Effect of the economic crisis on the production of immunology patents managed through the Patent Cooperation Treaty agreement from 2004–2011

Elena Campos and Adolfo Campos
Clinical Medicine-Immunology, University Miguel Hernandez, San Juan de Alicante 03550, Spain
Corresponding author: Adolfo Campos. Email: adolfo.campos@umh.es

Summary

Objectives: To determine the evolution of patents in immunology, as a result of research and innovation in the years 2004–2011.
Design: The search for patents published internationally in immunology was made by using the SCOPUSTM database. SCOPUS gives information about over 23 million patents. The extracted data from patents were: inventors and applicants; their nationalities; sections, classes and subclasses of the International Patent Classification.
Participants: 89 countries
Setting: Data have been obtained from the database SCOPUS. It has been used for the international patent classification.
Main outcome measures: Patents by country, Productive sectors, Productive areas
Results: A total of 17,281 patents were applied for immunology during 2004–2011 of which 16,811 were from 30 Organisation for Economic Cooperation and Development countries, and 5326 from 28 countries in the European Union. These patents were granted in 89 countries and 13,699 of them were submitted by researchers from only one country. Private entities applied for 62.45% of all patents, universities 17.48%, hospitals 3.40% and public research organisations and private applicants applied for the rest. The university that made more applications was the University of California with 315 and the company was Genentech Inc. (US) with 302. The reduction in the number of applications of international patents in all disciplines of science also affected the area of immunology.
Conclusions: Collaboration in immunology between universities, companies and hospitals is hard because their interests are different. It is shown in patent applications that the majority of patents in immunology are applied for by only one entity. Patents in immunology are developed, mainly, in aspects such as medical preparations, peptides, mutation or genetic engineering, therapeutic activity of chemical compounds and analysing materials by determining their chemical or physical properties.

Keywords
patents, technological balance, immunology, PCT, innovation

Background

Research is reckoned as an important contributor to the technological and economic development of a country, which is why public and private entities invest large sums of money in it.1 This has recently produced a large amount of literature based on bibliometric analyses of scientific production2 but very few analyses on intellectual property;3,4 thus, it is difficult to quantify the value of indicators such as patents. These analyses are useful in the fields of innovation, technology transfer and industrial competitiveness, as well as to promote investment in innovation and to provide a framework for the trading of the assets of industrial property via patents and trademarks.5

The economic problems in recent years have affected all countries, with short- and medium-term consequences, particularly related to lack of confidence. Confidence in the future depends greatly on the capacity for innovation shown by businesses and the state.

Investment in knowledge creation had increased in recent years, reaching about 1.1 billion dollars in 2009.5 The demand for industrial property fell in 2009, but despite the difficult economic conditions, it recovered in 2010. The recovery in international patent filings observed in 2010 gained strength in 2011.6

Among the countries with the highest number of patent applications through the Patent Cooperation Treaty in 2011 are Saudi Arabia (81.48%), China (33.42), Ukraine (26.60), Russia (20.80), Japan (20.95), Poland (19.59), Mexico (18.84), Austria (17.79), Brazil (17.21), Belgium (12.78), Turkey (12.70), Denmark (11.83) and India (11.19). However, countries such as Malaysia (−24.28), Hungary (−17.44), Portugal (−17.24), Netherlands (−14.00), Ireland (−4.96), Finland (−2.71), Spain (−2.65), Luxembourg (−1.99), Australia (−1.80),
Israel (−1.62) and the United Kingdom (−0.96) had a smaller growth.

Patents in this context are the result of a big effort in innovation. Thus, the connection between science and politics is a priority for the European Union, as it was agreed in the Lisbon Strategy for Growth and Jobs. It is therefore important to be aware of the evolution of patents in the specific setting of scientific knowledge, in order to analyse the possible opportunities and forms of future development. The 2008 Compendium of Patent Statistics established a series of very interesting conclusions about patents, particularly in such fields as information and communication technology, nanotechnology, biotechnology, technologies related with the environment, nuclear energy and fuel cells.

Despite that the generation and transfer of knowledge between science and industry are very important to achieve a good technological balance, bibliometric studies on patents are scarce in specific areas of knowledge.

Methods
A search about patents applied internationally in the field of immunology was carried by using the SCOPUS™ database. SCOPUS gives information about over 23 million patents.

