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# THE PORTUGUESE SCIENTIFIC PRODUCTION: A STUDY FROM 1980 TO 2015 ACCORDING TO THE DATA OF THE INSTITUTE OF SCIENTIFIC INFORMATION (ISI)

# A PRODUÇÃO CIENTÍFICA PORTUGUESA: UM ESTUDO DE 1980 A 2015 DE ACORDO COM OS DADOS DO INSTITUTO DE INFORMAÇÃO CIENTÍFICA (ISI)*

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**Abstract:** This article discusses the scientific production of Portugal from 1945 onwards, comparing the decades 1980/90 and 2005/15. During these two decades, the public production of the internationally recognized country increased 35 times in 2016, with patents registered 45 times. This is a result of public policies aimed at the development of S&T, of academia and business partnerships, and of personnel qualification, driven by membership in the European Union. Between 2005/15 the areas that published the most were: Biochemistry & Molecular Biology; Chemistry, Physical; Astronomy & Astrophysics; Material Science Multidisciplinary and Genetics & Heredity.

**Keywords:** Science and technology qualitative data. Scientific production. Portuguese science. Growth of scientific production.

**Resumo:** Este artigo discute a produção científica de Portugal a partir de 1945 comparando as décadas de 1980/90 e 2005/15. Nestas duas décadas, frutos de políticas públicas voltadas ao desenvolvimento da C&T, da parceria academia-empresas e qualificação de pessoal, impulsionadas pelo ingresso na União Europeia, a produção científica do país reconhecida internacionalmente aumentou 35 vezes em 2016 , as patentes registradas 45 vezes. Entre 2005/15 as áreas que mais publicaram foram: Bioquimica & Biologia Molecular; Química

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Física; Astronomia & Astrofisica; Ciencia dos Materiais Multidisciplinar e Genetica & Hereditariedade.

**Palavras-chave:** Dados qualitativos em ciência e tecnologia. Produção científica. Ciência portuguesa. Crescimento da produção científica.

> *The past, as a predictor of the future, is clearly a limited instrument in an area as innovative as the one this article discusses.* (Correia, P, 2015) [1].

## 1. INTRODUCTION

After the era of great advances in navigation in the fifteenth and sixteenth century when it led the great discoveries and new shipping routes, consolidating an empire, up until the 1980s Portugal was considered a country with little expression from the point of view of the contribution to the expansion of scientific knowledge. This panorama began to change as of the 1980s, when the fruits of the Carnation Revolution (1974) began to emerge, which allowed for the democratization of Portuguese society. Since 1980, policies have been drawn up aimed at the development of S&T in the country and, together with joining the European Union, bring Portugal to the world scientific panorama.

According to the latest data available in PORDATA, the country's investments in science in 2012 were 262.8 euros when the European average is 461 euros per inhabitant. Although insufficient and below the European average, these investments led the country to 35th place in the ranking of the world scientific production of document quantity and to 24th place in the world scientific production by the CNCI.

The Ministry of Science, Technology and Higher Education of Portugal considers that the scientific production of the internationally recognized country has multiplied 35 times between 1982 and 2012 and the areas that stand out are Biochemistry & Molecular Biology, Material Science, Multidisciplinary; Chemistry-Physical; Environmental Sciences and Astronomy & Astrophysics. Among the institutions with recognized scientific production are the University of Lisbon (with the Instituto Superior Técnico), the University of Porto, the Technical University of Lisbon, the University of Coimbra and the University of Aveiro and the University of Coimbra, but there is also the strong presence of research institutions such as São João Hospital.

[1] This work was supported by Portuguese national funds through the FCT - Foundation for Science and Technology, under project «UID/CPO/00713/2013».

## 2. OBJECTIVES

The objectives of this article are:

- To know and to analyze the scientific production of Portugal between the years of 1980/90 and 2005/15,
- Analyze the position in the ranking of Portugal in the world of the production of scientific knowledge,
- Identify the areas of knowledge and institutions in the country where the greatest changes occurred between the years 1980/90 and 2005/15.

## 3. Methodology

Data on scientific production was extracted from the InCites database of Clarivate Analitics. Incites is a personalized, citation-based online assessment tool that allows you to perform scientific productivity analysis and comparison of results with countries around the world. Building on the Web of Science record set, InCites brings together analytical tools and metrics that enable you to quantify and qualify search results.

The counting of the number of country publications was done carefully, considering the problems that arise when such notes are sought (Gauffriau et al. 2007; Larsen and Von Ins 2010). These problems are related to the occurrence of double counting of scientific literature, when we compare the production of different countries, institutions and/or fields of knowledge. This is due to the origin of each publication, when this results from the cooperation between researchers connected to two or more countries, institutions or different areas. In such cases, the article will be counted more than once.

It should be noted that the countries of the United Kingdom in this work are identified as part of the European Union.

## 4. OVERVIEW OF WORLD SCIENTIFIC PRODUCTION

Science is fundamental for the development of contemporary society. And the communication of its results is "vital for the advancement and development of Science. It is through them that the dissemination of knowledge, the interaction between researchers and the legitimization of scientific production by peers, induces the generation of new knowledge." (Almeida, E.C and Guimarães, J. 2010)

World scientific production, whose content is very complex and specialized, and its communication has grown exponentially. To analyze it, it is necessary to use objective indicators, analyzing production quantitatively. Bibliometrics is lavish in both the number of analyst groups engaged in the production of bibliometric reports and in the performance of indicator studies.

The different areas of knowledge present different behaviors. The areas of human and social sciences traditionally disseminate their results by means of books, that is, a format distinct from periodical publications and most often referring to local and national contents. The so-called "hard" science areas predominate in succeeding periodicals (serial publications).

