Sound Research, Unimportant Discoveries: Research, Universities, and Formal Evaluation of Research in Spain

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Nobel Prizes are an important indicator of research excellence for a country. Spain has not had a science Nobel Prize winner since 1906, although its gross domestic product (GDP) is high, research and development (R&D) investments, in monetary terms, are high, and conventional bibliometric parameters are fairly good. Spanish research produces many sound papers that are reasonably cited but does not produce top-cited publications. This absence of top-cited publications suggests that important achievements are scarce and, consequently, explains the absence of Nobel Prize awards. I argue that this negative research trend in Spain is caused by the extensive use of formal research evaluations based on the number of publications, impact factors, and journal rankings. These formal evaluations were introduced to establish a national salary bonus that mitigated the lack of research incentives in universities. When the process was started, the results were excellent but, currently, it has been kept too long and should be replaced by methods to determine the actual interest of the research. However, this replacement requires greater involvement of universities in stimulating research.

Introduction

Scientific, experimental research and development (R&D) is widely acknowledged as playing a vital role in the knowledge-based economies that characterize advanced countries. Therefore, countries with limited experience in science and technology (S&T) are attempting to develop competitive R&D systems. The gross domestic product (GDP) is obviously an important factor in determining the amount of research that any country can tackle, but it does not determine the importance of the country's scientific achievements. Similarly, the percentage of the GDP that is applied to research is high in countries with knowledge-based economies, but this parameter should not be the only reference for research policy in less advanced countries. It is not just a matter of investing more; where and how to invest in research are also important factors (European Commission, 2003). R&D policies should especially stimulate real scientific advance and not merely the production of a large number of publications.

The bulk of the research that is currently carried out in all countries can be categorized as "normal science," using Thomas Kuhn's term (Kuhn, 1970). In contrast, "revolutionary science" is a low proportion of the total output but produces the most important scientific advances. The capacity of institutions and countries to produce revolutionary science (Charlton, 2007a), as well as leadership in S&T (Shelton & Holdridge, 2004) has been estimated from the statistics of Nobel Prizes awarded. Although other international awards can also be used as a metric (Charlton, 2007b, 2007c), Nobel Prizes are the gold standard of quality in scientific achievement in the fields where they are awarded (Shelton & Holdridge, 2004). Using the criterion of the number of Nobel Prizes awarded, few countries carry out much research that produces real advances in scientific and technological knowledge because only 10 countries have obtained almost 90% of all Nobel Prizes in physics, chemistry, and medicine. Furthermore, despite the interest that research has received in the last quarter of the 20th century as a means of boosting national economies, very few countries have joined the club of countries that have won Nobel Prizes in the sciences in that period. This observation exemplifies the difficulties that countries lagging in S&T face to catch up with the leaders.

Research and Universities in Spain

The case of Spain is interesting and may illustrate the described problems. The Spanish GDP has a reasonable position in the world, which contrasts with the absence of Nobel Prize awards in the sciences, with the lone exception of the 1906 Nobel Prize in Medicine. However, this absence is consistent with some economic indicators related to R&D, which are weaker than expected. External deficit, world market

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share of exports of high-technology products, and technology balance of payment receipts in relation to GDP (European Commission, 2007) all suggest that the capacity of Spain to innovate is low and that the R&D system is probably weak. The low number of triadic patents (inventions patented in the European Patent Office, the US Patent and Trademark Office, and the Japanese Patent Office) in relation to R&D expenditure (Baudry & Dumont, 2006) also supports the inference drawn from economic parameters. In contrast, several conventional indicators of scientific output suggest a better performance of the R&D system. For example, if the number of published papers is normalized by public expenditure on R&D (relative to GDP) and country population, the Spanish parameter is close to those of France or Germany although far from that of Switzerland (European Commission, 2007). Similarly, Spain ranks ninth among the countries with the highest number of scientific publications, eleventh among the countries with the highest number of citations, and twelfth considering its share of the top 1% of highly cited publications (ISI Web of Knowledge, Essential Science Indicators; King, 2004) ahead of Belgium, Denmark, and Austria, which are Nobel-prize winners in the sciences.

Taken together, the data above imply the paradox that competitive research as revealed by some bibliometric indicators does not generate Nobel Prizes winners and produces scarce socioeconomic benefits. From another perspective, the paradox could arise if, in certain countries, the number of scientific publications or citations to them may not accurately reflect the research activity that produces real innovations and socio-economic benefits.

To understand the apparent Spanish paradox it is necessary to consider that there are many different ways to carry out research. In the best-case scenario, research is innovative and imaginative, aimed at producing important extensions or solving important scientific puzzles within existing paradigms. In the worst-case scenario, research comprises mere repeat studies of something that has been previously found by imaginative researchers, or addresses irrelevant problems. Scientists involved in imaginative research have a low, but appreciable, probability of producing a significant scientific breakthrough or even of laying the foundations for a paradigm shift. In contrast, more routine research, or research addressing problems that are relevant only for a small group of researchers, deals with minor new ideas and is very unlikely to produce significant scientific or technological advances. Although there is no clear line separating imaginative and routine research trends, experienced scientists can distinguish between these trends by reading the publications of the groups involved. In contrast, in many cases, separating these two research trends by means of bibliometric analysis may be complex. In fact, routine research is likely to produce a higher number of papers than imaginative research because in imaginative research, the success is less likely. The greatest problem with routine research is that it may be attractive to scientists, especially when structural constraints limit production. This attraction occurs in Spanish universities where research is carried out with very little technical support. Thus, the ratio between non-academic employees and faculty members is 0.53, with low variability among universities (47,321 and 89,166 people, respectively, are reported by Ministerio de Ciencia e Innovación for 2005). Moreover, many of the non-academic employees are involved in student administration and tasks related to teaching. In contrast, in the Spanish National Research Council (Consejo Superior de Investigaciones Científicas, CSIC), which is the most important non-academic research institution in Spain, the equivalent ratio, between permanent researchers, and technical and administrative employees is 2.24 (2,444 and 5,471 people; CSIC, 2005 Annual Report).

Research and Governance in Spanish Universities

Another difficulty for countries in the process of developing competitive R&D systems is the consolidation of competitive universities. This achievement is necessary because universities are principal actors in countries' R&D systems (Etzkowitz, 1990; Etzkowitz & Leydesdorff, 2000) and again the case of Spain and its comparison to other countries can illustrate the difficulty. For example, the GDPs of Spain and Canada are very similar but regarding S&T the two countries are completely different. Canada, a science Nobel Prize winning country, has two or three universities ranked among the 50 best universities in the world, while in Spain, the two best universities rank around position 200, in both cases, depending on the year and the source of the ranking (*The Times, Higher Education Supplement*, or *Shanghai Jiao Tong University*). Furthermore, while Canada has 18 universities in the top 300 group, Spain has only three (*Shanghai Jiao Tong University*, 2008). Since 1979, when the first draft of a law for modernizing the Spanish university system was revealed (Rodríguez-Navarro, 1994), political promises for improving Spanish universities failed to deliver ranking improvements that bring at least one university to a high position. Working against the improvements, in Spanish universities, cronyism may overshadow scientific performance in the appointment of academics (Anon, 1998) and scholars from abroad may often not be welcome (Anon, 1998; Bosch, 1998; Ferrer, 2000). The latter behaviour has been very harmful for Spanish universities and the main obstacle for their improvement. Therefore, its historical causes are relevant for this study and perhaps a reference for other countries. It is worth observing that the spectacular research development in China has been supported by the return of overseas scholars (Zhou & Leydesdorff, 2006).