For this study, only patent applications under the Patent Cooperation Treaty were considered. The patents were obtained by using the search term ‘immunology’ in the years 2004 to 2011 during February of the following year.

Obtained data from patents were: inventors and applicants, their nationalities, and sections, classes and subclasses of the International Patent Classification (IPC), using eighth version 2008.01 (http://www.wipo.int/classifications/ipc/en).

Results
Evolution by countries
A search in the SCOPUS database for immunology patents produced a total of 17,281 patent applications during 2004–2011 of which 16,811 were from 30 Organisation for Economic Cooperation and Development (OECD) countries and 5326 from 28 countries in the European Union.

The analysis of these patents shows that they were granted in 89 countries; 13,699 (79.27%) of them were submitted by researchers from only one country, 2781 by researchers from two countries, 446 by researchers from three countries, 74 by researchers from four countries, 5 by researchers from five countries, 3 by researchers from six countries, and only one by researchers from eight countries.

It was in the year 2007 that we found the highest number of patent applications, and from that year it decreased progressively in all countries, except China (Table 1).

Despite the recovery in the number of patent applications produced in 2011 in the field of immunology, there was still a reduction in international patent applications. Likewise, the so-called emerging countries have hardly any patents applied through Patent Cooperation Treaty in recent years.

The United States was the main patent applicant with 10,464 (60.55% of the total), 8445 were carried out just by US researchers and 2019 together with researchers from other countries, 60.02% of patents from OECD and 38.85% from the European Union were granted to researchers from one single country (Table 1).

Productive sectors
Private entities produced 10,793 (62.45%) of all patents, followed by universities (3022, 17.48%) and hospitals (588, 3.40%); the other 1960 came from Public Research Organizations (PROs) and, mostly, private applicants.

On the few occasions when there has been collaboration between different sectors, in most cases this has been established between private entities and universities; collaborations between universities and hospitals are very few (Table 2).

Productive areas
Patents in immunology are assigned mainly (9212) in subclass A61K (preparations or medical dressing, dental), 5455 to C07K (peptides), 3987 to C12N (microorganisms or enzymes, compositions thereof, spread, preservation or maintenance of microorganisms, mutation or genetic engineering), 3865 to A61P (therapeutic activity of chemical compounds or medicinal preparations), and 3097 to G01N (investigating or analysing materials by determining their chemical or physical properties) (Table 3).

Top applicants
The University of California (US) with 315 patent applications was the largest filer among educational institutions, followed by Johns Hopkins University (US), the University of Texas (US), the
Table 1. Evolution of immunology patents managed under the Patent Cooperation Treaty agreement during 2004–2011.

| Country        | 2004  | 2005  | 2006  | 2007  | 2008  | 2009  | 2010  | 2011  | 2004–2011 |
|----------------|-------|-------|-------|-------|-------|-------|-------|-------|-----------|
| United States  | 1,069 | 1,301 | 1,660 | 1,738 | 1,584 | 1,339 | 819   | 954   | 10,464    |
| Great Britain  | 186   | 163   | 199   | 259   | 218   | 197   | 132   | 94    | 1,448     |
| Germany        | 156   | 177   | 189   | 210   | 188   | 180   | 111   | 100   | 1,311     |
| Switzerland    | 97    | 80    | 109   | 134   | 123   | 139   | 93    | 106   | 881       |
| France         | 83    | 104   | 147   | 133   | 134   | 102   | 70    | 68    | 841       |
| Canada         | 66    | 79    | 103   | 102   | 106   | 74    | 46    | 56    | 632       |
| Israel         | 59    | 77    | 103   | 87    | 79    | 89    | 67    | 62    | 623       |
| Australia      | 85    | 76    | 89    | 86    | 96    | 67    | 62    | 40    | 601       |
| Holland        | 57    | 65    | 68    | 90    | 82    | 52    | 29    | 34    | 477       |
| Japan          | 68    | 68    | 81    | 97    | 58    | 44    | 35    | 18    | 469       |
| Italy          | 35    | 43    | 74    | 65    | 48    | 50    | 34    | 35    | 384       |
| Belgium        | 25    | 35    | 54    | 61    | 69    | 67    | 29    | 31    | 371       |
| Denmark        | 8     | 41    | 56    | 49    | 53    | 48    | 31    | 26    | 341       |
| Sweden         | 29    | 37    | 36    | 61    | 62    | 36    | 21    | 18    | 300       |
| Austria        | 42    | 25    | 27    | 35    | 24    | 24    | 14    | 9     | 200       |
| Spain          | 23    | 23    | 27    | 31    | 25    | 24    | 15    | 25    | 193       |
| China          | 16    | 19    | 18    | 27    | 16    | 20    | 26    | 36    | 178       |
| South Korea    | 13    | 19    | 35    | 20    | 28    | 25    | 15    | 6     | 161       |
| India          | 7     | 23    | 29    | 25    | 20    | 24    | 9     | 13    | 150       |
| Singapore      | 7     | 11    | 20    | 26    | 19    | 21    | 23    | 17    | 144       |
| All the countries | 1,837 | 2,090 | 2,656 | 2,828 | 2,602 | 2,218 | 1,555 | 1,495 | 17,281*   |
| Patents From one country | 1,497 | 1,684 | 2,140 | 2,293 | 2,040 | 1,762 | 1,114 | 1,169 | 13,699   |
| Patents From several countries | 329 | 384 | 513 | 520 | 518 | 452 | 299 | 305 | 3,320 |
| OECD Patents | 1,805 | 2,030 | 2,594 | 2,751 | 2,516 | 2,174 | 1,509 | 1,432 | 16,811   |
| European Union -28 Patents | 606 | 640 | 808 | 880 | 8012 | 717 | 455 | 418 | 5,326 |