For a long time, we had a predominance of the Northern Hemisphere in the development of S&T. The three major blocks considered in scientific production, North America, Europe and South Asia, were absolute leaders until 2001. Nowadays, this development has become multipolar, where the trio of the European Union, Japan and USA has given way to a large number of research centers, bringing South Korea, Brazil, China and India into the S&T scenario. The efforts of these countries to increase investments in higher education and postgraduate studies (Almeida, 2013) are remarkable. India has opened 30 new universities to increase the number of students enrolled in higher education by more than 6 million.

In Portugal, although many efforts have been made since the Carnation Revolution, and its scientific production occupying the 35th position in world production (Table 1), the resources employed are still considered insufficient. In 2012 262.8 euros were spent in science when the European average is 461 euros per inhabitant. However, when analyzing the quality of this production, we can see that the situation of Portuguese science, even though we can only observe the context of the European Union, is above the world average (CNCI) with 1.07, higher than in countries such as China, Spain and Japan. However, the situation of Portuguese science in the European context is still considered as not very expressive in terms of the number of documents published. According to *"Produção Científica Portuguesa, 1990-2015: Séries Estatísticas"* (Portuguese Scientific Production, 1990-2015: Statistical Series) while it is in 11th place in the ranking of the European Union in the number of publications indexed in the Web of Science per million inhabitants, it is in 4th place in the average annual growth rate between 2005 and 2015 in the number of publications indexed in the Web of Science per million inhabitants, if we compare the years 2005 and 2015.

**Table 1. WORLD SCIENTIFIC PRODUCTION IN THE PERIOD 1980 TO 2015**

| Country | Rank Documents | Web of Science Documents | Rank Category Normalized Citation Impact | Category Normalized Citation Impact | Rank Times Cited | Times Cited | % quant |
|---|---|---|---|---|---|---|---|
| USA | 1 | 15,668,964 | 4 | 1.36 | 1 | 317,718,283 | 27,84 |
| ENGLAND | 2 | 3,416,864 | 7 | 1.32 | 2 | 62,329,263 | 6.07 |
| GERMANY | 3 | 3,106,279 | 21 | 1.14 | 3 | 54,764,994 | 5.52 |
| JAPAN | 5 | 2,846,821 | 32 | 0.87 | 4 | 43,044,121 | 5.06 |
| FRANCE | 6 | 2,202,952 | 22 | 1.12 | 5 | 39,058,338 | 3.91 |
| CANADA | 7 | 2,015,540 | 12 | 1.25 | 6 | 36,903,774 | 3.58 |
| ITALY | 8 | 1,618,202 | 23 | 1.11 | 7 | 25,658,173 | 2.88 |
| CHINA | 4 | 2,923,357 | 40 | 0.8 | 8 | 23,559,062 | 5.19 |
| NETHERLANDS | 12 | 994,507 | 3 | 1.44 | 9 | 21,770,980 | 1.77 |
| AUSTRALIA | 9 | 1,261,594 | 13 | 1.24 | 10 | 21,150,054 | 2.24 |
| SWITZERLAND | 15 | 703,847 | 1 | 1.52 | 11 | 17,037,644 | 1.25 |
| SPAIN | 10 | 1,151,952 | 25 | 1.06 | 12 | 16,664,299 | 2.05 |
| SWEDEN | 16 | 683,400 | 6 | 1.33 | 13 | 15,546,319 | 1.21 |
| BELGIUM | 18 | 525,902 | 5 | 1.34 | 14 | 9,876,888 | 0.93 |
| SCOTLAND | 21 | 488.923 | 8 | 1.31 | 15 | 9,543,443 | 0.87 |
| INDIA | 11 | 1,086,900 | 48 | 0.66 | 16 | 9,260,962 | 1.93 |
| DENMARK | 24 | 384,727 | 2 | 1.47 | 17 | 8,716,512 | 0.68 |
| SOUTH KOREA | 13 | 807,090 | 35 | 0.85 | 18 | 8,423,086 | 1.43 |
| ISRAEL | 22 | 436,468 | 18 | 1.17 | 19 | 8,330,867 | 0.78 |
| FINLAND | 26 | 323,201 | 16 | 1.21 | 20 | 6,411,661 | 0.57 |
| BRAZIL | 17 | 656,866 | 41 | 0.76 | 21 | 6,254,838 | 1.17 |
| AUSTRIA | 25 | 368,086 | 17 | 1.19 | 22 | 6,130,529 | 0.65 |
| TAIWAN | 20 | 522,642 | 34 | 0.86 | 23 | 5,731,055 | 0.93 |
| RUSSIA | 14 | 777,621 | 49 | 0.54 | 24 | 5,695,847 | 1.38 |
| POLAND | 19 | 523,289 | 37 | 0.82 | 25 | 5,030,311 | 0.93 |
| NORWAY | 28 | 271,069 | 10 | 1.28 | 26 | 5,023,837 | 0.48 |
| NEW ZEALAND | 34 | 226,856 | 15 | 1.22 | 27 | 3,733,529 | 0.4 |
| HONG KONG | 32 | 237,734 | 9 | 1.29 | 28 | 3,679,156 | 0.42 |
| GREECE | 27 | 273,613 | 27 | 0.98 | 29 | 3,373,461 | 0.49 |
| TURKEY | 23 | 422,099 | 44 | 0.72 | 30 | 3,317,318 | 0.75 |
| SINGAPORE | 36 | 211,549 | 11 | 1.27 | 31 | 3,095,915 | 0.38 |

