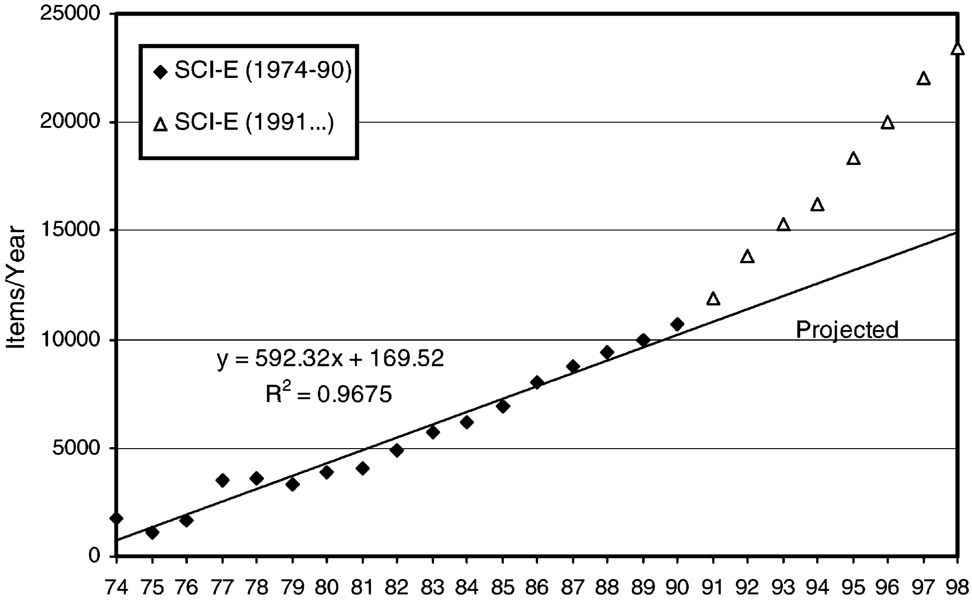


Fig. 3. The data-based predicted evolution of Spanish scientific production from 1974 to 1990.

science ceased (see Fig. 2), was a time of increased acceleration in the rate of publication, which eventually became exponential. This occurred under conditions which can only be described as adverse, in the sense that not only had investment levelled off, but also growth was taking place in a more difficult environment, given that production was approaching its foreseeable limit in a setting where further gains in the international ranking required quasi-logarithmic increases in productivity.

Moreover, if we extrapolate the values prior to the 1990s (when the increases in the government's funding were greatest) to this decade, a paradox appears in that the foreseen growth in production, although in itself important, was significantly less than the actual measured growth, by a difference of approximately 7000 published items, i.e. almost one-third more than the predicted number for 1997 (Fig. 3).

How did this situation come about? Some possible explanations, for example the idea that the private sector had stepped in with new sources of support, can be readily excluded, as shown in Table 5. In fact, the importance of the central government in research activity increased in terms of its percentage contribution during the final years of the 1990s, in spite of the slow-down in investment.

Research and development is therefore currently an endeavour supported essentially by the State, and which has become increasingly dependent on the universities in the sense that it is these centres where research resources have increasingly been concentrated. Thus, the situation in Spain has diverged from that in other European countries: in Spain, 29% of all university graduates working in research are employed in the private sector, as compared to the 53% who are employed by the university system. On the other hand,

Table 5
Percentage of R&D funding provided by the Spanish government between 1989 and 1996

| Year | Participation (%) |
|---|---|
| 1989 | 43.1 |
| 1990 | 41.7 |
| 1991 | 43.5 |
| 1992 | 48.9 |
| 1993 | 51.3 |
| 1994 | 52.3 |
| 1995 | 51.0 |
| 1996 | 51.0 |
| 1997 | 47.8 + 6.8[a] |
| 1998 | 42.7 + 6.7[a] |

Source: INE.
[a] CEE funds.