Historically, at least up to the late 1970s, Spanish faculties, schools, and colleges could be categorized as "research active" or "research inactive." Science and humanity faculties were typically research active, while engineering schools and faculties of law, medicine, veterinary science, pharmacy, etc. were research inactive. In the former, the faculty members had a full-time academic activity, including research, although most of the research was of little relevance. In the latter, most of the school or faculty members had their main activity outside the university, many in state administration but also in private firms. The main job for graduates from research active faculties was teaching. In contrast, graduates from research inactive schools and faculties carried out almost all the technical work that Spain needed: buildings, railroads, roads, industry, health, political consulting, etc. Therefore, the members of research inactive schools and faculties formed a politically influential collective, which could not be ignored when the first democratic Law of Universities was passed in 1983 (Ley, 1983).

The most remarkable characteristic of Spanish universities since the 1983 Law is a non-meritocratic autonomous self-governance, with a broad participation of students, non-academic employees, and research-inactive academics (Ley, 1983; Ley, 2001; Ley, 2007). In most universities, academics holding a PhD degree have a 51% quota in the election of the senate and rector, but many of these academics are research inactive. Probably as a consequence of this type of self-governance, Spanish universities have not been interested in the incorporation of external scholars, either coming from another national institution or from abroad (Anon, 1998; Bosch, 1998; Ferrer, 2000). Extensive appointment of internal candidates has occurred even though all university laws have limited the autonomy of universities in the appointments of permanent professors. The 1983 Law established appointment commissions in which the number of members of external universities was higher than the number of members of the university involved (Puigdomenech, 1986), but the procedure was not successful (Anon, 1989; Bosch, 1998; Ferrer, 200). Therefore, the 2001 Law established a national appointments commission that examined all candidates and awarded a small number of national entitlements. The 2007 Law has maintained the previous entitlements, but introduced a formal mechanism of evaluation.

Another consequence of the described self-governance characteristics of Spanish universities is the absence of institutional interest for improving research. Even the personal disposition of a particular rector to foster research would be at odds with the senate because important measures for improving research might negatively affect the status of research inactive professors. Furthermore, because many workers and students have limited influence in university governance, except for the election of the rector, this election is converted into a welfare negotiation in which many voters' demands are exclusively related to their daily needs. Therefore, independently of their personal aptitudes or capacities, rectors that are elected in Spanish universities have strong commitments to a large proportion of electors who are not competent researchers. The official position of rectors regarding research is revealed by an extensive report that was prepared to address the problems of the Spanish university system under the auspices of the Council of Rectors of Spanish universities in the year 2000 (Crue, 2000). In this 569-page report, research was discussed only in general terms without specific analyses of research outputs and omitting the most important problems. For example, it did not mention that most university professors do not have international publications or that they are of insignificant relevance. Especially important is that the report did not analyze the role of the research incentives in boosting research in universities, although they were crucial for research in Spanish universities when the report was prepared.

Research Incentives

To mitigate the lack of research incentives in universities, national incentives were introduced in 1989 through creation of a National Commission for the Evaluation of Research Activity (Comisión Nacional Evaluadora de la Actividad Investigadora, CNEAI; Real Decreto, 1989a). The CNEAI evaluates the research outputs of tenured professors of all ranks in the university. The evaluation, which is performed for 6-year periods, establishes a salary bonus for each period positively evaluated. The economic motivation for positive evaluations is low, equivalent to less than 3% of the average yearly salary of a tenured professor in the lowest category requiring a PhD degree (Jiménez-Contreras, Anegon, & López-Cozar, 2003). I find it interesting, for this study, that the CNEAI incentives were extended to the CSIC.

CNEAI evaluations are carried out by 11 committees: 1, mathematics and physics; 2, chemistry; 3, molecular biology; 4, biomedicine; 5, natural sciences; 6, engineering; 7, behavioral, social, and educational sciences; 8, economy; 9, law; 10, history and art; 11, philology. The evaluations by the first six committees, which are the only evaluations relevant for the purpose of the present study, have always been carried out by formal procedures using the number of published papers and journal titles as criteria.

Since the creation of the CNEAI, Spain has dramatically increased its bibliometric indicators (Jiménez-Contreras, Anegon, & López-Cozar, 2003). Possibly because of this success, several national and regional agencies to evaluate professors have been created following the CNEAI model, thus building an important system for formally evaluating R&D activities, which may have increased the CNEAI effect. However, the h indexes (Hirsch, 2005) of full professors in Spanish universities seem to be increasing more slowly than the total number of papers. Thus, low h indexes have been reported for microbiology and veterinary sciences (Imperial & Rodríguez-Navarro, 2007) and for neuroscientists in psychology faculties (Salgado & Paez, 2007).

Of relevance here, a notable characteristic of Spanish universities is that incentives for technical and artistic work (hereafter, technical services) may be much higher than incentives for research. In 1989 the Government ruled that tenured university faculty members could increase their salary by carrying out technical services for up to approximately four times the salary of a full-time professor dedicated to public research and teaching (Real Decreto, 1989b). According to calculations made in 1993, the maximum annual bonus that could be obtained at the end of academic life from the accumulation of five 6-year CNEAI periods by a full professor was about 14 times lower than the annual amount that could be obtained by any professor carrying out technical services the first year after obtaining tenure

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(Rodríguez-Navarro, 1994). In consequence, within university incomes, those from technical services are more important than those from patenting. A recent survey that covers most Spanish universities (Romo, Conesa, & Martínez, 2006) records 36 million euros of income for technical services and 1.7 million euros for patents in 2005. However, aggregate values from many universities provide only partial information because of the large variability of the figures among different universities. According to the income data of the universities in the Autonomous Community of Madrid (Ortega-Castro, Pérez-Esparrells, & Rahona-López, 2006), technical universities account for most of the technical services. In these universities, the income from services may be more than 100 times higher than the income from patents.

Research Questions

The central problem of this study is the contradiction that exists between, on the one hand, fairly high conventional bibliometric indicators: number of scientific publications or citations and share of top 1% most cited papers, and, on the other hand, the absence of Nobel Prize awards in the sciences, the low number triadic patents, and the low capacity of innovation in Spain. The fact that this contradiction does not exist in leading research countries raises questions about the existence of different ways of performing research. To tackle this problem, two previous considerations are necessary: that only a very small proportion of scientific publications report achievements of Nobel Prize level and that this proportion may vary substantially among countries. Moreover, conventional bibliometric indicators, including the 1% most cited papers, may be several orders of magnitude larger than the number of Nobel Prize level achievements. Therefore, only in countries in which the research activity is similarly efficient in generating important achievements will the bibliometric indicators based on the bulk of scientific publications reflect the research activity that generates Nobel Prize awards in the sciences. This condition is probably fulfilled by leading research countries, but not necessarily by other countries.

