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# Production of scientific and technological knowledge in Catalonia (2000-2014)

Presentation of the results of the analysis of the R&D system in Catalonia in the period 2000-2014: size, scientific and technological output, and innovation.

This report uses internationally recognized sources. The source of the data on the scientific publications was National Citation Report for Spain (NCR), and the National Science Indicators (NSI), two ad hoc databases extracted from the Web of Science (WOS) of Thomson Reuters. The source of the data on the number of patent applications was PATSTATS, a database built by the European Patent Office (EPO).

## Introduction

The aim of this study is to analyse the size and output of the Catalan research and development system (R&D system). Total R&D personnel and number of researchers were used to compare the size of the R&D system. Likewise, the number of publications in peer-reviewed journals and associated qualitative aspects (indicators based on the number of citations to those publications) were used to estimate and analyze the scientific output of the Catalan R&D system. The inventive and innovative performance was analysed using the number of patent applications.

## Results

### Size of the R&D system

This section describes the size of the Catalan R&D system, analysing two groups: 1) total R&D personnel, which includes researchers and support staff; and 2) the number of researchers.

This analysis includes two indicators: 1) the head count, and 2) the full-time equivalent (FTE).

### Objectives

To compare the Catalan R&D system with that of other regions and countries in terms of size. Two R&D systems are considered comparable when their sizes differ by less than 5%.

### Results of the analysis

According to EUROSTATS the Catalan system was composed by an annual average of 63,000 researchers and support staff (approximately 45,000 FTE), and an annual average of 40,000 researchers (26,000 FTE) between 2009 and 2013. According to these figures the Catalan system was comparable in size to that of the city of Stuttgart, and to Norway and Scotland (figure 1).

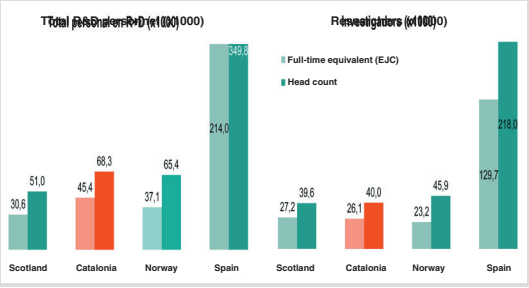


Figure 1. Total R&D personnel and researchers in head count and FTE, 2009-2013 (source: authors).

Summary

— The Catalan R&D system has a size equivalent to those of Scotland and Norway.
— Within the Spanish State, Catalonia is, like Madrid, one of the most important poles of research.
— In the production of scientific publications, the Catalan R&D system is still in a process of expansion and increasing internationalization. The visibility and excellence of Catalan publications was 10% above the world average during the 15 years analysed in the study.
— Two thirds of the 21 research fields analysed represent strengths of the Catalan R&D system.
— The inventive and innovative performance of Catalonia shows weaknesses when compared with Norway's patent applications per active population and patent applications in high-tech fields.

## Production of scientific and technological knowledge

This analysis is based on the publications in peer-review scientific journals reporting at least one organization in Catalonia. The bibliometric indicators used in this section were calculated taking into account only articles, reviews, proceeding papers or conference papers, which are regarded as main vehicle of research results.

### Objectives

1. To analyse the publication output of the Catalan R&D system in the context of Spain.

2. To compare the productivity of the different R&D systems in Europe.

3. To analyse the internationalization of the Catalan R&D system.

4. To analyse the visibility and excellence of the Catalan R&D system.

### Publication output

The number of documents produced in the Catalan system increased steadily, adding on average of 10,000 documents each year between 2000 and 2014. The publication output in the last five years of this period (2010-2014) was even greater, 14,000 documents per year on average. The internationalization of the system showed the same trend and reached its maximum at the end of the period with more than half the output published in collaboration with authors in other countries (figure 2).