| Country | Rank Documents | Web of Science Documents | Rank Category Normalized Citation Impact | Category Normalized Citation Impact | Rank Times Cited | Times Cited | % quant |
|---|---|---|---|---|---|---|---|
| SOUTH AFRICA | 31 | 242,224 | 28 | 0.96 | 32 | 2,829,148 | 0.43 |
| PORTUGAL | 35 | 221,299 | 24 | 1.07 | 33 | 2,710,406 | **0.39** |
| IRELAND | 39 | 186,955 | 18 | 1.17 | 34 | 2,667,808 | 0.33 |
| WALES | 41 | 164,902 | 14 | 1.23 | 35 | 2,661,638 | 0.29 |
| MEXICO | 30 | 242,350 | 41 | 0.76 | 36 | 2,562,837 | 0.43 |
| HUNGARY | 37 | 198,419 | 32 | 0.87 | 37 | 2,511,344 | 0.35 |
| ARGENTINA | 38 | 190,860 | 37 | 0.82 | 38 | 2,281,596 | 0.34 |
| CZECH REPUBLIC | 33 | 227,620 | 26 | 1.02 | 39 | 2,268,814 | 0.4 |
| IRAN | 28 | 271,069 | 41 | 0.76 | 40 | 1,809,049 | 0.48 |
| CHILE | 45 | 118,480 | 31 | 0.9 | 41 | 1,499,915 | 0.21 |
| THAILAND | 46 | 110,327 | 29 | 0.92 | 42 | 1,173,451 | 0.2 |
| NORTHERN IRELAND | 48 | 79,754 | 18 | 1.17 | 43 | 1,158,002 | 0.14 |
| EGYPT | 42 | 140,132 | 47 | 0.68 | 44 | 1,086,518 | 0.25 |
| ROMANIA | 40 | 165,728 | 46 | 0.69 | 45 | 862,279 | 0.29 |
| SAUDI ARABIA | 47 | 107,234 | 30 | 0.91 | 46 | 852,372 | 0.19 |
| MALAYSIA | 43 | 133,325 | 36 | 0.85 | 47 | 795,028 | 0.24 |
| UKRAINE | 44 | 131,084 | 50 | 0.48 | 48 | 782,379 | 0.23 |
| SLOVAKIA | 49 | 78,315 | 37 | 0.82 | 49 | 666,319 | 0.14 |
| PAKISTAN | 50 | 77,060 | 44 | 0.72 | 50 | 539,416 | 0.14 |
| Total | | 50,226,051 | | | | 838,552,838 | |

Source: InCites, Clarivate Analytics. Extracted in 07/12/2017.

We can see in Table 1 that the top ten countries that published the most were the USA, England, Germany, China, Japan, France, Canada, Italy, Australia and Spain. These come to a total of about 72.1% of the world's scientific production among the 50 countries that publish the most. The European Union, together with the USA, is dominant in world presence. The USA occupies first place in the ranking of published documents and citations (Table 1*)*. However, when we analyze the number of normalized citations we find that the first country in the ranking is Switzerland, which although has a smaller number of documents, its production is proportionally more cited than the USA, which is in 4th place, behind Denmark and the Netherlands, that are respectively in, 24th place and 12th place in

the rank of published documents among the 50 countries selected. In analyzing the countries of the European Union (for this analysis we consider the countries of the United Kingdom still as part of the European Union), England is in 1st place in terms of number of documents and Portugal is in 15th place.

Portugal is in 35th place considering the total amount of world scientific production of documents, 17 places behind Brazil, which is in 17th place. However, if we analyze the impact of the citations of these articles we see that Portugal is in 24th place, ahead of Brazil which is in 41st place, China in 40th place and Spain in 25th place. It is 16 places ahead of Brazil. In addition, if we consider that the *CNCI Category Normalized Citation Impact (CNCI) value, which indicates the number of citations normalized by the world average, where 1 represents performance on a par with the world average, values above 1 are considered above average and values below 1 are considered to be below average,* Portugal is slightly above the world average while Brazil is below the world average for the citation index. In relation to the CNCI of the 18 countries that make up the European Union, only 4 countries have an index below the world average. Almeida and Guimarães (2013) state that "the comparison between the five-year periods 1981-1985 and 2006-2010 shows that Brazil is part of a small group of countries (South Korea, China, India, Turkey, Taiwan, Singapore, Portugal, Hong Kong, Spain, Mexico and Greece) that have achieved high growth rates (eight times or more) in scientific production in the last 30 years, i.e. at least four times the world average in the period... In the first five years, none of these countries showed significant individual production (less than 1%) or collective production (less than 3% as a whole); today, these 12 countries together represent 27% of world scientific production, constituting a remarkable progression in the context of international scientific production..."

Switzerland is 52% above the world average for a population of eight million and a half, which makes an average of 8,330 documents per 100,000 inhabitants in the period 1980/2015. Portugal appears 24th in the ranking with 7% more than the world average with a population of 10 million 200,664 thousand inhabitants, presenting 2,160 documents per 100 thousand inhabitants in the same period.

**Scientific Production X Number of Inhabitants**

The following table shows the number of documents published between the years 1980/2015 per 100 thousand inhabitants. We found in the top 10 places: Scotland,

Switzerland, Sweden, Denmark, England, Holland, Finland, Canada, Wales and Israel. Developed countries that have heavy investments in higher education, S&T and with a small population compared to developing countries. In this table Portugal appears in 29th place, ahead of important countries like South Korea and Russia and Brazil in 43rd place.