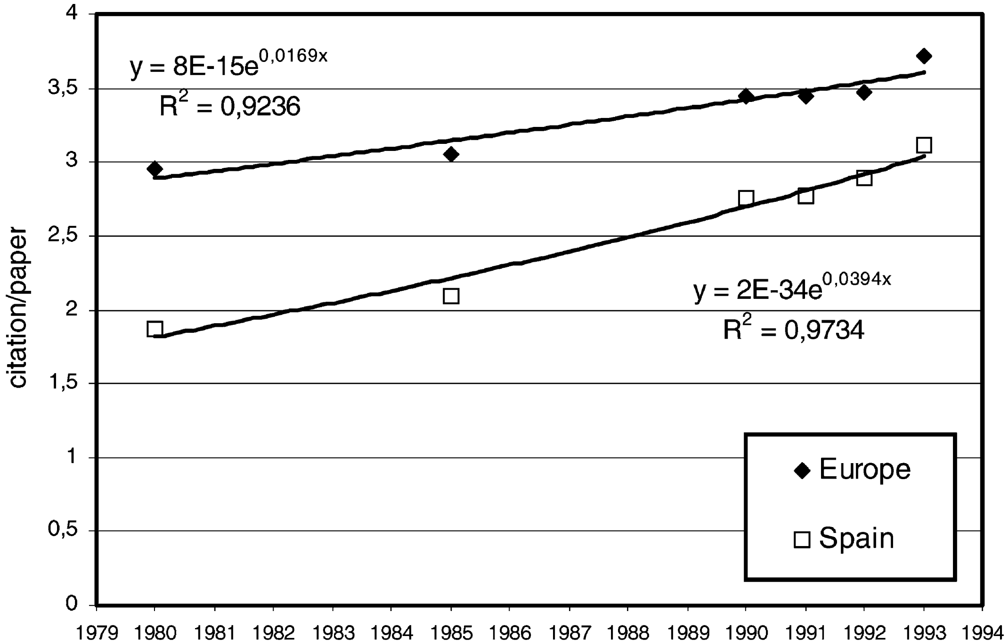


Fig. 4. Citation rates for articles published by Spanish authors and by authors from other European countries between 1980 and 1994.

in EU4 (France, the United Kingdom, Germany and Italy) the numbers are just the opposite, with 57% of all graduates working in private companies and only 27% in universities. Moreover, economic restrictions have lead to a situation where mean expenditure per researcher in Spanish universities is 4.6 million pesetas, whereas in EU4 this figure was threefold as high: 12.3 million pesetas (9.4 in France and 9.0 million pesetas in Italy) (Luque López, 1998). This figure remains low despite the fact that Spanish universities have attracted one-third of the entire public investment in R&D in last few years. Nevertheless, none of these apparent obstacles appears to have interfered with the growth in Spanish scientific production so far.

Currently, it can be argued that R&D on a national level is essentially supported by the State, particularly through the public universities. This explains the emphasis on academic research and its increased international importance, as basic research (as opposed, for example, to applied research and technology) is the type of scientific output most accurately identified by the SCI.

It might also be possible to regard this growth as a result of a ‘high output-low intensity’ publication policy which produces many publishable items of relatively low impact. This, however, is not the case. The rate of growth in citations to articles by Spanish authors has increased somewhat more than the European average, although it should be borne in mind that citations were initially far below the European average (Fig. 4). The same type of growth pattern was identified in the preceding decade (Garfield, 1994). The tendency to attain European levels of production in science and technology is therefore evident at all levels.

In addition, several authors have reported continual growth in the impact factor (IF) of the journals in which Spanish authors have published during the 1980s and 1990s. Cano and Julián (1992), for example, report rising mean IFs in the physical and experimental sciences and in biomedicine for the period 1983–1989. More recently, it has been shown that the average IF for biomedical publications clearly increased throughout the first half of the 1990s in comparison with the periods 1986–1989 and 1990–1994 (Gómez et al., 1997a).

The search for possible explanations for this seemingly paradoxical gain points toward the cumulative effect of the policies initiated during the second half of the 1980s (Science Law, National Plan, LRU, etc.). However, although this might account for the maintenance in the growth rate, it seems inadequate in itself to account for the further impetus which was not only sustained throughout the decade, but also led to new bursts of productivity from 1994 onwards. In fact, 1994 saw a refinement of the criteria used by the CNEAI. In comparison with the original set of 'rules', which were somewhat vague on certain points, the new criteria spelled out more clearly the criteria for which research bonuses were awarded.

Another possible cause for these gains is the increase in researchers' international mobility, leading to increased international contacts and international publications. The greater the number of researchers who spend time abroad, and the more publications arise from work done in foreign laboratories, the more plausible this hypothesis becomes. In other words, if few Spanish researchers visited foreign countries in relation to the number of items published, or if the number of publications decreased as research stays abroad increased, this would speak against a relationship between stays abroad and productivity as an explanation for this growth. Indeed, according to data for international mobility supported by the two main public organisations which fund such stays [the National Plan and the Public Health Research Fund (*Fondo de Investigaciones Sanitarias*, FIS) in the biomedical system], the number of Specialised Research Training Grants (*Becas de Ampliación de Estudios*, BAEs) awarded from 1 year to the next (and that support research both within Spain and abroad) actually tended to decrease between 1991 and 1995. In 1991, a total of 259 BAEs were awarded; this figure had fallen to only 108 in 1995. Moreover, the proportion of BAEs used to support research abroad also shrank markedly during this period, from a total of 1541 months supported in 1991 to 781 in 1995. The total number of BAEs actually awarded for stays abroad during this 6 years period was only 450 (Menéndez and Benito, 2000).