Important achievements do not have a simple metric, and, here, I study the use of the number of top-cited papers as an indicator. It has been claimed that top-cited papers and important achievements are not equivalent concepts (Anon, 2009). However, this is not critical as long as the metric of top-cited papers is a better indicator of important achievements than other bibliometric indicators. Therefore, first, I tackle the problem of the apparent paradox of Spanish research by comparing the production of top-cited papers in Spain and in leading research countries. This comparison allows to test this approach and simultaneously to study the problem. Second, I study whether the apparent paradox of Spanish research is caused by specific characteristics of research in Spanish universities. The two concrete questions of this study are the following:

- Is the apparent paradox of high bibliometric indicators but low triadic patents and Nobel prizes of Spanish research explained by a low number of important achievements among a high number of total publications?
- Can the above-mentioned apparent paradox of Spanish research be the consequence of the Spanish system of formal evaluations of research?

To answer the first question, I made several types of searches in the database of the ISI Web of Knowledge as described below. Remarkably, my counts are much smaller than conventional bibliometric indicators. For example, in Table 3, I selected the 100 top-cited national papers in each of the fields of chemistry, physics, engineering, and biology and biochemistry from a total of 1,147,180; 895,430; 767,549; and 565,450 papers, respectively. For the second question, I discuss the historical constraints that have hampered research in Spanish university and the corrective research policies that have resulted in the current massive use of formal evaluations. Finally, I discuss whether risk-averse research trends in Spain can be the cause of the particular characteristics of the Spanish research performance.

Bibliometric Methods

The Web of Science database and the Essential Science Indicators from Thomson's ISI Web of Knowledge were used throughout this study. To retrieve the publications of a certain country (field tag, CU=), I used the name of that country, for example, Spain. To retrieve national papers, the name of that country was joined by the Boolean Operator NOT to the 14 countries most active in research (King, 2004), except the country involved. A similar procedure was followed for retrieving the publications of a certain organization (field tag, OG=), but to exclude other organizations I identified them as suborganizations (field tag, SG=). When necessary, the retrieved publications were sorted by the number of citations. All searches were carried out in February and March 2008, except for those carried out in the Essential Science Indicators section and those needed to prepare Fig. 1 (see below).

For Table 2, the lists of publications for the 3 years 1999, 2000, and 2001 were sorted by number of citations. These years were selected to match the year of the study of Baudry & Dumont (2006) about triadic patents (Table 1). In these lists, starting from the top, I identified publications in journals included in any category related to chemistry or physics in the lists of the Journal Citation Reports. Publications in multidisciplinary journals (i.e. *Nature, Science*, and *Proceedings of the National Academy of Sciences USA*) were, after reading the Abstracts, categorized into chemistry, physics, or ignored. To eliminate review papers, I firstly deleted the papers published in well-known review journals. Next, I considered the "Document Type" recorded in the database, but occasionally used my own categorization after reading the abstract. I found a short number of discrepancies, but even in the case of mistakes, they are unlikely to have any effect on the results. For MIT and Caltech, because of the small size of these institutions comparable to Spain, I recorded publications exclusively from these institutions and publications in collaboration with other U.S. institutions if at

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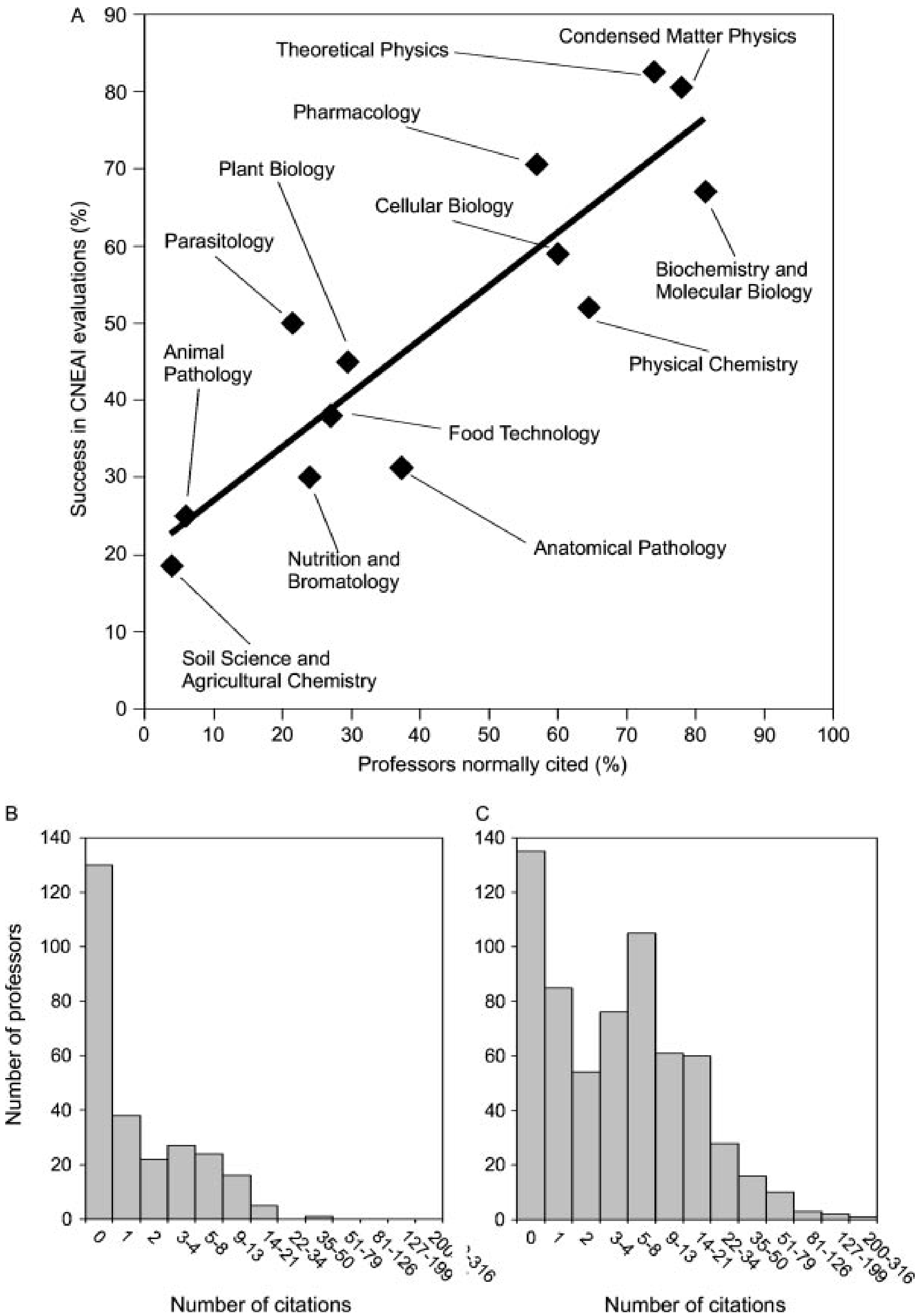