**Table 2. SCIENTIFIC PRODUCTION X POPULATION BY COUNTRY 1980 - 2015**

| Country (or dependency) | Rank - Documents per 100,000 inhabitants | Population 2017** | Web of Science Documents per 100,000 inhabitants – Total period of 1980-2015 | Web of Science Documents – Total period of 1980-2015 | Web of Science Documents per inhabitant - period of 1980-2015 |
|---|---|---|---|---|---|
| Scotland | 1 | 5,373,000 | 9,100 | 488,923 | 0.09 |
| Switzerland | 2 | 8,454,083 | 8,330 | 703,847 | 0.08 |
| Sweden | 3 | 9,920,624 | 6,890 | 683,400 | 0.07 |
| Denmark | 4 | 5,711,837 | 6,740 | 384,727 | 0.07 |
| England | 5 | 53,012,456 | 6,450 | 3,416,864 | 0.06 |
| Netherlands | 6 | 17,032,845 | 5,840 | 994,507 | 0.06 |
| Finland | 7 | 5,541,274 | 5,830 | 323,201 | 0.06 |
| Canada | 8 | 36,626,083 | 5,500 | 2,015,540 | 0.06 |
| Wales | 9 | 3,004,600 | 5,490 | 164,902 | 0.05 |
| Israel | 10 | 8,323,248 | 5,240 | 436,468 | 0.05 |
| Australia | 11 | 24,641,662 | 5,120 | 1,261,594 | 0.05 |
| Norway | 12 | 5,330,800 | 5,080 | 271,069 | 0.05 |
| New Zealand | 13 | 4,604,871 | 4,930 | 226,856 | 0.05 |
| U.S.A | 14 | 326,474,013 | 4,800 | 15,668,964 | 0.05 |
| Belgium | 15 | 11,443,830 | 4,600 | 525,902 | 0.05 |
| Northern Ireland | 16 | 1,810,863 | 4,400 | 79,754 | 0.04 |
| Austria | 17 | 8,592,400 | 4,280 | 368,086 | 0.04 |
| Ireland | 18 | 4,749,153 | 3,940 | 186,955 | 0.04 |
| Germany | 19 | 80,636,124 | 3,850 | 3,106,279 | 0.04 |
| Singapore | 20 | 5,784,538 | 3,660 | 211,549 | 0.04 |
| France | 21 | 64,938,716 | 3,390 | 2,202,952 | 0.03 |

| Country (or dependency) | Rank - Documents per 100,000 inhabitants | Population 2017** | Web of Science Documents per 100,000 inhabitants – Total period of 1980-2015 | Web of Science Documents – Total period of 1980-2015 | Web of Science Documents per inhabitant - period of 1980-2015 |
|---|---|---|---|---|---|
| Hong Kong | 22 | 7,401,941 | 3,210 | 237,734 | 0.03 |
| Italy | 23 | 59,797,978 | 2,710 | 1,618,202 | 0.03 |
| Greece | 24 | 10,892,931 | 2,510 | 273,613 | 0.03 |
| Spain | 25 | 46,070,146 | 2,500 | 1,151,952 | 0.03 |
| Japan | 26 | 126,045,211 | 2,260 | 2,846,821 | 0.02 |
| Taiwan | 27 | 23,405,309 | 2,230 | 522,642 | 0.02 |
| Czech Republic | 28 | 10,555,130 | 2,160 | 227,620 | 0.02 |
| Portugal | 29 | 10,264,797 | 2,160 | 221,299 | 0.02 |
| Hungary | 30 | 9,787,905 | 2,030 | 198,419 | 0.02 |
| South Korea | 31 | 50,704,971 | 1,590 | 807,090 | 0.02 |
| Slovakia | 32 | 5,426,252 | 1,443 | 78,315 | 0.01 |
| Poland | 33 | 38,563,573 | 1,360 | 523,289 | 0.01 |
| Romania | 34 | 19,237,513 | 860 | 165,728 | 0.01 |
| Chile | 35 | 18,313,495 | 650 | 118,480 | 0.01 |
| Russia | 36 | 143,375,006 | 540 | 777,621 | 0.01 |
| Turkey | 37 | 80,417,526 | 520 | 422,099 | 0.01 |
| South Africa | 38 | 55,436,360 | 440 | 242,224 | 0 |
| Argentina | 39 | 44,272,125 | 430 | 190,860 | 0 |
| Malaysia | 40 | 31,164,177 | 430 | 133,325 | 0 |
| Iran | 41 | 80,945,718 | 330 | 271,069 | 0 |
| Saudi Arabia | 42 | 32,742,664 | 330 | 107,234 | 0 |
| Brazil | 43 | 211,243,220 | 310 | 656,866 | 0 |
| Ukraine | 44 | 44,405,055 | 300 | 131,084 | 0 |
| China | 45 | 1,388,232,693 | 210 | 2,923,357 | 0 |
| Mexico | 46 | 130,222,815 | 190 | 242,350 | 0 |
| Thailand | 47 | 68,297,547 | 160 | 110,327 | 0 |
| Egypt | 48 | 95,215,102 | 150 | 140,132 | 0 |
| India | 49 | 1,342,512,706 | 80 | 1,086,900 | 0 |

| Country (or dependency) | Rank - Documents per 100,000 inhabitants | Population 2017** | Web of Science Documents per 100,000 inhabitants – Total period of 1980-2015 | Web of Science Documents – Total period of 1980-2015 | Web of Science Documents per inhabitant - period of 1980-2015 |
|---|---|---|---|---|---|
| Pakistan | 50 | 188,925,000 | 41 | 77,060 | 0 |

**Source: Elaboration of data by United Nations, Department of Economic and Social Affairs, Population Division. World Population Prospects: The 2015 Revision

According to OECD data for February 2017, Portugal invested 1.28% of GDP in research and development in 2015, while the EU average in 28 countries was 1.9%.

When data are verified by number of scientific publications, they are expanded for all sciences and types of publications, per 100 thousand inhabitants, we see that Portugal, had the following evolution:

- 1981: 3.1 publications per 100 thousand inhabitants;
- 1990: 10.1 publications per 100 thousand inhabitants;
- 2000: 43.5 publications per 100 thousand inhabitants;
- 2010: 136.2 publications per 100 thousand inhabitants and
- 2015: 206.0 publications per 100 thousand inhabitants

We have seen a 20-fold increase in the number of scientific publications from 1990 to 2015. (cf. PORDATA), if we consider from 1981 the increase is 66 times the number of publications.