Other authors have analysed the international mobility of Spanish researchers funded by the *Secretariado de Estudios Universitarios e Investigación* (Secretariate of University Studies and Research, SEUI) within their programmes for research personnel (Martín Sempere et al., 1996) for the years 1984–1994, and we have collected data on approved funding between 1997 and 2000 (although this latter period falls outside the period analysed here). The trend which emerges is irregular, with a slight tendency toward increased funding. However, the total figure of 1468 grants (for the decade 1984–1994) suggests that this figure is too low to be a decisive factor. Martín Sampere and colleagues analysed the percentage of researchers who obtained funding for different disciplines: 400 of these grants went to the social sciences and humanities, and the remaining 1000 or so represented between <1% and 8–9% of the human resources allotted to each discipline. The overall average was 4% for all public centres. Researchers working in the field best represented in the SCI database (mathematics, physics, chemistry, life sciences, medical sciences and technological sciences) received in all 592 of these grants, which supported stays abroad for an average of 3.92% eligible researchers in all fields over a period of 10 years (0.4% per year).

Bearing the above data in mind, it seems difficult to explain the increase in publications during the 1990s on the basis of the number of travel grants. This is especially true if we take into account that for both types of financial support, the curves plotted from these data as reported by the relevant government agencies are clearly incompatible with the data we obtained from our analysis. This, however, does not rule out the possibility that programmes to support research stays abroad might play a favourable role in enhancing research productivity.

Linked to the question of international mobility is international collaboration, which has grown steadily since the beginning of the 1980s, the earliest decade for which statistics are available. Currently, approximately one-third of all publications in the ISI database are by authors from more than one country (Bellavista et al., 1997). Has this factor contributed to Spain's increased presence in the database? This question cannot be answered here. International co-operation is common in research, and is not a factor that particularly characterises the Spanish system. Moreover, co-operative links with colleagues in other countries were already being formed before the Spain's current science policies were developed, and these links appear to have arisen independently of the peaks and troughs in public funding that we describe in the present article. In other words, collaboration with foreign colleagues has increased steadily during periods of both relatively generous and comparatively scarce

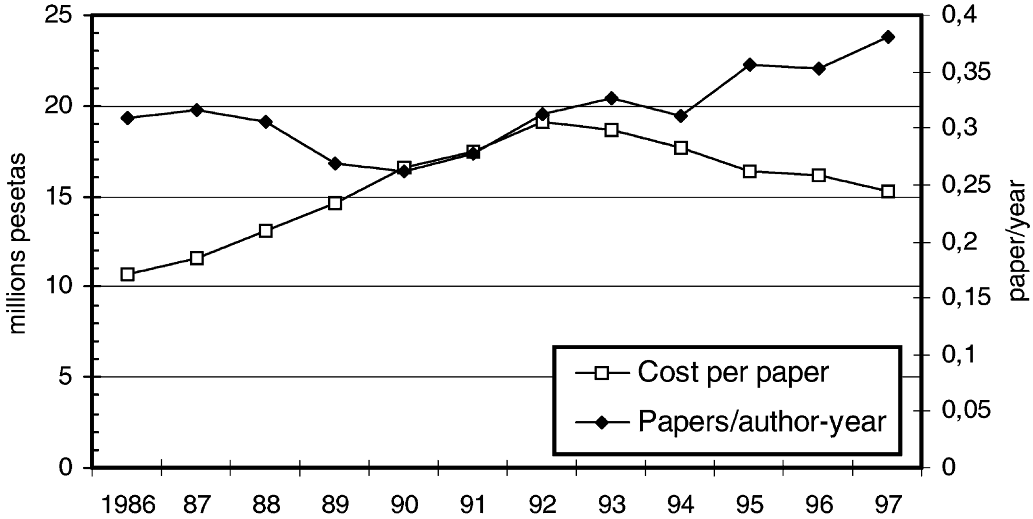


Fig. 5. The productivity of Spanish researchers vs. cost per paper published.

funding, and the number of articles signed by both Spanish and non-Spanish researchers has increased in both international and national journals (Martín Sempere et al., 1999). This collaboration can be interpreted as one cause of Spain's greater presence in international journals, and also as a result of the political stimulus for publishing outside of Spain that the CNEAI provided. However, it is interesting to note that during periods of scarce funding for stays abroad, researchers themselves apparently made special efforts to create and maintain ties with foreign colleagues in order to gain access to publication in international journals. The policies of the CNEAI may well have helped to motivate the pro-active approach to international co-operation.