*262 patents do not specify the nationality or the researchers or the applicants.
University of Harvard (US) and the University of Michigan (US).

Likewise, the top five applicant companies with highest number of patent applications in the Patent Cooperation Treaty during this period were Genentech Inc. (US), Novartis AG (CH), Abbott Lab (US), Wyeth Corp (US) and Glaxo Group Ltd (GB) (Table 4).

**Patents and population and gross national income**

The applications published by each country showed no correlation with population size or with its gross national income per capita (Table 5).

**Discussion**

This is one of the first systematic reviews of patents to analyse countries, authorship details, centres and research fields. Studies on patents are useful to ensure effective research funding from both public and private organisations. These studies stimulate research and technological innovation, and are quite important for improving indicators that measure the benefit of the innovation.10

The Knowledge Society is changing, not just academically (Bologna Plan, or the lesser known Alexandria Plan) but also in areas like science, technology and economy; progress and wealth sources that affect the quality of life. Technological innovations in immunology are contributing to the design of new drugs and new methods of clinical diagnosis. Future models, dealing with basic homeostasis, immunity against pathogens, antigen presentation mechanisms, cytokines, mechanisms of autoimmunity, gene recombination, cell cycle regulation, signal transduction and cell sociology will all generate patentable advances such as vaccines and/or treatments.

From the research and development (R&D) point of view, immunology covers three main areas. First, immunodiagnostics, which uses the processing and analysis of images to detect abnormalities in the immune system during the early stages of a disorder, thus reducing the healthcare costs for the health care provider. Second, immunotechnology, which takes elements from the immune system to be used as drugs, thus acting more efficiently and with fewer adverse effects on the relevant cells and areas of the body.
Table 3. Distribution by international patent classification section, class and subclasses, of the Immunology patents managed under the Patent Cooperation Treaty agreement during 2004–2011.