## Scientific production and the S&T funding system in Portugal

Quoted by Manuel Heitor (2015), the discussion about scientific production in Portugal has been recorded since 1780 when Anastácio da Cunha, a professor at the University of Coimbra, wrote about the scientific backwardness that accompanied Portuguese society. In 1865, Oliveira Martins wrote that besides the lack of raw materials, coal was lacking in more serious raw materials: "judgment, knowledge, acquired education, tradition gained, firmness of government and intelligence in capital." Stating that the destiny of the Portuguese, as a consequence, was to plow land or emigrate to Brazil. Heitor also brings José Mariano Gago who in 1990 in the Manifesto for Science in Portugal describes the country as poor, unequal, with a low level of quality of social, cultural and educational

life that articulates in the scientific and technological aspect with backward institutions, little innovative, not very productive, very dependent, rigid and isolated. The same author (Heitor) states that this panorama began to change in 1974, with the Carnation Revolution that brought the democratization to the country.

In 1995 the Ministry of Science and Technology was created and since 2005 there is a reinforcement of Portuguese investment in innovation and development. From 1996 the Portuguese institutions began to be evaluated independently by international experts, a fact considered key by Heitor (2015) for the construction of the Portuguese scientific system.

Since 2000 with the integration of the European Union there has been an increase in the critical mass in the country which will result in the integration of Portugal into the countries that produce knowledge that is considered cutting edge. It is the result of policies that also include the training of human resources, strengthening of scientific institutions and internationalization.

Heitor (2015) identifies six periods that characterized the evolution of the Portuguese S&T system:

- Until 1967, traces of a scientific basis with two Development Plans;
- From 1967 to 1985: beginning of a scientific planning with the attempt to create a system of science and technology.
- From 1985 to 1995: the integration of Portugal into the European Economic Community creates the conditions for the launch of a System of Innovation and Development with strong internationalization and financing.
- 1995 to 2005: the objective in the period is to approach the European average with independent international assessments and the training of highly qualified human resources through doctoral programs.
- 2005 to 2010: reinforcement in the critical mass and overcoming the scientific backwardness with strong public and private investment in an unprecedented way. Reinforcement in the internationalization and in the academia-company partnership.

- As of 2011: reduction of public and private investment due to the international financial crisis. Changes in evaluation rules, growing selectivity in support of people and areas of knowledge. Reduction of support to the Social and Human Sciences.

We can see, relating, the number of scientific publications per 100 thousand inhabitants, with five of the six periods identified by Heitor (2015) that the policies adopted were of extreme importance for the scientific development of Portugal with a 66-fold increase in production between 1981 and 2015, whose figures ranged from 3.1 publications in 1981 to 206 publications in 2015.

As an illustration of the above, the Ministry of Science, Technology and Higher Education of Portugal (2016) states that the scientific production of the internationally recognized country multiplied by 35 between 1982 and 2012. In this same period the increase of patents registered in Europe increased 45 times and the negative balance of technology payments has been balanced since 2007. In 2012 the doctoral professors in public universities exceeded 70%.

## 5. DATA AND DISCUSSION

### Portuguese Scientific Production

We observe that until the 1970s the production was very reduced compared to the other periods. It began to grow from 1980 when it had 4,054 documents published. It is worth noting that the growth occurs after the Carnation Revolution (1974), but before joining the European Union (1986). From the 1980s the growth is exponential. Between 1980 and 1990 a 5-fold increase. Between 1990 and 2000 a 3-fold increase and between 2000 and 2010 the number of documents doubled. If we consider the last 4 decades we see that the number of documents published went from 4,054 to 111,334, an increase of 27 times.

Considering the scientific production of the period of each survey with the total population at the time, we see that in 1990 Portugal accumulated 245.2 documents per 100,000 inhabitants. In 2015, 1,317.72 documents per 100,000 inhabitants between 2005/2015. In this sense, it can be observed that the growth was not only in absolute numbers, but in the proportion per inhabitants.

## 6. AREAS OF KNOWLEDGE

The following table presents the 50 areas of knowledge in a total of 242 areas that contributed the most in Portuguese scientific production, in the number of citations, according to data from the Web of Science.

**Table 3. SCIENTIFIC PRODUCTION BY AREA OF KNOWLEDGE PORTUGAL - BY CITATION - 1980/90 and 2005/15**

| Area | 2005 2015 ORDERED BY NUMBER OF CITATIONS (TIMES CITED) | | | | 1980 1990 ORDERED BY NUMBER OF CITATIONS (TIMES CITED) | | | |
|---|---|---|---|---|---|---|---|---|
| | Rank Citation *242 areas | Web of Science Documents | Category Normalized Citation Impact | Times Cited | Rank Citation *187 areas | Web of Science Documents | Category Normalized Citation Impact | Times Cited |
| ASTRONOMY & ASTROPHYSICS | 1 | 2,564 | 2.19 | 83,050 | 7 | 72 | 1.15 | 2,059 |
| BIOCHEMISTRY & MOLECULAR BIOLOGY | 2 | 3,656 | 1.31 | 69,115 | 1 | 140 | 0.97 | 5,188 |
| PHYSICS, PARTICLES & FIELDS | 3 | 2,306 | 2.11 | 56,354 | 4 | 80 | 1.39 | 2,511 |
| CHEMISTRY, PHYSICAL | 4 | 3,214 | 1.05 | 54,701 | 2 | 152 | 0.98 | 3,091 |
| ECOLOGY | 5 | 1,976 | 1.59 | 45,410 | 65 | 11 | 0.9 | 247 |
| MATERIALS SCIENCE, MULTIDISCIPLINARY | 6 | 3,268 | 1.06 | 44,565 | 17 | 69 | 1.13 | 1,222 |
| GENETICS & HEREDITY | 7 | 1,957 | 1.5 | 44,402 | 23 | 38 | 0.8 | 961 |
| PHYSICS, MULTIDISCIPLINARY | 8 | 1,240 | 2.43 | 44,383 | 33 | 49 | 0.66 | 666 |
| ENVIRONMENTAL SCIENCES | 9 | 2,602 | 1.29 | 42,076 | 29 | 29 | 2.11 | 720 |
| NEUROSCIENCES | 10 | 1,658 | 1.7 | 37,885 | 8 | 27 | 1.77 | 1,851 |
| CELL BIOLOGY | 11 | 1,430 | 1.75 | 37,715 | 38 | 37 | 0.39 | 588 |
| CHEMISTRY, MULTIDISCIPLINARY | 12 | 1,965 | 1.2 | 37,420 | 5 | 106 | 2.85 | 2,484 |
| PHYSICS, NUCLEAR | 13 | 1,312 | 2.4 | 34,189 | 3 | 103 | 1.14 | 2,519 |
| MICROBIOLOGY | 14 | 1,685 | 1.34 | 33,456 | 27 | 23 | 1.2 | 851 |
| ONCOLOGY | 15 | 1,362 | 1.71 | 30,678 | 34 | 26 | 0.77 | 658 |
| CLINICAL NEUROLOGY | 16 | 1,303 | 2.76 | 30,157 | 12 | 21 | 2.22 | 1,653 |