Participation in international programmes, especially European ones, undoubtedly increased international contacts. However, it should be borne in mind that the growing support which Spain received through collaborative projects with foreign centres has been, in monetary terms, practically the equivalent of the economic contributions Spain has made to these programmes 'up front' (CICYT, 1999).

What, then, are the stimuli that university professors and OPIS researchers have received which have lead in recent years to increasing productivity and anticipated impact of their work, in view of the fact that government spending in research levelled off in the late 1980s? The increase in the number of researchers explains only part of the total increase in publication output. Another possible explanation is illustrated in Fig. 5, which shows how productivity per author and per year increased steadily since the beginning of the 1990s, after a decline at the end of the 1980s. As a result of this increased productivity in the absence of increased funding for research, the cost per published article has also decreased since 1992.

Because the factors reviewed above are not able in themselves to explain the change in the growth rate (although clearly they are of some relevance), the determining factor in this recent increase in the publication of Spanish research in international journals appears to be the introduction, in 1989, of mechanisms of evaluation of publicly-sponsored research activity. Originally, the LRU envisaged incentives for both teaching and research activity. However, teaching remained under the control of individual universities, which allocated the incentives in an arbitrary manner. In the absence of an explicit evaluation and reward mechanism, these incentives became essentially across-the-board salary bonuses for virtually all university teachers. On the other hand, research incentives were overseen by the central administration through a new organisation formed specifically for this purpose: the CNEAI (created through a Real Decreto on 28 December 1989). The objectives of this organism were twofold: to selectively increase researchers' salaries (i.e. an economic motivation; see the following section), and to officially finalise the process which would bring the publication patterns of Spanish researchers into line with the patterns seen in the rest of the Western world. It was hoped that this would further increase the international visibility of Spanish research, a process which was already underway but which received a final thrust from this organism. The formulas and criteria used to achieve these objectives have been described in detail in several reports (Sanz Menéndez, 1995; Miguel, 1997).

It is important to mention one further detail of relevance to this discussion. The text of the Real Decreto itself (1086/1989) states that the ultimate objective of the new law is to foster university professors research productivity and improve the diffusion of this research both nationally and internationally. The reference framework upon which the system is based can be deduced from the legal text, which states that the system should 'evaluate scientific and technological production and its national and international dissemination, using as a procedure the evaluation by a group of experts based on selective reports about publications, provided by the researchers themselves'.

Despite the differences between the ways in which different governments finance and evaluate research, in general the Spanish system uses a method of evaluation—peer review—which is fairly similar to that used in industrialised countries such as the USA, The Netherlands and Australia (Research Evaluation, 2000). However, it is interesting to consider how the Spanish system compares with approaches to research evaluation tried in other countries and in other settings. There are clear similarities between the Spanish system and the Research Assessment Exercises used in the UK since the beginning of the 1990s (Research Assessment Exercise, 2001). If we consider, however, the specific features of the Spanish system, the following two points clearly stand out:

1. Whereas in most countries evaluation is carried out at the level of the institution or research group, in Spain evaluation is carried out at the level of the individual researcher.
2. Whereas the criteria used by the panel of reviewers to determine research quality are, in most systems, fairly diverse and more or less generic, in the Spanish case they are fairly explicit. Indeed, the regulations themselves, as published in the BOE, state that 'preference will be given to those articles which are published in journals of recognised prestige, that is to say, those journals which occupy a notable position in the lists, organised by scientific field, which appear in the Subject Category Listing of the Journal Citation Reports of the Science Citation Index (Institute of Scientific Information, Philadelphia, PA, USA)'. Therefore, Spanish researchers who work within the fields of Mathematics, Physics, Chemistry, Cellular and Molecular Biology, Biomedical Sciences, Environmental Sciences, Engineering and Architecture, Social Sciences, and Economics know that their research will automatically be evaluated favourably if it is published in a journal which occupies a notable position in the JCR lists of the SCI and the SSCI. Only researchers working in the fields of Humanities and Judicial Sciences use alternative criteria. The message that these criteria send to researchers is therefore absolutely clear.

To summarise, the system, despite its similarities to the RAE, seems to be clearly focussed on proffering a personal (as opposed to a team or group) enticement. The potential reward does not appear to have any direct influence on success in obtaining funding for research. Nonetheless, the Spanish CNEAI system of *sexenio* has come to be associated with success in obtaining funding, inasmuch as a history of *sexenio* bonuses is considered a factor that increases the chances of a favourable ex ante evaluation of a grant application submitted to government R&D funding agencies.