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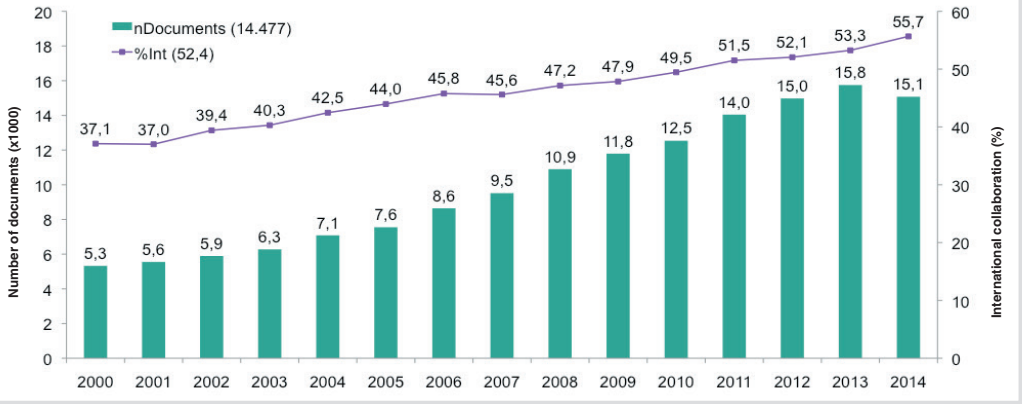
Source: own data drawn from the National Citation Report (NCR) database of Thomson Reuters.

* The average for 2010-2014 is shown in parentheses.

**Figure 2. Evolution of the number of published papers involving researchers in Catalonia (nDocuments) and % of documents published in collaboration with researchers in other countries (%Int)**




Within the context of Spain Catalonia ranked second according to the number of documents, but ranked first according to the indicators of visibility (Relative Citation Index [RCI]), excellence (Highly Cited Papers [HCP]), Relative Highly Cited Papers [RHCP]) and internationalization (%Int). As shown in the table 1 the number of documents was 1% lower in Catalonia than in Madrid between 2010 and 2014, in contrast the RCI, HCP, RHCP and %Int were 8%, 48%, 50% and 13% greater in Catalonia.

Regarding productivity, the Catalan R&D system ranked fifth in Europe according to the number of documents produced per thousand researchers between 2010 and 2014, three positions above the one achieved considering the 15 years between 2000 and 2014. Scotland and Norway, the two similar systems in terms of size ranked sixth and nineteenth (table 2).

## Visibility and excellence

Both the visibility and excellence of publications with participation of researchers in Catalonia stood above the respective reference values. The RCI was 10% greater than the world average for most of the analyzed period, and 13% during the last five years (2010-2014). As for the excellence, the system produced annually 200 HCPs on average between 2000 and 2014, and 320 in the last five years (2010-2014). The RHCP was 50% greater than the expected 1% from 2003 onward, and doubled the expected value in 2010, the maximum value was observed in 2012, after which the RCHP showed a slight declined until the end of the period.

## Strengths

In this section the level of activity (publication output) and the visibility (RCI) are combined in order to identify the fields of research that performed above the world average in these two parameters, what the authors called "strengths". In order to have a relative measure of activity the percentage of publications to the total output of Catalonia was obtained for every research field in the Essential Science Indicators (ESI, 21 broad areas). Then, these values were divided by the respective percentage of publications in the world to obtain the Relative World Share (RWS). As for the RCI, this is already a relative indicator. Setting the RWS and the RCI on tow axis allows placing the research fields on a plane according their performance in these two parameters. Those located simultaneously above the global averages are considered strengths of the system.

## Objective

The aim is to offer a global vision of the Catalan R&D with a strategic approach, highlighting the scientific and technological fields that can currently be considered strengths of the system.

## Results of the analysis

According to this analysis 14 (two-thirds) out of the 21 scientific fields in the ESI were located in the area

Source: authors based on the National Citation Report (NCR) of Thomson Reuters.

AC: Autonomus Community.