| Area | 2005 2015 ORDERED BY NUMBER OF CITATIONS (TIMES CITED) | | | | 1980 1990 ORDERED BY NUMBER OF CITATIONS (TIMES CITED) | | | |
|---|---|---|---|---|---|---|---|---|
| | Rank Citation *242 areas | Web of Science Documents | Category Normalized Citation Impact | Times Cited | Rank Citation *187 areas | Web of Science Documents | Category Normalized Citation Impact | Times Cited |
| BIOTECHNOLOGY & APPLIED MICROBIOLOGY | 17 | 1,709 | 1.46 | 26,699 | 39 | 33 | 0.72 | 581 |
| PHARMACOLOGY & PHARMACY | 18 | 1,677 | 1.55 | 24,497 | 32 | 37 | 0.85 | 675 |
| PHYSICS, APPLIED | 19 | 2,068 | 0.98 | 23,706 | 11 | 60 | 1.56 | 1,681 |
| IMMUNOLOGY | 20 | 1,067 | 1.45 | 23,671 | 37 | 30 | 0.64 | 595 |
| ENGINEERING, CHEMICAL | 21 | 1,411 | 1.36 | 23,643 | 16 | 54 | 1.98 | 1,290 |
| PHYSICS, CONDENSED MATTER | 22 | 1,435 | 1 | 23,216 | 21 | 87 | 0.59 | 1,054 |
| MARINE & FRESHWATER BIOLOGY | 23 | 1,864 | 1.21 | 22,156 | 25 | 36 | 1.52 | 895 |
| ENGINEERING, ELECTRICAL & ELECTRONIC | 24 | 2,329 | 1.42 | 20,624 | 67 | 30 | 0.6 | 242 |
| EVOLUTIONARY BIOLOGY | 25 | 906 | 1.17 | 17,294 | 122 | 2 | 0.77 | 59 |
| PLANT SCIENCES | 26 | 1,458 | 1.15 | 16,829 | 20 | 39 | 1.26 | 1,061 |
| FOOD SCIENCE & TECHNOLOGY | 27 | 1,186 | 1.38 | 16,406 | 95 | 6 | 1.47 | 123 |
| INFECTIOUS DISEASES | 28 | 822 | 1.64 | 15,991 | 87 | 10 | 0.52 | 144 |
| CHEMISTRY, INORGANIC & NUCLEAR | 29 | 1,066 | 1.25 | 15,891 | 6 | 98 | 1.13 | 2,096 |
| NANOSCIENCE & NANOTECHNOLOGY | 30 | 872 | 1.22 | 15,235 | 123 | 2 | 1.98 | 57 |
| GEOSCIENCES, MULTIDISCIPLINARY | 31 | 1,294 | 1.22 | 14,783 | 51 | 22 | 1.02 | 394 |
| CHEMISTRY, APPLIED | 32 | 877 | 1.44 | 14,674 | 112 | 2 | 2.49 | 77 |
| CHEMISTRY, ANALYTICAL | 33 | 1,030 | 1.11 | 13,870 | 10 | 59 | 1.75 | 1,775 |
| METEOROLOGY & ATMOSPHERIC SCIENCES | 34 | 585 | 1.73 | 13,530 | 74 | 10 | 2,12 | 186 |
| 186CHEMISTRY, ORGANIC | 35 | 908 | 1.08 | 13,460 | 19 | 69 | 0.77 | 1,064 |

| Area | 2005 2015 ORDERED BY NUMBER OF CITATIONS (TIMES CITED) | | | | 1980 1990 ORDERED BY NUMBER OF CITATIONS (TIMES CITED) | | | |
|---|---|---|---|---|---|---|---|---|
| | Rank Citation *242 areas | Web of Science Documents | Category Normalized Citation Impact | Times Cited | Rank Citation *187 areas | Web of Science Documents | Category Normalized Citation Impact | Times Cited |
| BIOCHEMICAL RESEARCH METHODS | 36 | 850 | 1.23 | 13,133 | 70 | 12 | 0.66 | 222 |
| PHYSICS, ATOMIC, MOLECULAR & CHEMICAL | 37 | 1,109 | 0.89 | 12,951 | 14 | 74 | 0.84 | 1,435 |
| CARDIAC & CARDIOVASCULAR SYSTEMS | 38 | 717 | 1.87 | 12,675 | 88 | 14 | 0.44 | 143 |
| OCEANOGRAPHY | 39 | 886 | 1.3 | 12,051 | 36 | 13 | 1.58 | 632 |
| POLYMER SCIENCE | 40 | 752 | 1.24 | 11,773 | 53 | 19 | 0.99 | 362 |
| PHYSICS, FLUIDS & PLASMAS | 41 | 786 | 1.47 | 11,472 | 77 | 7 | 1.25 | 176 |
| ENGINEERING, ENVIRONMENTAL | 42 | 586 | 1.48 | 11,329 | 73 | 15 | 1.46 | 187 |
| ENDOCRINOLOGY & METABOLISM | 43 | 829 | 1.2 | 11,217 | 46 | 21 | 0.65 | 466 |
| ENGINEERING, BIOMEDICAL | 44 | 677 | 1.87 | 10,940 | 85 | 12 | 0.67 | 146 |
| CRITICAL CARE MEDICINE | 45 | 246 | 3.34 | 10,668 | 180 | | | |
| MATERIALS SCIENCE, BIOMATERIALS | 46 | 492 | 1.48 | 10,637 | 151 | 1 | 0.33 | 11 |
| MEDICINE, RESEARCH & EXPERIMENTAL | 47 | 748 | 1.82 | 10,634 | 24 | 22 | 3.41 | 904 |
| ENERGY & FUELS | 48 | 832 | 1.17 | 10,357 | 60 | 10 | 3.76 | 269 |
| TOXICOLOGY | 49 | 765 | 1.26 | 10,340 | 102 | 5 | 1.03 | 107 |
| BIODIVERSITY CONSERVATION | 50 | 514 | 1.61 | 10,289 | 180 | | | |