FIG. 1. Correlation between citations received by professors of Spanish universities and their success in CNEAI evaluations.
(A) Professors that obtained positive evaluations in the populations of tenured professors assigned to a field of knowledge, expressed as a percentage of the population, versus the percentage of that population that was normally cited. For the calculation of the latter percentage, I used the citation distributions in the different fields of knowledge, which can be described by the sum of a normal (binomial) distribution and a Poisson distribution of very low mean. The percentage of the population recorded on the abscissa in plot A corresponds to the population in the normal distribution, without considering the number of citations (Bibliometric methods). (B) Example of a field of knowledge (plant biology), in which most of the population is not cited and the Poisson population is larger than the normal population. (C) Example of fields of knowledge (biochemistry, molecular biology, and pharmacology), in which most of the population is cited and the normal population is larger than the Poisson population. In B and C, citation frequency distribution of tenured professors of all ranks in the corresponding fields; data have been grouped in intervals that are proportional to the transformation log (N + 1), where N is the number of citations.

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TABLE 1. Number of publications in scientific journals and triadic patents, and their ratio in OECD countries.

Country	Publications	Triadic patents[a]	Ratio
Japan	79,966	11,757	7
Germany	81,184	5,777	14
USA	252,503	14,985	17
Finland	8,622	489	18
Sweden	17,275	811	21
Switzerland	16,606	753	22
France	56,948	2,127	27
The Netherlands	23,677	857	28
Austria	8,529	274	31
South Korea	14,819	478	31
Belgium	12,050	359	34
Denmark	9,858	254	39
Italy	37,610	767	49
Norway	5,747	109	53
UK	112,386	1,794	63
Australia	26,882	321	84
Canada	44,815	519	86
Iceland	387	4	98
Ireland	5,916	45	131
Hungary	4,856	33	147
New Zealand	5,489	36	152
Spain	25,880	113	229
Slovak Republic	1,120	4	280
Portugal	3,601	8	450
Mexico	7,718	15	514
Czech Republic	4,820	9	535
Greece	5,736	6	956
Turkey	6,259	6	1,043
Poland	10,576	10	1,058

Note. Year 2000

[a]Taken from "Comparing Firms' Triadic Patent Applications Across Countries: Is There a Gap in Terms of R&D Effort or a Gap in Terms of Performances?" by M., Baudry & B. Dumont, Research Policy, 35, 324–342, 2006.

TABLE 2. Number of citations of the most cited publications, and mean number of citations of the top five most cited publications in Chemistry or Physics in the recorded countries and institutes in 1999–2001.[a]

	1999		2000		2001	
Country or Institute	1st	top-5 mean	1st	top-5 mean	1st	top-5 mean
Spain[b]	307	217	189	167	180	159
South Korea[b]	854	463	853	317	283	214
Switzerland[c]	952	459	656	367	411	298
MIT[d]	2,661	1,374	596	455	666	457
Caltech[d]	710	551	1,292	608	350	209

[a]Papers in all journals that are classified in any of the chemistry of physics fields in the Journal of Citation Reports and papers in multidisciplinary journals dealing with chemical or physical-related problems; review papers were not included.
[b]National papers, all the author addresses in this country.
[c]National papers; papers with CERN participation were not included.
[d]National papers in which at least 50% of the authors belong to the institution.

least 50% of the authors belonged to MIT or Caltech. Biology and biomedicine were not included in Table 2 because publications in these fields are difficult to distinguish from clinical publications from hospitals and National Health institutes, which I decided not to include in the present study.

Top-cited papers were also identified in the Essential Science Indicators of the ISI Web of Knowledge on January 2009. On January 1, 2009, the database was updated to include data from January 1, 1998, to October 31, 2008. The database identifies "Highly Cited Papers" (the most cited 1% by field and year of publication) and provides lists of publications sorted by research fields or by countries and research fields. To obtain the data reported in Table 3, I sorted the "Highly Cited Papers" in the fields of chemistry, physics, engineering, and biology, and biochemistry by the number of citations and identified the 100 most cited national papers in each field, i.e., in which all the authors belonged to the same country. Then, I counted the number of papers of the compared countries in the lists of the 100 most cited national papers. Because these 100 most cited national papers were published in a 10-year period, papers published in the first years of the period had a longer time to be cited and a higher probability to appear in the list. However, papers in the upper part of the lists in chemistry, physics, and biology and biochemistry received 500–1,000 citations per year, while those in the lower part received 100–150. In the field of engineering, figures were approximately one half of the corresponding ones in the other three fields. This observation suggest that the exclusion of really top-cited papers from the lists of the 100 most cited national papers in each field is reduced to papers of 2007 and 2008. More important, this publication-year dependence of the top 100 most cited papers is not a problem for this study because it applies to all countries used for the comparison. As in Table 2, for MIT and Caltech, Table 3 records publications exclusively from these institutions and publications in collaboration with other U.S. institutions if at least 50% of the authors belonged to MIT or Caltech.

For Tables 4, 5, and 6, the identification of universities in the Thomson databases presents several technical problems that have been discussed elsewhere (van Raan, 2005). In addition, some publications from Engineering Schools, especially in the Polytechnic University of Madrid (UPM), omit the name of the university. Therefore, the names of the schools were also used in the searches. Another problem is the presence of CSIC institutes in university campuses. These institutes are independent from the university, but the name of the university appears as their postal addresses and, therefore, publications of these institutes are retrieved in the searches as publications of the university. This problem does not have a general solution because many university departments maintain scientific collaborations with CSIC institutes and the deletion of all collaborative papers may have an important effect on the apparent production of the university. In the case of the Polytechnic University of Valencia (UPV; Tables 6 and 7), there is a very active CSIC institute for chemistry on the university campus. Therefore, I present two types of data, either maintaining or deleting the publications with "CSIC" in the address field. Differences do not affect the conclusions of the present study,

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TABLE 3. Total number of publications and number of them in the top 100 most cited national publications in the fields of chemistry, physics, engineering, and biology and biochemistry of the recorded countries and institutes in the last 10 years.[a]

Country or institute	Chemistry		Physics		Engineering		Biology & biochemistry	
	Total	in top 100	Total	in top 100	Total	in top 100	Total	in top 100
Germany	98,801	7	103,195	4	45,932	2	45,334	9
France	67,516	4	73,210	3	37,721	1	35,543	1
Canada	32,961	1	24,893	2	33,362	4	26,849	1
Spain	44,904	0	28,935	0	20,738	0	16,040	0
South Korea	33,240	1	34,157	2	29,376	1	13,003	0
Switzerland	18,491	4	21,833	1	10,287	3	10,736	1
The Netherlands	19,267	5	17,128	3	13,547	1	12,483	2
MIT[b]	3,781	3	7,959	3	4,549	1	2,040	0
Caltech[b]	2,156	4	4,396	1	1,889	1	953	0

[a]The last 10 years is the recording period of the Highly Cited Papers, ISI Web of Knowledge (see Bibliometric methods). In top 100 most cited national papers, all author addresses in the same country.
[b]National papers in which at least 50% of the authors belong to the institution.