**Table 1. Bibliometric indicators of the most active regions in R&D in the Spanish State and percentage change (2010-2014)**

| AC | Documents[1] | RCI[2] | HCP[3] | RHCP[4] | % INT[5] |
|---|---|---|---|---|---|
| Madrid | 73.151 (-1%) | 1,051 (8%) | 1.094 (48%) | 1,496 (50%) | 46,4 (13%) |
| Catalonia | 72.387 (--) | 1,130 (--) | 1.623 (--) | 2,242 (--) | 52,5 (--) |
| Andalusia | 43.845 (65%) | 1,031 (10%) | 511 (218%) | 1,165 (92%) | 42,8 (23%) |
| Valencian Com. | 32.156 (125%) | 1,084 (4%) | 477 (240%) | 1,483 (51%) | 42,5 (24%) |
| Galicia | 17.154 (322%) | 1,045 (8%) | 217 (648%) | 1,265 (77%) | 41,9 (25%) |
| Basque Country | 14.802 (389%) | 1,053 (7%) | 210 (673%) | 1,419 (58%) | 48,1 (9%) |

1. Number of documents, i.e. articles, reviews, proceeding papers and conference papers. 2. Relative Citation Index (RCI): quotient between the actual number of citations and the average number of citations adjusted by journal, document type and year of publication. An RCI of 1.20 indicates that the publications had a visibility 20% greater than the average document of the same type, journal and publications year. 3. Highly Cited Papers (HCP): documents among the 1% most cited in the world. This indicator is obtained by comparing the number of citations received by all the documents in the WOS published in the same discipline and year. 4. Relative Highly Cited Papers (RHCP): quotient between the number of HCP and the total number of documents of the aggregate. An RHCP of 1.20 indicates that the aggregate had 20% more HCP documents than expected (1%). 5. Percentage of documents in international collaboration (%Int): proportion of documents reporting more than one country.

Source: authors combining data obtained from the NCR and Eurostat.

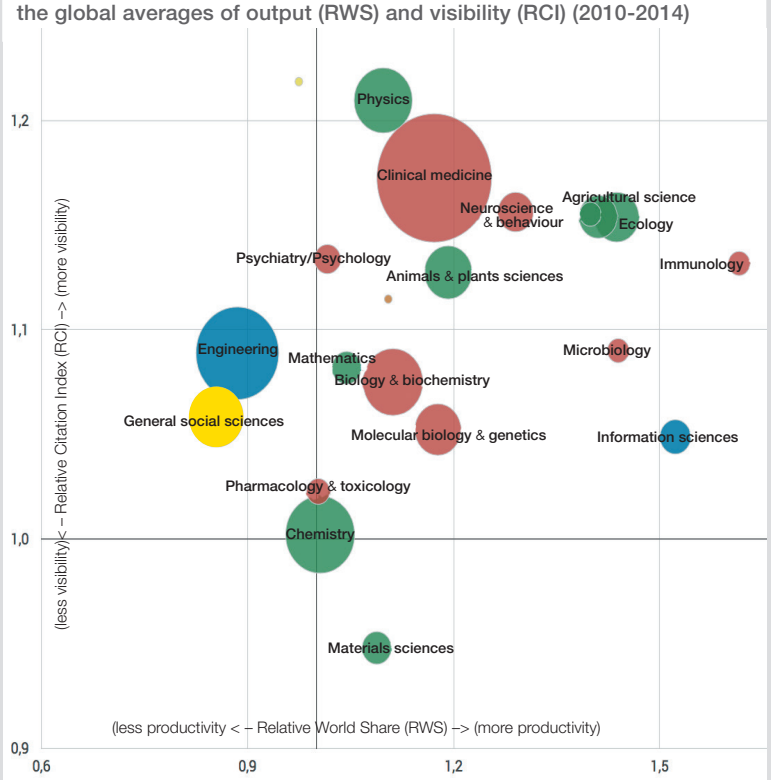
Relative World Share (RWS): ratio between the percentage of documents that a specific scientific or technological discipline accounts for in Catalonia and the percentage of documents the same discipline accounts for in the WOS, the world. An RWS of 1.20 indicates that the discipline in question produced 20% more publications than the world average.