Source: InCites, Clarivate Analytics. Extracted in 07/12/2017.

Among the 50 areas of knowledge most cited in the 2005/15 period, the first 10 areas that stand out in descending order are Astronomy & Astrophysics (1;7), Biochemistry & Molecular Biology(2;1), Physics-Particles & Fields(3;4), Chemistry-Physical (4;2), Ecology (5;65), Materials-Science-Multidisciplinary (6;17), Genetics & Heredity (7;23), Physics-Multidisciplinary (8;33), Environmental sciences (9;29) and Neurosciences (10;8), where the first number, within parentheses, represents the position in 2005/2015 and the second in 1980/1990. The area of Physics-Multidisciplinary, although occupying the 8th position, was

the area that had the highest increase, comparing, in the CNCI index, from 0.66 to 2.43, an increase of 3.7 times.

In this comparative table of the 50 best ranked areas, as citation, in the 2005/15 period compared to the 1980/90 period, we see that 5 areas remain in the top 10 places, in both periods, as Astronomy & Astrophysics (1;7), Biochemistry & Molecular Biology(2;1), Physics-Particles & Fields(3;4), Chemistry-Physical (4;2), and Neurosciences (10;8).

When analyzing the number of citations we see that the growth is expressive: Astronomy & astrophysics went from 2,059 citations in 1980/90 to 83,050, 40 times higher, a rate that accompanies the evolution of the scientific production of Portugal; Biochemistry & Molecular Biology went from 5189 in 1980/90 to 69,115 in 2005/15, a rate 13 times higher; Physics, Particles & fields in 1980/90 presents 22 times greater evolution rate than the number presented in 1980/90, jumping 2511 citations to 56,354 in 2005/15; Chemistry Physical had 3091 in 1980/90 and went to 54,701 citations in 2005/2015, 17 times higher.

Another 4 areas that in 1980/90 were in the top 10 had a decrease, although they are still among the 50 areas that stood out most of 2005/15 as Physics-Nuclear; Chemistry-Multidisciplinary; Chemistry, Inorganic & Nuclear and Chemistry-Analytical.

In total we have 32 areas that have risen in the ranking of citations: Astronomy & Astrophysics; Physics, Particles & Fields; Ecology; Materials Science, Multidisciplinary; Genetics & Heredity; Physics, Multidisciplinary; Environmental Sciences; Cell Biology; Microbiology; Oncology; Biotechnology & Applied Microbiology; Pharmacology & Pharmacy; Immunology; Marine & Freshwater Biology; Engineering, electrical & Electronic; Evolutionary Biology; Food Science & Technology; Infectious Diseases; Nanoscience & Nanotechnology; Geosciences, Multidisciplinary; Chemistry, Applied; Meteorology & Atmospheric Sciences; Biochemical Research Methods; Cardiac & Cardiovascular Systems; Polymer Science; Physics, Fluids & Plasmas; Engineering, Environmental; Endocrinology & Metabolism; Engineering, Biomedical; Materials Science, Biomaterials; Energy & Fuels; Toxicology.

There are 16 areas that fell in the ranking of citations: Biochemistry & Molecular Biology; Chemistry, Physical; Neurosciences; Chemistry, Multidisciplinary; Physics, Nuclear; Clinical Neurology; Physics, Applied; Engineering, Chemical; Physics, Condensed Matter; Plant Sciences; Chemistry, Inorganic & Nuclear; Chemistry, Analytical; Chemistry, Organic; Physics, Atomic, Molecular & Chemical; Oceanography; Medicine, Research & Experimental.

When analyzing the CNCI index of the first four areas mentioned in the "citation ranking" we see a growth from the qualitative point of view: Astronomy & Astrophysics nearly doubled the index going from 1.15 to 2.19; Biochemistry & Molecular Biology was 0.97 to 1.31, an increase of 35%; Physics, Particles & Fields advanced 51% going from 1.39 in 1980/90 to 2.11 in 2005/15; Physical Chemistry despite being the least expressive was from 0.98 to 1.05 being above the average of 1. This shows that in these areas there was an improvement in the quality of the publications, especially when compared to the production of the other countries. The area of Neurosciences, one of the prominent areas among the first 10 had a growth rate 20 times greater in the comparison between the period 1980/90 and 2005/15, going from 1851 citations to 37,885 citations.

Three areas deserve special mention, since they performed well in the CNCI index in relation to the number of citations and, in 1980/1990, they were not among the top 100 in the "ranking", however, they were among the 50 most outstanding areas of 2005/15, in quantity of quotations: *Evolutionary Biology; Materials Science, Biomaterials and Toxicology*. The Evolutionary Biology area, with CNCI of 0.77, in 1980/90, achieved in 2005/15 the index of 1.17, and jumped from 122th to 25th place. The area *Materials Science, Biomaterials,* with CNCI of 0.33 in 1980/90, achieved in 2005/2015 the CNCI index of 1.48 and rose from 151st to 46th place. The Toxicology area had the CNCI index of 1.03 in 1980/1990 and in 2005/15 reached 1.26 and went from 102nd place to 49th place in the ranking of number of citations.