TABLE 4. Spanish national papers and Spanish national papers published in *Nature* or *Science* between 1983 and 2007.

Year	Total	*Nature* or *Science*		Ratio of total to all *Nature* and *Science* papers
		All types	articles	
1983	5,610	3	0	1,870
1984	6,038	3	2	2,013
1985	6,724	3	2	2,241
1990	9,437	5	2	1,887
2000	19,378	15	4	1,292
2003	23,052	10	1	2,305
2004	25,086	13	7	1,930
2005	26,834	14	1	1,917
2006	29,597	13	8	2,277
2007	28,551	16	7	1,784

but counting CSIC papers as UPV papers may lead to erroneous conclusions if the UPV is compared with other universities. A similar problem, but involving many more CSIC institutes, did not allow us to include the Autonomous University of Madrid in this study. However, the inclusion of the Autonomous University of Madrid in Table 5 would have been appropriate because this university and the University of Barcelona are the best Spanish universities, both ranking around position 200 in world university rankings (*The Times, Higher Education Supplement*, or *Shanghai Jiao Tong University*). Regrettably, I did not find a search procedure to solve this problem. The Complutense University of Madrid, included in Table 5, is the top third Spanish university in the six editions of the *Academic Ranking of World Universities* of the *Shanghai Jiao Tong University* (http://www.arwu.org/rank2008/EN2008.htm), placed in the 200–300 interval. The ranking of the *Shanghai Jiao Tong University* provides an indicator of the number of articles indexed in Science Citation Index-expanded and Social Citation Index. According to this indicator, the University of Barcelona and Complutense University of Madrid are the two most active Spanish universities in publication. Three other Spanish universities are placed in the 400–500 interval of the *Shanghai Jiao Tong University* ranking, all with lower publication indicators than the universities of Barcelona and Complutense of Madrid. It is unlikely that Spanish

TABLE 5. Score on SCI in the university ranking of the Shanghai Jiao Tong University, number of publications and citations, *h* index, and number of publications with more citations than the University of Harvard *h* index of two research active Spanish universities, CSIC, and selected elite universities.

University	Score on SCI Shanghai JTU[a]	Publications	Citations	Citations per publication	*h* index	Publications ≥209 citations
U Barcelona	49	2,008	35,342	17.6	70	8
U Complutense Madrid	41	1,648	21,342	12.9	57	7
CSIC	n.i.[b]	4,304	76,199	17.7	86	12
U Harvard	100	10,885	361,382	33.2	209	209
U Tokyo	91	8,330	137,340	16.5	121	47
U Toronto	76	5,962	115,879	19.4	126	63
U Cambridge	69	5,432	108,675	20.0	126	67
U Oxford	66	5,183	106,943	20.6	123	66

Note. Publications in all research fields in 2000. SCI indicates Science Citation Index; CSIC, Consejo Superior de Investigaciones Científicas.
[a]Academic Ranking of World Universities, Shanghai Jiao Tong University, 2003 edition. Score based on articles cited in Science Citation Index-expanded, and Social Science Citation Index.
[b]Not included in the ranking.

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TABLE 6. Number of publications, citations, and *h* indexes of Spanish Polytechnic and general universities.

University	Professors[a]	Publications	Citations	*h* index
UPC	2,305	1,683	13,862	39
UPM	3,325	1,301	9,018	32
UPV	2,163	1,211	12,227	42
UPV w/o CSIC[b]	2,163	910	5,982	28
U of Barcelona	4,184	6,994	99,548	89

Note. Publications in all research fields in the time span of 2000–2002. UPC indicates Polytechnic University of Catalonia; UPM, Polytechnic University of Madrid; UPV, Polytechnic University of Valencia; CSIC, Consejo Superior de Investigaciones Científicas.

[a]Year 2000.

[b]The reasons for eliminating publications in which the CSIC appears in the address are explained in bibliometric methods section.

universities excluded from the *Shanghai Jiao Tong University* ranking are more active in research publication than the universities of Barcelona and Complutense of Madrid, because in the absence of alumni awarded with Nobel Prizes or Fields Medals, which is the case of Spanish universities, the maximum weight for the ranking is from research publications.

For Table 7, I used a set of 120 journals in chemistry, and 160 journals in physics, selected from the Subject Category lists of the *Journal Citation Reports* (JCR). To select the two sets of journals, which each represent around 25% of all journals in the corresponding research fields, I first selected categories with the words Chemistry (or chemical) or physics in their titles. Then, in each category, the journals were sorted by impact factor and the 25% top journals, approximately, were selected. Because the aim of this study was to identify the most highly cited papers, I selected more journals from the lists with journals of the highest impact factors.

For Figure 1, the names of the university professors were obtained from the lists by fields of knowledge of the *Consejo Nacional de Universidades*, 1994. These lists include all permanent professors in each field of knowledge and were used by the *Consejo Nacional de Universidades* for the random selection of members of appointment commissions, as I explain below. For each professor, I identified all publications and the corresponding citations up to the search year, 1994. Professors with common Spanish surnames were not included in the study because the same name in the database may correspond to several persons who cannot be identified independently by a simple procedure. From the list of professors and citations, frequency distributions of professors according to citation intervals were constructed for each field. Frequency distributions in each field could be fitted to the sum of a Poisson distribution with a very low mean plus a normal distribution (Rodríguez-Navarro, 1994). In Figure 1A, the percentage of the population that is in the normal distribution is plotted. For this calculation, I assumed that all professors with three to four citations or more were in the normal distribution (Figures 1B and 1C). This assumption allowed me to complete the normal distribution and calculate the number of professors in it. Because of the omission of professors with common surnames the abscissa values in Figure 1A correspond to samples including approximately 60% of the whole population. These samples can be considered to be random because it seems unlikely that common surnames correlate with a lower or higher scientific activity. Ordinate values correspond to the percentage of success for 6-year evaluations in each field. This percentage was calculated by dividing the number of professors with positive evaluations by the total number of professors in each field.

Results

Spanish research has distinctive features.

Spanish Research Outputs

The apparent paradox of Spanish research can be simply described by the high ratio between scientific publications and triadic patents. According to this ratio, Spain ranks 22nd among the 30 OECD countries (Table 1). Although a low number of triadic patents can have several structural causes: that high ratio raises the possibility that the proportion of innovative publications may be low.