| Section | Class | Subclass | Year | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | Total | % 2011/maximum |
|---------|-------|----------|------|------|------|------|------|------|------|------|------|-------|----------------|
| A       | all   |          |      | 1,515| 1,596| 2,317| 2,719| 2,300| 2,019| 1002 | 902  | 14,370 | 33.17            |
| A01     | all   |          |      | 80   | 73   | 74   | 95   | 96   | 86   | 81   | 56   | 1,493  | 58.33            |
| A01K    |       |          |      | 45   | 35   | 33   | 45   | 32   | 18   | 19   | 10   | 237    | 22.22            |
| A01N    |       |          |      | 28   | 28   | 15   | 29   | 39   | 45   | 33   | 34   | 251    | 75.55            |
| A01H    |       |          |      | 7    | 10   | 24   | 20   | 22   | 11   | 27   | 11   | 132    | 40.74            |
| A23     | all   |          |      | 38   | 43   | 25   | 25   | 25   | 6    | 7    | 201   | 16.27            |
| A23L    |       |          |      | 22   | 22   | 12   | 17   | 12   | 15   | 4    | 5    | 109    | 22.72            |
| A61     | all   |          |      | 1,395| 1,440| 1,688| 2,590| 1,908| 1,859| 945  | 875  | 12,700 | 33.78            |
| A61K    |       |          |      | 985  | 1,140| 1,123| 1,727| 1,269| 1,233| 895  | 840  | 9,212  | 48.63            |
| A61P    |       |          |      | 332  | 230  | 520  | 782  | 592  | 581  | 408  | 420  | 3,865  | 53.70            |
| A61B    |       |          |      | 41   | 35   | 11   | 15   | 9    | 9    | 2    | 4    | 126    | 9.75             |
| A61L    |       |          |      | 6    | 15   | 12   | 14   | 17   | 19   | 9    | 10   | 102    | 58.82            |
| A61F    |       |          |      | 7    | 6    | 7    | 17   | 7    | 6    | 6    | 3    | 59     | 17.64            |

(continued)
organism. And third, immunotools, which uses elements of the immune system for the detection, localisation, management and repair of damaged organs and tissues.

Development and progress in science, technology and economy in immunology, as in many other fields, are determined by different factors, such as a more business-oriented culture; in order to improve this,
some universities have already incorporated into their study plans subjects related to how to start up a business and support programme to strengthen the connection between R&D and businesses. It is also important to note the fact that due to the current economic situation business people are changing their minds in this respect, and they are seen to be more willing to welcome this kind of collaboration.

History has shown that countries and companies that invested in new products and innovative activities during periods of economic recession have found themselves in an optimal position to take advantage from the situation once the economy has recovered.

Patent applications, as a whole, decreased in 2009 but began increasing in 2010 and 2011. However, the trend in immunology was decreasing until 2011, which was not expected by the World Intellectual Property Organization (WIPO) for 2020.

It is important to notice the scarce collaboration between different economic sectors in immunology. As the president of the European Patent Office said, the most successful countries in innovation are the ones that promote a good cooperation between universities, research centres and industries.

In immunology, this collaboration between public and private research sectors should therefore be supported and encouraged, although this is not a definitive solution.

At the same time, the inter-institutional collaboration is maintained in a conceptually elusive and difficult area to achieve, for various reasons such as: cultural clashes, overly bureaucratic agencies, rewards poorly designed or ineffective management of the offices of university technology transfer.

The organisations that fund research want results to be easily measured (articles or impact factors) and the researchers themselves try to fill their curriculum with the sort of contributions that work faster. The goals of research are sometimes confused with the means of making the results known.

To establish a good connection between sectors, it is necessary to establish clear criteria for the selection of partners and addressing conflicts of interest; likewise, cooperation can sometimes interfere with academic freedom and altruistic research.

It is shown that immunology patents are assigned to fewer sections, classes and subclasses of the International Patent Classification during the last two years.

The cultural tradition in the European Union and the cultural and economic ties with the United States make this country the main technological partner for researchers. Almost half of all patents are presented together with a United States partner. China is starting its internationalisation.

Less than 20% of patents come from universities, although some of them are part of the group of entities that have the most patents in immunology.

In 2008–2009, expenditure on R&D&i is maintained despite the financial crisis. In the European Union, the fall of Gross Domestic Product was higher than the amounts allocated to R&D, producing a net effect of increasing the percentage of investment in R&D&i.

It is also important to consider the impact of intellectual property rights protection on the growth rate of a country. Regression techniques have shown that in countries with a Gross Domestic Product below

---

Table 5. Countries by published patents, population and gross national income per capita.