**Table 2. Number of documents per thousand researchers**

| System | Rank. 2000-2014[1] | Total 2000-2014[2] | Rank. 2010-2014[3] | Total 2010-2014[4] |
|---|---|---|---|---|
| Cyprus | 5 | 324 | 1 | 465 |
| Switzerland | 2 | 403 | 2 | 462 |
| Netherdlands | 1 | 410 | 3 | 402 |
| Italy | 3 | 347 | 4 | 373 |
| Catalonia | 8 | 280 | 5 | 355 |
| Scotland | 4 | 339 | 6 | 345 |
| Ireland | 10 | 266 | 7 | 324 |
| Croatia | 15 | 222 | 8 | 319 |
| Slovenia | 6 | 297 | 9 | 316 |
| Belgium | 7 | 287 | 10 | 312 |
| Wales | 9 | 270 | 11 | 285 |
| Luxembourg | 20 | 149 | 12 | 273 |
| Romania | 19 | 165 | 13 | 265 |
| Northen Ireland | 13 | 239 | 14 | 263 |
| Iceland | 18 | 171 | 15 | 261 |
| Sweden | 11 | 250 | 16 | 261 |
| Denmark | 12 | 239 | 17 | 255 |
| Norway | 17 | 197 | 18 | 242 |
| Spain | 16 | 197 | 19 | 241 |

1. Ranking of the average number of documents per thousand researchers between 2000 and 2014. 2. Average number of documents per thousand researchers between 2000 and 2014. 3. Ranking according to the average number of documents per thousand researchers between 2000 and 2014. 4. Average number of documents per thousand researchers between 2000 and 2014.

**Figure 3. Position of the broad research fields of Catalonia in relation to the global averages of output (RWS) and visibility (RCI) (2010-2014)**




Source: authors based on the NCR and WOS databases. Global averages correspond to the perpendicular black lines that divide the plane into quadrants. The colours of the fields indicate the area in which they are situated: biomedicine, red; natural sciences, green; engineering and technology, blue; social sciences, yellow. Output in art and humanities has been excluded from the analysis because bibliometrics cannot be applied in this field.

of strengths of the system considering last five years of the period (2010-2014). The publications in these broad areas account for 90% of the total output of Catalonia. Space science showed the highest values, for which was located at the extreme of the quadrant of strengths, while area showing the largest number of publications was Clinical medicine. Physics, neuroscience and behaviour, biology and ecology, immunology, agricultural sciences, mathematics, biology and biochemistry, molecular biology and genetics, microbiology, and computer science are also among the strengths of the Catalan R&D system. Pharmacology and toxicology, and chemistry are partially within the quadrant of strengths. Materials science is located as an opportunity that would become another strength if its publication output increases in the next years. The large area including engineering and social sciences would become strengths if they increase visibility in the next years (figure 3).

## Patents

The inventive and innovative performance of Catalonia, rather than the exclusive of the R&D system in particular, is analysed using the total number of patent applications and the number of patent applications in high-tech fields as recorded by the European Patent Office (EPO).

### Objectives

1. To compare the innovative capacity of Catalonia with that of other regions and countries.

2. To quantify the differences.

### Results of the analysis

Based on the annual average number of patent applications Catalonia, London, Hannover and Norway showed comparable inventive and innovative capacity (differences lower than 5%) between 2008 and 2012. In contrast, according to the number of patent in high-tech fields Hannover and London showed greater capacity, however Catalonia and Norway continued to show similar values (figure 4).

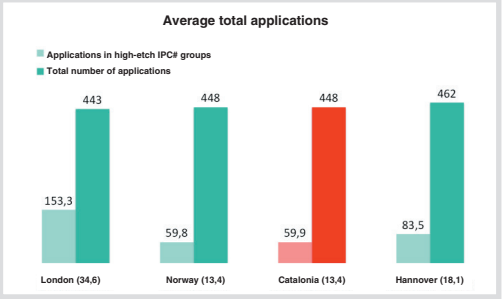
According to the number of applications per million of active population the innovative capacity of Hannover was almost four times that of Catalonia. In comparison with London, Catalonia showed similar number of patent applications in all categories, but half the number of applications per million of active population in high-tech fields. Compared with Norway, Catalonia showed similar number of patent applications high-tech fields, however showed 50% less number of applications in all categories (figure 5).

### Discussion

The Catalan R&D system is comparable in size to that of the very active countries Scotland and Norway. The analysis shows that, in both the total personnel involved in R&D tasks and in the subset of researchers, Catalonia has an amount of R&D personnel equivalent to that of Scotland and Norway, which are among the 20 most productive countries in Europe.