To investigate this possibility, I studied the production of top-cited publications by Spanish researchers. For that purpose, I identified the five most cited publications (reviews were not considered) in chemistry and physics that were authored exclusively by researchers from Spain (national papers; the reasons for excluding international papers are discussed below) in each year from a series of three. As a

TABLE 7. Number of publications, citations and *h* indexes of Spanish polytechnic and general universities in selected journals in chemistry or physics (time span 2000–2002).

	Chemistry			Physics		
University	Publications	Citations	*h* index	Publications	Citations	*h* index
UPC	85	741	14	945	10,996	41
UPM	19	258	11	858	8,818	39
UPV	176	3,436	31	481	4,746	31
UPV w/o CSIC[a]	69	1,287	22	–	–	–
U Barcelona	430	9,160	42	3,639	51,474	71

Note. UPC indicates Polytechnic University of Catalonia; UPM, Polytechnic University of Madrid; UPV, Polytechnic University of Valencia.

[a]The reasons for eliminating the publications in the field of chemistry in which the CSIC appears in the address are explained in bibliometric methods section.

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comparative reference, I carried out similar identifications for South Korea and Switzerland. South Korea was selected because it started developing an efficient research system more recently than Spain (see below) and Switzerland because it has an efficient research system and its investment in R&D is smaller than that of Spain (Baudry & Dumont, 2006). I also identified the five most cited publications from two elite research institutions, MIT and Caltech (bibliometric methods). The results show that Spanish research in chemistry and physics does not participate in the production of the most cited papers (Table 2). For instance, in the year 2000, Spanish researchers published one paper that received 189 citations (up to March 2008), but one paper from South Korea received 853 citations and one from Caltech received 1,292 citations. Focusing on top-cited publications South Korea was more competitive than Spain and as competitive as Switzerland in research in chemistry and physics.

The capacity of Spanish research to produce top-cited papers was also assessed from the Essential Science Indicators of the Thomson Web of Science. This database identifies "Highly Cited Papers" (the most cited 1% by field and year of publication) in the last 10 years. By using the Citation Rankings by Countries, I found that the number of "Highly Cited Papers" recorded for Spain was lower than for scientific advanced countries. For example, the percentage of "Highly Cited Papers" (over the total number of papers) in all fields was 0.87% for Spain, 2.2% for Switzerland, and 1.3% for Germany. However, these figures provide very little information because most of the Spanish "Highly Cited Papers" were international papers, in which many of the number of Spanish researchers was very low. In several fields, physics, clinical medicine, immunology, neuroscience and behaviour, and molecular biology, approximately 80%–90% of the Spanish publications were international. In the other fields, the proportion decreased to 50%–65%. The fields of chemistry and agricultural sciences were exceptions because international papers were only approximately 35%. The proportion of international papers in the whole production of Spain was approximately 25%. In all countries, the proportion of international papers in "Highly Cited Papers" was higher than the corresponding proportion for the whole production. However, the difference between the two proportions in leading research countries was much lower than in Spain. More important, as a general rule with very few exceptions, when papers in a field were sorted by publication year and number of citations, the first Spanish paper, which was normally an international paper, was far from being top cited, and the first Spanish national paper ranked much lower than the first Spanish international paper.

For a better quantification of these observations, I identified the 100 most cited national papers (all authors from the same country) in the fields of chemistry, physics, engineering, and biology and biochemistry, which are important scientific fields that account for a large proportion of the papers of all countries. In the list of the 100 most cited national papers in each field, the papers from different countries and institutions can be counted. The purpose was to compare Spain with Nobel Prize winning countries and with South Korea. I selected three countries producing more R&D publications than Spain—Germany, France, and Canada—and three producing less than Spain—The Netherlands, Switzerland, and South Korea. MIT and Caltech were included, as in Table 2, as an example of elite research institutions. The results summarized in Table 3 were conclusive: Spain was the only country with zero papers in all fields. South Korea, MIT, and Caltech failed in the field of biology and biochemistry, but not in the other three fields. Two important considerations are necessary for interpreting the absence of Spanish publications from the lists of the 100 most cited national papers. The first relates to the large differences in citations per year that exist among papers in the upper and lower parts of the lists, which indicates that the lists exclude few top-cited papers (bibliometric methods). The second is that although papers from large countries with large R&D investments were much more abundant than papers from small countries, many papers from small countries were present in top positions: the most cited national paper in chemistry is from The Netherlands, and the third from Switzerland; the first in physics is from Austria and the tenth from The Netherlands; the seventh in engineering is from Finland; the fifth in biology and biochemistry is from Israel. The data in Table 3 and these considerations confirm the conclusions drawn from the analysis of the data in Table 2 regarding the low performance of Spain in producing top-cited papers, including the better performance of South Korea.

During the study of the Spanish "Highly Cited Papers," which covered 10 years, I did not detect a significant increase in the number of the highly cited papers in recent years. This observation suggested that the quality of research might not be changing in recent years. To further address this issue, I studied the number of Spanish national papers published in the highly selective journals *Nature* and *Science*. Regarding the number of national publications of all types, i.e., letter, editorial comments, articles, etc., which probably reflect the overall scientific activity of high level, the annual ratio between the total number of papers published anywhere and those in *Nature* and *Science* has remained constant in the last 25 years (Table 4). In publications classified as "articles," the variability was very high, probably because numbers were very low. However, in 24 years the proportion of the number of articles in *Nature* and *Science* with reference to the total number of papers published anywhere did not show any significant increase.

Research in Universities

The research publication activity in Spanish universities is weaker than in the top universities of leading countries in science. The two Spanish universities with the highest research publication activity in the *Academic Ranking of World Universities* of the *Shanghai Jiao Tong University* (see bibliometric methods), University of Barcelona and Complutense University of Madrid, do not match the publication activity of the world's elite universities. However, there are important differences depending on the selected indicator (Table 5). Excluding the University of Harvard, the conventional bibliometric indicators of the University of Barcelona, number of publications and citations, are only three times lower than those in the other four elite universities, and the number of citations per publication is only slightly lower (<10%) than the mean of the four elite universities. All this is consistent with the notion discussed above, which supports that research in Spain produces sound papers that are reasonably cited. Larger differences in research performance are suggested by the differences in the h index (Hirsch, 2005), but their appreciation is more difficult. Therefore, the last column in Table 5 records the number of publications with more citations than the h index of the University of Harvard for the papers in the year 2000. Although this number is not very high, 209, only eight papers of the University of Barcelona and seven in the Complutense University of Madrid reached it, comparable to 47–67 papers in the four elite universities. Moreover, consistent with the notion that most top-cited papers in Spain are international, only 2 of the 15 papers of the University of Barcelona and Complutense University of Madrid with 209 or more citations, one in each university, were national papers. Remarkably, even the CSIC, which is the Spanish institution specifically devoted to research, shows notable differences with elite universities. Once again, maximum differences are observed in bibliometric indicators that detect the number of highly cited papers, for example, only 12 papers have 209 or more citations.

As a general rule, publication activity in technical universities in Spain is less active than in general universities. Currently, the situation of technical universities represents a crucial problem for Spain, because, on one hand, they have more connections with industry than general universities, but, on the other hand, they seem to carry out very little internationally competitive research.