| Country | Patents 2004–2011 | Population by millions | Gross national income per capita/billions of dollars |
|---------|-------------------|------------------------|----------------------------------------------------|
| US      | 10,464            | 307                    | 46,360                                             |
| GB      | 1,448             | 62                     | 41,370                                             |
| DE      | 1,311             | 82                     | 42,450                                             |
| CH      | 881               | 8                      | 65,430                                             |
| FR      | 841               | 63                     | 42,620                                             |
| CA      | 632               | 34                     | 41,980                                             |
| IL      | 623               | 7                      | 25,790                                             |
| AU      | 601               | 22                     | 43,770                                             |
| NL      | 477               | 17                     | 48,460                                             |
| JP      | 469               | 128                    | 38,080                                             |
| IT      | 384               | 60                     | 35,110                                             |
| BE      | 371               | 11                     | 45,270                                             |
| DK      | 341               | 6                      | 59,060                                             |
| SE      | 300               | 9                      | 48,840                                             |
| AT      | 200               | 8                      | 46,450                                             |
| ES      | 193               | 46                     | 32,120                                             |
| CN      | 178               | 1,331                  | 3,650                                              |
| KR      | 161               | 49                     | 19,830                                             |
| IN      | 150               | 1,155                  | 1,220                                              |
| SG      | 144               | 5                      | 37,220                                             |
3400 US dollars (in 1980 dollars) there is no significant relation between intellectual property rights and growth, but above this threshold the relation is significantly positive.\textsuperscript{17}

Falvey et al.\textsuperscript{17} found that those countries that gave greater intellectual property rights protection were more attractive destinations for foreign patents. Countries need companies to investigate and put products on the market; otherwise, the countries will become technological colonies of other countries.

**Declarations**

**Competing interests:** None declared

**Funding:** None declared

**Ethical approval:** Not required because the study is not based on living beings.

**Guarantor:** EC

**Contributorship:** EC: Work design, interpretation of results and manuscript preparation. AC: Obtaining data, Data analysis and manuscript preparation.

**Acknowledgements:** None

**Provenance:** Not commissioned; peer-reviewed by Yannish Naik.

**References**

1. Rosenberg N. Why do firms do basic research (with their own money)? *Res Policy* 1990; 19: 165–174.
2. Almeida JAS, Pais AACC and Formosinho SJ. Science indicators and science patterns in Europe. *J Informetrics* 2009; 3: 134–142.
3. Patel VM, Ashrafian H, Ahmed K, et al. How has healthcare research performance been assessed? A systematic review. *J R Soc Med* 2011; 104: 251–261.
4. Narin F and Olivastro D. Linkage between patents and papers: an interim EPO/US comparison. *Scientometrics* 1998; 41: 51–59.
5. WIPO Director General Highlights Importance of Intellectual Property for Innovation and Technology Transfer. Geneva, May 10, 2010. http://www.wipo.int/pressroom/en/articles/2010/article_0013.html.
6. International Patent filings set new record in 2011. Geneva, March 5, 2012. http://www.wipo.int/pressroom/en/articles/2012/article_0001.html.
7. Commission of the European Communities. Working together for growth and jobs next steps in implementing the revised Lisbon strategy. http://www.okeobservatory.gr/projpdf/pdf_tekenid_53.pdf.
8. OECD (Organisation for Economic Co-operation and Development). *Compendium patent statistics*. Paris: OECD, 2008.
9. Plaza LM and Albert A. Análisis de la producción científica española citada en patentes biotecnológicas en EE.UU. *Rev Exp Doc Cient* 2004; 27: 212–220.
10. European Commission. Green Paper. From challenges to opportunities: towards a common strategic framework for EU. Research and Innovation funding. COM (2011) 48, Brussels, 9.2.2011. http://www.europarl.europa.eu/meetdocs/2009_2014/documents/com/com_com(2011)0048_/com_com(2011)0048_en.pdf.
11. Daban M and Vendrell M. Impacto de las biorregiones en el impulso de iniciativas emprendedoras. *SEBBM* 2009; 161: 12–18.
12. European Commission. Innovation Union competitiveness report, Luxembourg: Publications Office of the European Union, 2011.
13. International Patent Filings Dip in 2009 amid Global Economic Downturn. Geneva, February 8, 2010. http://www.wipo.int/pressroom/en/articles/2010/article_0003.html.
14. Ross LF, Norton JW, Young SA, et al. Is academic medicine for sale? *N Engl J Med* 2000; 343: 508–510.
15. Trouiller P, Olliaro P, Torreele E, et al. Drug development for neglected diseases: a deficient market and a public health policy failure. *Lancet* 2002; 359: 2188–2194.
16. Thompson MA and Francis WR. An empirical analysis of the impact of patent protection on economic growth: an extension. *J Econ Develop* 1999; 24: 67–76.
17. Falvey R, Foster N and Greenaway D. Trade, imitative ability and intellectual property rights. *Rev World Econ* 2009; 145: 373–404.