### 3.4. Results of the CNEAI evaluation policy

It should be recalled that CNEAI evaluation system involves only tenured staff at research centres, although once tenure is obtained, research bonuses can be requested for articles published while the applicant was still awaiting tenure. Access to research funds is, in principle, not affected by success in *sexenio* applications. In other words, the additional time devoted to research-related work in response to the call for applications for *sexenio* bonuses was not financed through supplementary funding or the incorporation of additional staff. This means that in practical terms, the time devoted to research was 'stolen' from time that 'should' have been devoted to mainly teaching activities. In addition, research activities carried out under these circumstances would have needed to be organised and carefully planned to get the most out of these efforts.

We might then speculate that the CNEAI policy may have led to some covert 'reallocation' of funds intended to finance teaching activities (as all university positions in Spain are awarded, essentially, to cover teaching needs rather than research needs). Could this reallocation have underwritten the significant increase in research activity that occurred in Spain during the 1990s? Although evidence from well-designed studies is lacking, there is a widespread perception among Spanish university professors that teaching has been receiving less attention than before the advent of the *sexenio* programmes. Nevertheless, an analysis of the data available to date regarding budgetary allocations during this period fails to reveal evidence of a possible change in priority, as the salaries of university professors are calculated as part of the yearly global R&D budget, but are not itemised separately.

The discussion below will focus on the effects that the CNEAI has had on Spanish scientific production. The economic motivation, in fact, is less important than other factors, since the maximum increase in salary that researchers are eligible for after 6 years evaluation period (a *sexenio*) is equivalent to less than 3% of the average yearly salary of titular university teachers. Moreover, only if a salary increase were awarded for all five potential evaluation periods during a researcher's university career (i.e. after 30 years of research activity) would the resulting raises make the researcher's income approximately equivalent to the salary of a full professor (*catedrático*, the highest academic rank in the Spanish public university system) who had received no such bonuses for research publications. As a result, the main incentive, which was initially economic, became the recognition gained for the research, and the associated possibilities of professional promotion, as research organisations have increasingly considered these raises as proof of scientific excellence. This stimulus explains why more than 80% of all researchers (in both universities and other OPIS) applied for such bonuses they were first made available. However, as Fig. 6 shows, only 60% of all applicants were wholly or partially successful, which means that approximately half of the researchers were initially excluded from the benefits of the new evaluation system.

In subsequent years the evaluation criteria were revised several times, the most important change occurring in 1994. However, the underlying philosophy has in essence been maintained, in that priority has always been given to the publication of 'conventional' works (books, original research articles or patents), with preference given, in the case of journal articles, to those published in one of the international journals included in the Journal Citation Reports. As a consequence, researchers have continued to adapt their publication behaviour to the new rules of the game—so to speak—with two apparent repercussions. Firstly, publications included in the Science Citation Index have increased (while publication in national journals has declined, a process which had begun in previous decades); secondly, the proportion of research-bases salary increases which have been awarded has increased gradually (from 60 to 75% of all applications submitted), as researchers increasingly adapt their work to the evaluation criteria. Interestingly, there has been an overall decline in the number of applications, which may be a reflection of increased self-censorship by the applicants as they try to ensure that their application in any given 6 years evaluation period is approved. This rather cautious approach probably reflects the fact that according to the rules of the research bonus programme, a rejected application makes an author ineligible for re-application for the following three years (Orden Ministerial, 2 December 1994, article 14).

Applications are evaluated by experts in 11 scientific fields: Mathematics and Physics, Chemistry, Cellular and Molecular Biology, Biomedical Sciences, Life and Earth Sciences, Engineering and Architecture, Social/Economical/Political/Behavioural/Educational Sciences, Economics and Business Studies, Law and Jurisprudence, History and Art, and Philosophy/Philology/Linguistics. Each field has specific guidelines which must be followed for all evaluations, but the first five fields consider only 'conventional' publications, whereas the other fields consider, to a greater or lesser degree, other types of contributions to published knowledge. The types of publications