To characterize the research activity in technical schools, I selected the three oldest and foremost polytechnic universities in Spain: the Polytechnic Universities of Catalonia (UPC), Madrid (UPM), and Valencia (UPV). They were created by joining old engineering schools that were originally founded as independent schools. Newer engineering schools in Spain were created following the model of the old ones and are mostly staffed by professors trained in the three selected universities. A comparison of scientific bibliometric indicators between these three technical universities and general universities reveals the problem.

Table 6 records the total number of scientific papers, citations to these papers, and h indexes over a time span of 3 years in the three technical universities, UPC, UPM, and UPV, and the University of Barcelona. Data from 3 years, 2000–2002, were aggregated to show higher and more representative figures than those of a single year. Differences in the results for the University of Barcelona and the technical universities are dramatic. The number of papers in technical universities was five times lower and the number of citations was almost 10 times lower. However, these figures might be misleading because Spanish technical universities are usually not involved in biomedical and biological research, which is the field of research with the highest number of citations. Therefore, I performed a second study using a collection of 120 chemistry and 160 physics journals (Table 7). Again, the superiority of research publication in the University of Barcelona is clear. In physics, the differences are less dramatic than in chemistry but they are still very important, and the conclusions that can be drawn from data summarized in Tables 6 and 7 are entirely consistent. The number of faculty members of the University of Barcelona, was higher than that for the technical universities (Table 6). However, regarding the number of researchers in S&T, it is worth observing that the University of Barcelona covers art, humanities, and social sciences as well as S&T. Therefore, the number of academics of the University of Barcelona working in S&T might not be very different from that in technical universities, and only a very low research activity can explain the low bibliometric indicators of technical universities in Spain.

CNEAI Evaluations

An important question regarding the effect of the CNEAI evaluations relates to the formal requirements for positive evaluations in science and technology (committees 1–6). To answer this question two periods can be distinguished. The first period started in 1990 and lasted 8 or 10 years. Positive evaluations in this period were awarded to researchers who showed a minimal capacity to publish papers in international journals. This requirement could be demonstrated empirically because, since 1985, all university professors belong to one of a series of fields of knowledge in which research activities are very different. The assignment of professors to fields of knowledge was necessary for the random selection of external members of the aforementioned university tenure appointing commissions (Puigdomenech, 1986). In any of these fields, the distribution of the frequencies of the number of scientific citations obtained by its members fitted to the sum of a normal distribution and a Poisson distribution with a very low mean (Figures 1B and 1C show the distributions in two fields with different research activities). Most of the professors in the Poisson distribution had no citations and had never published a paper in an international journal.

To test the level of the CNEAI requirements, I compared the percentage of the population with positive CNEAI evaluations with the percentage of the population in the normal distribution. In this test, a low percentage of positive CNEAI evaluations comparable to the percentage of the normally cited population would indicate that positive CNEAI evaluations required cited papers with a certain level of excellence. On the contrary, a percentage of success significantly higher than the normally cited population would indicate that not cited professors obtained positive evaluations from criteria different from international publications. By plotting the percentage of the population in the normal distribution versus the percentage of success in the evaluations in each field, I found that the two percentages were very similar and showed a fairly high correlation (Figure 1A). The plot shows that the regression line cuts the y-axis at 20%. This small deviation suggests that criteria in the less competitive fields, soil science or animal pathology, were less strict, but the statistical significance of the deviation was not tested. Aside from these exceptions, the test demonstrated that positive CNEAI evaluations in the first period were awarded to professors publishing papers in international journals, even if the papers received a very low number of citations.

In the second period, the CNEAI has required some publications in journals situated in the upper third of the ISI journal listing by subject category sorted by impact factor. The starting year of this period is not clear. It was after 1997 (the author was the General Coordinator of the CNEAI from 1993 to 1997) and before 2002 when the new requirement of the CNEAI was first reported (Jiménez-Contreras, López-Cozar, Ruiz-Pérez, & Fernández, 2002). In 2005, the requirement was legally ruled (Resolución, 2005a). In that year, similar requirements based on the journal impact factors were also applied in other scientific programs (Resolución, 2005b).

Discussion and Conclusion

The Spanish R&D system might be characterized by the absence of Nobel Prize awards. However, these awards are low frequency events, whose significance is difficult to assess, and other indicators are necessary to characterize the R&D systems of most countries. The high ratio between the number of scientific publications and triadic patents in Spain (Table 1) leads directly to a typical characterization of the Spanish R&D system: an acceptable performance of the public system but a low private investment in R&D. Another usual characterization is that the public R&D system in Spain is more interested in science than in technology. However, characterizations of this type are based on the comparison of two dissimilar parameters, patents and publications, which are difficult to compare because both indicators have specific problems. The former is a progress indicator, but that may be affected by different patenting cultures, and the latter might be an academic output involving routine research and little scientific progress. Therefore, the first part of this report was aimed at determining the capacity of Spain for producing top-cited national publications comparable to leading research countries.

Two approaches for the estimation of top-cited national papers (Tables 2 and 3) coincided in showing an almost complete absence of Spanish national papers that are top ranking among highly cited papers. Furthermore, the metric of top-cited national papers indicate that South Korea is ahead of Spain in research performance as suggested by triadic patent metric (Baundry & Dumont, 2006) but not by the total number of papers or citations or the metric of top 1% most cited papers (King, 2004). Spain and South Korea are interesting cases because they are atypical countries when compared to leading research countries, in that a strong growth of scientific production has taken place in the last 15–20 years (Jiménez-Contreras, Anegon, & López-Cozar, 2003; Zou & Leydesdorff, 2006). In these two countries, the number of top-cited national papers correlates better than other bibliometric indicators with the number of triadic patents. Furthermore, the better performance of South Korea in Tables 2 and 3 suggests that the low Spanish performance in highly cited papers is not the consequence of the recent development of its R&D system.

In summary, in answer to the first research question, the metric of top-cited national papers indicates that, comparable to scientific advanced countries, conventional bibliometric indicators overestimate the capacity of the Spanish R&D system to produce important achievements. This overestimation is, in part, due to international papers, which count for all participant countries without differentiating between research leaders and other participants. In addition, conventional bibliometric indicators may not estimate correctly the number of important achievements when the number of sound papers is high. The issue is that only important achievements receive Nobel Prize awards. Furthermore, their number may be a more important determinant of the innovative capacity of a country than the number of sound papers.

An interesting result of the present study was the finding of a constant ratio between the total number of Spanish national papers and the number of Spanish national papers in *Nature* and *Science* during the last 25 years (Table 4). I do not propose the use of *Nature* and *Science* papers as a metric, but the finding may be significant. It should be taken into account that in parallel with the use of the impact factor for evaluation in Spain, papers in *Nature* and *Science* have been glorified, and many Spanish researchers may have followed research and publication trends that increase the probability of publishing in these journals as discussed by Cameron (2005). Considering these possible trends and the high level of the papers published in *Nature* and *Science*, the data in Table 4 suggest that the quality of science has not improved in Spain during the last 25 years.