The constant and steady increase in publication output is matched by the internationalization of the

Figure 4. Average number of patent applications (all categories) and in high-tech fields as recorded by the EPO between 2008 and 2013. (Source: Patent applications to the EPO by priority year by NUTS 3 regions).




Catalan system. The system increased its average output by 40% between 2010 and 2014, producing 14,000 documents annually, more than half of which were published in collaboration with researchers in other countries.

Catalonia is one of the poles of research in Spain. With only 1% fewer documents than Madrid (a statistically insignificant difference), the Catalan output showed 8%, 50% and 13% more visibility, excellence and internationalization, respectively. The rest of the R&D systems in Spain were at a considerable distance from Catalonia in all bibliometric parameters: output (number of documents), visibility (RCI), excellence (HCP and RHCP) and international cooperation (Int%).

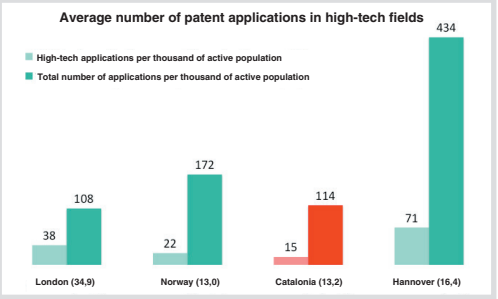
The R&D system in Catalonia showed high productivity ranking ahead of Scotland and Norway. According to the number of publications per thousand researchers Catalonia ranked 5th in Europe, while Scotland and Norway ranked 6th and 19th, respectively.

The scientific and technological output of the Catalan system achieved higher levels of visibility and excellence than the global averages. The indicator of visibility (RCI) was 10% greater than the world average between 2000 and 2014, and 13% during the last five years. As for the number of publications in the top 1% most cited in the world (HCP), Catalonia produced an average of 320 yearly in the last five years of the analyzed period, and peaked at 2.5% (two and a half times the expected value) in 2012.

Fourteen out of 21 broad areas of research can be considered strengths of the Catalan R&D system. Two thirds of all areas considered in the analysis concentrated simultaneously more activity and visibility than the respective global averages, for which they were considered strong areas of research of the system. The publications in these areas accounted for 90% of the total output of the Catalan R&D system between 2000 and 2014.

Catalonia's inventive and innovative capacity showed limitations in comparison with other systems in Europe. While innovation is not the sole responsibility of the R&D system, it was included in the analysis in order to complement the vision offered by this report. The results show weaknesses in comparison with comparable systems in the number of patent applications in high-tech fields, and in the number of applications per million of active population.

Figure 5. Average number of patent applications (all categories) and in high-tech fields recorded at the EPO between 2008 and 2013. (Source: High-tech patent applications to the EPO by priority year by NUTS 3 regions).




## Conclusions

1. The Catalan R&D system is equivalent in size to that of Scotland and Norway, which are among the 20 most productive countries in Europe. However, the authors recommend keeping a vigilance attitude concerning the number of researchers in the system.

2. The Catalan R&D system is still expanding, increasing its publication output and internationalization steadily. The number of documents increased by 40% in the last five years and more than half were in collaboration with researchers in other countries.

3. Catalonia, like Madrid, is one of the poles of research in the Spain, with bibliometric indicators of output, visibility, excellence and internationalization that place it at a considerable distance from the rest of the systems.

4. The Catalan R&D system showed a high productivity in terms of publications per thousand researchers, ranking 5th in Europe, ahead of Scotland and Norway, two similar systems in terms of size.

5. The visibility and excellence of publications involving researchers in the Catalan system stood above the world average during the 15 years analysed. Both the visibility indicator (RCI) and the excellence indicator (RHCP) peaked around 2012: RCI at 13% above the world average and RHCP at 2.5 times the expected value.

6. Two thirds of the broad research fields analysed can be considered as strengths of the Catalan R&D system: space science, clinical medicine, physics, neuroscience and behaviour, biology and ecology, immunology, agricultural sciences, mathematics, biology and biochemistry, molecular biology and genetics, microbiology, and computer science. In terms of production, these areas accounted for 90% of Catalonia's output between 2000 and 2014.

7. The inventive and innovative capacity of Catalonia showed weaknesses in the number of patent applications per million of active population and in high-tech fields.

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