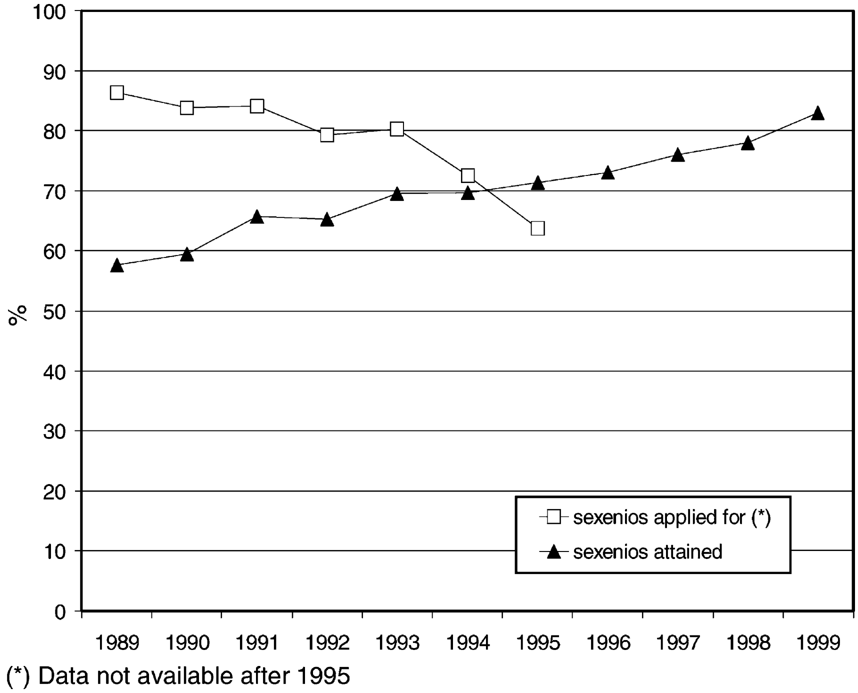


Fig. 6. Annual percentage success rates for publication-linked salary increases awarded to Spanish researchers between 1990 and 1999. (□): percent of all applications presented referred to all potentially approvable applications. (▲): percent of submitted applications that were successful.

that may earn a salary increase in the field of law is particularly long.

In general, the performance across different fields, in terms of success rates, has been very similar. In all fields, there has been a gradual decrease in the numbers of applications, although the average number of applications received referred to the total potential number of eligible applications for the whole period is 77.3%, a group of applications which can be considered representative of all potentially eligible applications (it should be recalled that some authors with publications that would earn them a raise decline to submit an application). However, although the strategy used when applying for a research bonus is similar across fields, the results are not.

When the trends with time for different scientific fields are compared (Table 6), the overall tendency is clear, although the patterns for specific fields are not consistent. The fields of Mathematics and Physics, Chemistry, and Cellular and Molecular Biology showed high or very high success rates, which continued to increase over the following years (as measured by their correlation coefficient). More raises were awarded in these fields than in other subjects, and the success rate reached around 90% by the year 1999. Although the success rate is 10% lower in the field of Life and Earth Sciences, the general tendency for most applications to succeed was similar to the trend for the four most successful fields noted above. The patterns in the other two 'scientific' fields, Biomedicine and Engineering/Architecture, are different. In Biomedicine the increase in the success rate has been slower and less constant, at around 10%, whilst in Engineering/Architecture a very rapid increase occurred during a brief period, as it was not until 1993 that the proportion of successful applications began to show a steady increase. The fields of Social Sciences and Humanities show somewhat erratic patterns (with low correlation coefficients), and below-average rates of increase. Only the field

Table 6
Success rate in obtaining sexennial publication-linked salary increases, by scientific field

| | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 |
|---|---|---|---|---|---|---|---|---|---|---|
| Matemathics/Physics | 59.4 | 80.0 | 75.9 | 78.1 | 83.6 | 86.3 | 90.4 | 91 | 90 | 89 |
| Chemistry | 70.4 | 75.2 | 79.9 | 84.4 | 74.0 | 78.2 | 89.9 | 92 | 89 | 93 |
| Cell/Molecular Biology | 79.6 | 74.2 | 71.2 | 85.8 | 82.5 | 86.4 | 90.2 | 92 | 96 | 94 |
| Medicine | 59.0 | 69.3 | 68.1 | 64.9 | 65.5 | 77.8 | 75.0 | 70 | 75 | 68 |
| Earth Science | 57.3 | 64.8 | 67.1 | 71.8 | 65.0 | 69.3 | 75.6 | 78 | 72 | 79 |
| Engineering/Architecture | 53.8 | 63.8 | 47.9 | 45.4 | 57.0 | 61.0 | 70.2 | 78 | 73 | 74 |
| Social Sciences | 46.4 | 48.1 | 54.2 | 70.0 | 57.6 | 60.4 | 63.7 | 56 | 71 | 62 |
| Economics | 47.2 | 66.7 | 56.1 | 59.8 | 64.9 | 61.9 | 49.7 | 50 | 52 | 54 |
| Law | 69.9 | 78.0 | 75.6 | 82.3 | 80.3 | 63.5 | 64.4 | 83 | 88 | 84 |
| History/Art | 64.4 | 65.2 | 67.2 | 73.8 | 70.5 | 62.3 | 69.7 | 78 | 74 | 80 |
| Philosophy/Philology | 60.0 | 51.5 | 60.0 | 58.6 | 77.3 | 78.1 | 71.1 | 76 | 83 | 91 |
| Average across fields | 60 | 66 | 65 | 70 | 70 | 71 | 73 | 76 | 78 | 83 |

Source: CNEAI, 2000.

of Philosophy/Philology/Linguistics appears to show notable progress (a 30% increase in success rate from 1990 to 1999).