Research Policies can Generate Risk-Averse Research Trends and Scientific Stagnation

If the Spanish R&D system produces an abnormally low number of important achievements with reference to the number of sound papers, the interesting question is what may be the cause for this research trend. Spain is different from leading research countries in the economical and technical support provided to research. However, it is not clear how these conditions could decrease the production of highly innovative research but not the publication of sound papers in the most rigorous journals. A possible explanation for this research trend could be that many Spanish researchers carry out routine research and do not address important questions in the frontier of knowledge. If this were the case, the causes might be more dependent on the research culture originated by research evaluations than on economical and technical restraints.

As a general rule, Spanish universities do not evaluate research carried out by their staff or provided research

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incentives. In this scenario, positive evaluations by the CNEAI have become the gold medal awards for research in Spain and were, in fact, crucial for boosting research in the country. The CNEAI was an excellent idea for increasing the number of international publications (Jiménez-Contreras, Anegon, & López-Cozar, 2003), and its evaluation methods in its first period (Figure 1) were directly designated for this purpose but not for encouraging important achievements. This encouragement needs other methods. The requirement of a certain number of publications in top journals in the lists of journals sorted by impact factors (Subject Category Selection, Journal Citations Reports, ISI Web of Knowledge) was probably aimed to that encouragement. However, as already discussed, there is no empirical evidence suggesting that the performance of the Spanish R&D system is increasing in terms of producing important achievements. Probably, the method has increased the number of sound papers published in high impact factor journals (Jiménez-Contreras, López-Cozar, Ruiz-Pérez, & Fernández, 2002) but not the number of top-cited papers. Since the seminal paper by Seglen (1997), it is well known that journal impact factors do not allow us to predict the number of citations that each paper the journal publishes will receive and the use of this procedure for evaluating research has been extensively criticized (see, for example, Cameron, 2005). It can be assumed that the procedure cannot be better for stimulating research through research incentives than for evaluating research. In addition to other problems, the procedure might have extended the idea that a publication in a high-impact factor journal is the most valuable goal that can be accomplished, without any other consideration regarding the scientific or technical value of the research.

In general terms, and perhaps in all countries, there is a permanent risk that imaginative and innovative research will decrease. Revolutionary science is riskier than normal science because success is less likely (Charlton & Andras, 2005; Charlton, 2008), but the abuse of formal evaluations makes imaginative normal research also risky. Imaginative research is not highly productive in terms of number of papers, especially in Spanish universities, where technical support for research is low. Under these conditions, the opportunity cost of imaginative research may be unacceptable for some researchers. Probably all types of formal evaluations fail to encourage important achievements. A bad method may be simple publication counts, as discussed for Australia (Butler, 2003), but the use of the impact factors of the journals as in Finland (Adam, 2002) or Spain might not be better. More complex methods may also fail and it has been argued that the efforts to increase the RAE score in the United Kingdom "over a couple of decades will rid universities of potential Nobel Prize winners" (Colquhoun, 2007).

University Changes are Needed

Spain has been increasing its investments in R&D substantially during the last 10 years. In the middle of this period, Spanish investments in R&D, in monetary units, were not very different from those in The Netherlands and higher than in Switzerland. In 2006, Spanish investments were higher than in any of these countries (Baudry & Dumont, 2006; European Commission, 2005, 2006, 2008). Significantly, in the last 10 years, Spain has published a larger number of scientific papers than The Netherlands or Switzerland (25% and 75%, respectively; Essential Science Indicators). However, these countries outperform Spain in terms of number of Nobel Prize awards in the sciences, triadic patents, or top-cited national papers (Table 3). Even assuming that formal evaluations of research were the most important direct cause of this low research performance, they cannot be eliminated without considering that CNEAI evaluations were determinant for raising the level of university research and that the process is not finished.

In the six editions (2003-2008) of the *Academic Ranking of World Universities* of the *Shanghai Jiao Tong University* (http://www.arwu.org/rank2008/EN2008.htm), the University of Barcelona is the first Spanish university in the ranking, placed in the 150–200 interval, and the Complutense University of Madrid ranks third, placed in the 200–300 interval. Considering these leading positions and the ranking methodology, these two universities can be considered the most research active in Spain (see Bibliometric methods). Therefore, data in Table 5 present the top of research in Spanish universities, and it is clear that even for these two universities, further research improvements are necessary. Polytechnic universities deserve especial attention because these universities are the foundation of knowledge-based societies (Etzkowitz, Webster, Gebhardt, & Terra, 2000), and I have studied the three oldest and foremost polytechnic universities in Spain. In the *Shanghai Jiao Tong University* rankings, UPV ranks in the 300–400 or 400–500 intervals, depending on the edition, and it is not ranked in the 2004 edition. No other Spanish polytechnic university, including UPC and UPM, is ranked in any edition. These considerations and the data in Tables 6 and 7 suggest that the three studied polytechnic universities have similar publication activities and that they are the most research active polytechnic universities in Spain (see Bibliometric methods for the effect of on-campus CSIC institutes on bibliometric indicators). Comparison of the bibliometric indicators of these universities with those of the University of Barcelona suggest that further research improvements are also necessary in polytechnic universities.

Given these considerations and taking as reference the leading research countries, it appears that Spain needs to solve two problems simultaneously: (a) to increase the publication activity of a still large number of university professors, who never or very seldom publish in international journals; and (b) to increase the proportion of imaginative researchers among those who are already publishing sound papers in high impact factor journals. Although for the first problem formal evaluations may still help, it is unlikely that the second problem can be solved with formal evaluations without a higher involvement of the university in evaluating research with experts. The issue is that to increase the involvement of the university in research a previous change of the

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self-governance characteristics of Spanish universities is needed. I have already described how self-governance is associated with the low interest of the university in research. A good example supporting this association is the rector election that took place on February 2008, in the UPM. The two well-known international university rankings and all bibliometric indicators of UPM's research performance indicate that research activity in the UPM is low. Therefore, research should be a serious concern to anyone involved in UPM governance, but the electoral process demonstrated that this is not the case. Two candidates competed in the election and, during the campaign, the voters and their representatives in governance affairs presented their requirements to them. The representatives of professors and researchers of all ranks and one of the biggest national trade unions posed a total of 60 requirements, 75% of which could be considered labour negotiations, and there was not a single requirement about research.

In parallel with universities, research in Spain is carried out by the CSIC, which can, for comparative purposes, be considered a medium-sized university not involved in teaching and having more research resources than universities. All present general findings for Spain, the absence of both Nobel Prize winners and top ranking highly cited papers, also apply to the CSIC. The CSIC records in Table 5 show that research performance in the CSIC is better than the University of Barcelona but probably far from that of elite universities regarding important achievements. Because CSIC researchers are evaluated by the CNEAI, formal evaluations might also explain the low research performance of the CSIC.

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