If we accept that the evaluation criteria have been applied equally across all fields, these findings suggest three conclusions. Firstly, the evaluation procedure appears to have been most appropriate for research in fields belonging to the exact and experimental sciences, although the criteria were also followed by authors in the fields of Humanities and Law (but not in the fields of Social Sciences and Economics, or at least not to the same degree). This would explain the initial differences in success rates between these fields. Secondly, one could conclude that researchers in the fields of Biomedicine, Life and Earth Sciences, and Engineering/Architecture have adapted their publication behaviour more closely to the new criteria of the evaluation system, and that this has led to the increase in the percentage success rate and in the number of articles which appear in the ISI database.

On the other hand, this evaluation process seems not to have been assimilated by researchers in the field of Economics, and to have been accepted only to a limited extent by researchers in the Social Sciences. These fields lagged behind the others in the first assessment exercise, and have made the least progress in terms of successful applications over the last few years. Various reasons might account for this apparent failure of research in these fields. Firstly, the specific and necessarily local features of the research in economics and social sciences might make it more difficult to 'export' (the so-called local factor), and the researchers' lack of international contacts might have a negative influence. Secondly, the lack of internal homogeneity within the fields themselves—what we might call inadequate cognitive consensus—might lead to difficulties in identifying high quality research. Lastly, numerous unrelated subspecialties exist within these fields, a factor which would make peer review more complex and possibly less reliable.

These factors mean that additional efforts are needed to adapt the evaluation criteria to the peculiarities of these fields and their sub-disciplines within fields, and to increase researchers' familiarity with the CNEAI criteria. In other words, researchers in these fields should be given access to 'the rules of the game'. This is, of course, assuming that the main goal is to increase the international diffusion of Spanish research, and to bring it into line with international standards in different fields.

The last conclusion that the results in Table 6 suggests is concerned with the stability of behaviour within different fields. The consistency of the trends, measured as correlation coefficients, clearly shows that the 'experimental science' fields share a fairly regular pattern throughout the period analysed here. This may be due to the consistent application of the criteria by the evaluation committees and the likewise consistent response of the research community in each specialised field (or members' adaptation to the criteria after an initial delay, as in Engineering/Architecture). On the other hand, the inconsistent trends in the Social Sciences and Humanities may reflect the opposite behaviours, i.e. inconsistent application of the evaluation criteria on the part of both the reviewers and the applicants. This explanation, however, must be considered a provisional working hypothesis.

To judge the real effect that this research evaluation policy has had on researchers, it seems appropriate to consider that rather than being the result of CNEAI activities, the recent increase in scientific output may be due simply to an overall improvement in the efficiency of the system as a result of regulations introduced in the previous decade, and despite the freeze in government investment. Furthermore, the effect of increased international mobility and collaboration (the consequences of which are difficult to assess) may have more weight than has previously been realised.

Several other recent studies have also drawn attention to the importance of the change in mentality among Spanish researchers in the increases in research productivity since the early 1990s. As noted by others, Spanish scientists have apparently become more concerned about securing salary increases based on research production, and consequently pay greater attention to compliance with the new rules of the game. However, they have also taken account of some of the negative consequences of this new evaluation process. Firstly, the process has stirred alarm amongst editors of national journals, as it has led researchers to increasingly neglect these outlets. The editors attribute this process, amongst other things, to the criteria imposed by the CNEAI (Lience, 1994; Guerra Sierra, 1996; Feliú, 1995). Secondly, researchers themselves have critically reflected upon this phenomenon, which one author has termed 'impactolatry' (Camí, 1997). Lastly, and perhaps most importantly, the results of two recent surveys of publishing habits (one at a national level and the other at an international level) are revealing. In a survey of Spanish geologists (Rey et al., 1998), authors who preferred to publish in non-Spanish journals were asked to give reasons for their behaviour:

> 'I try to publish in foreign journals with a wide international diffusion and they usually are foreign' (82%).
>
> 'Papers in foreign journals are better considered by evaluation agencies' (66%).

The first quote can be considered an example of the classical or academic viewpoint; two out of every three participants surveyed believed this behaviour to be a good strategy for advancing their academic career. Moreover, geological research is not particularly international in scope to the extent that physics or basic medical research are, and this may suggest that, in the light of the data and arguments put forward earlier in this article, it reflects a reasoning which is shared by researchers in other scientific fields.

An international survey sponsored by the Association of Learned and Professional Society Publishers (ALPSP) reached the following conclusion:

> Authors are continuing to publish in learned journals primarily to communicate their findings and advance their careers. Direct financial reward is not an important issue. Their main aim is to reach the widest possible audience, with the quality of peer review and the impact factor of the journal being the main factors of importance in achieving their overall publishing objectives. In deciding where to submit their work, the perceived reputation of the journal, its impact factor, subject area, international reach and coverage by abstracting and indexing services are extremely important (Swann and Brown, 1999).

Apart from the fact that the two surveys confirm each other's results, the ALPSP study is surprising in that it concludes that financial reward is not an important influence on publishing behaviour. Like the two previously cited studies, Walford (Walford, 2000) concluded that researchers (in this case those working in the United Kingdom) who were the subjects of the Research assessment exercise felt motivated to chose the outlets for their publications on the basis of the criteria that the evaluation agency stated would be used to award merit. These authors tended to choose their target journals on the basis of citation ratings or impact factor. This finding supports the notion that Spanish scientists, as well as those from other countries, are increasingly concerned about their academic careers. This concern is translated into a stimulus to publish in international journals, and the main cause of this stimulus is the motivation to obtain recognition through the evaluation system—such as the one established in Spain by the CNEAI.

## 4. Conclusions

In the last 25 years Spanish research has undergone a remarkable increase in productivity as measured by the number of items recorded in international databases. This steady upward trend in scientific production, is not the result, in our opinion, of a pre-established plan by national government authorities. Nor can it be traced to a single cause such as the growth in government investment in science and technology. Rather, we argue that there are several different causes which have successively influenced research productivity during the different periods identified in the present analysis. These factors are:

- Firstly, a change in publication behaviour detectable since the 1970s (or even earlier in some institutions), and which, before other factors came into play, led to an initial increase in production. The change in behaviour appears to reflect the increasing contact between Spanish scientists and their peers in the international scientific community, as the opportunities and nature of these contacts normalised.
- Secondly, the availability of different types of political, economic, and human resources which were incorporated into the system of support for science and technology from 1982 onwards. These resources were mainly the development of a legal framework (the LRU, the Science Law, and the National Plan); increased financial support, which doubled during the 1980s; and the growth and occupational stabilisation of Spain's population of academic researchers in the 1980s. Moreover, when Spain became a full member of the European Economic Community in 1986, this facilitated the mobility of Spanish researchers within this continent, and allowed them to join internationally-sponsored research projects. Although these changes did not lead to a net increase in the money made available for research (as the money received from European projects was offset by the monetary contribution that the Spanish government made toward these projects), the new framework for international scientific relationships did facilitate the integration of Spanish scientists in the international community, and did facilitate their access to publication in international journals, which by that time was seen as a desirable goal.
- Thirdly, the existence of the CNEAI from 1989 onwards. The National Commission for the Evaluation of Research Activity came into being at a time when the effects of previous government policies began to fade and investment was levelling off. It marked the start of a system designed to evaluate individual research activity, and gave preference to the publication of work in international journals listed in the ISI's Journal Citation Reports. This stimulus has proved to be a highly efficient, as has been shown by the growth in production rates since 1990. This policy of incentives and toughened criteria has been maintained by successive administrations since 1996.

The system implemented by the CNEAI has been particularly efficient in the fields of the Exact and Experimental Sciences, for which it was initially designed. The only field that appears to have had difficulties in adapting to the evaluation system is Biomedicine, where increases in productivity have been slower to appear than in other fields. On the other hand, the field of Engineering/Architecture appears to have adapted successfully to the system in the last few years.

The fields of Social Sciences and Humanities have had lower growth rates in percentage terms (i.e. the proportion of applicants who were awarded *sexenios* in these disciplines was much lower in comparison with the 'experimental' sciences). With the exception of the field of Philosophy, the results so far suggest that researchers in these areas have yet to adapt fully to the evaluation system.

In this article we argue that the work of the CNEAI in Spain provides an example of a science policy which has been especially efficient in stimulating scientific production and the internationalisation of research. The results in terms of the numbers of published articles included in the ISI databases show that the policies used by the CNEAI achieved the results they were designed to bring about, namely, increases Spanish science productivity as measured almost exclusively by the number of articles from Spain in this bibliometric source.

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