There was a marked decrease in the CNCI index of the Chemistry-Multidisciplinary areas, from 2.85 in 1980/90 to 1.20 in 2005/15, a decrease of 1.65 (58%) and Chemistry-Analytical from 1.75 in 1980/90 to 1.11 in 2005/15, a decrease of 0.64 (37%).

Two areas did not appear in 1980/90: Critical Care Medicine and Biodiversity Conservation. Both areas had more than 10,000 citations and a CNCI of 3.34 and 1.61 respectively. If we consider that the most cited area in 1980/1990 was Biochemistry & Molecular, with 5,188 citations and a CNCI of 0.97, we can say that they presented an excellent performance.

When analyzing by the number of published documents we will note the following:

- The greater the number of documents, the greater the number of citations;
- It is observed the emergence of a new area among the 50 that published the most: Sport Sciences (45th place).

We also note that:

- Material Science Multidisciplinary went from 10th to 2nd place;
- Environmental Sciences went from 26th place in the ranking to 4th place;
- Astronomy and Astrophysics went from 9th to 5th place;
- Engineering, Electrical & Electronic goes from 25th to 6th;
- Physics, Applied from 12th to 8th place and
- Ecology went from 41st to 9th.

The only area that varied significantly in the downward direction was Chemistry Multidisciplinary, which went from 3rd to 10th place.

Comparing the decades of 1980/90 and 2005/15 with regard to the number of documents, we observed that the CNCI *(Impact of Citation by Normalized Category Indicator)* presents, in the first 47 places, values above 1, that is, above the world average. In the first 5 places, referring to the areas of Clinical Neurology; Physics, Multidisciplinary; Physics, Nuclear; Astronomy & Astrophysics and Physics, Particles & Fields, the value is equivalent to 2 times the world average.

When we look at the world average impact, we find that well-positioned areas in 2005/15 did not even appear in 1980/90: Architecture, Art; Agricultural Economics & Policy; Cell & Tissue Engineering. Note that the presence of the social and human sciences, qualitatively in the 2005/15 rank, is expressive. However, the number of documents published is inversely proportional and inexpressive. Although there is this distortion in the comparison of the CNCI value (much higher than normal), we are analyzing predominantly areas that do not have a strong hold like the exact sciences.

## 7. INSTITUTIONS OF PORTUGAL AND SCIENTIFIC PRODUCTION

The ranking of the best placed Portuguese institutions appears in the Table below.

**Table 4. SCIENTIFIC PRODUCTION OF THE INSTITUTIONS OF PORTUGAL - BY NUMBER OF DOCUMENTS**

| Institution | 2005/2015 | | | | 1980/1990 | | | |
|---|---|---|---|---|---|---|---|---|
| | Rank documents | Web of Science Documents | Category Normalized Citation Impact | Times Cited | Rank documents | Web of Science Documents | Category Normalized Citation Impact | Times Cited |
| University of Lisbon + Instituto Superior Tecnico | 1 | 47,858 | 1.2 | 551,512 | 1<br>3 | 2,401<br>951 | 0.83<br>1.00 | 34,243<br>16,630 |
| University of Porto | 2 | 33,286 | 1.16 | 400,007 | 2 | 1,177 | 0.91 | 17,347 |
| Technical University of Lisbon | 3 | 24,201 | 1.29 | 283,855 | | | | |
| University of Coimbra | 4 | 23,363 | 1.08 | 245,777 | 4 | 877 | 0.71 | 11,229 |
| University of Aveiro | 5 | 16,250 | 1.09 | 189,314 | 7 | 166 | 0.83 | 2,057 |
| NOVA University of Lisbon | 6 | 14,219 | 1.17 | 175,782 | 6 | 321 | 1.17 | 4,753 |
| University of Minho | 7 | 14,154 | 1.24 | 173,757 | 9 | 106 | 0.82 | 1,359 |
| University of Algarve | 8 | 4,764 | 0.99 | 51,609 | 21 | 15 | 1.54 | 537 |
| University of Trás-os-Montes & Alto Douro | 9 | 4,198 | 1 | 39,359 | 17 | 22 | 0.95 | 216 |
| Sao Joao Hospital | 10 | 4,162 | 0.80 | 28,997 | 8 | 136 | 0.56 | 1,131 |
| University of Beira Interior | 11 | 3,532 | 0.95 | 24,983 | 23 | 6 | 0.65 | 41 |
| Hospital Santa Maria | 12 | 3,276 | 0.92 | 28,844 | 5 | 361 | 0.49 | 2,733 |
| Hospital and University Centre of Coimbra (CHUC) | 13 | 3,175 | 0.79 | 25,031 | 11 | 86 | 0.63 | 834 |
| University of Evora | 14 | 3,116 | 1.13 | 38,728 | 15 | 27 | 0.52 | 303 |
| Polytechnic Institute of Porto | 15 | 2,946 | 1.14 | 21,412 | 25 | 2 | 0.25 | 10 |
| Instituto de Telecomunicacoes | 16 | 2,486 | 1.14 | 19,616 | - | | | |
| University Institute of Lisbon | 17 | 2,045 | 1.01 | 10,664 | 16 | 26 | 0.28 | 101 |
| Polytechnic Institute of Lisbon | 18 | 1,810 | 1 | 14,878 | 24 | 5 | 1.06 | 124 |
| Catholic University of Portugal | 19 | 1,660 | 1.06 | 19,202 | 18 | 21 | 1.00 | 331 |
| University of the Azores | 20 | 1,627 | 0.95 | 16,622 | 19 | 20 | 1.58 | 632 |

| Institution | 2005/2015 | | | | 1980/1990 | | | |
|---|---|---|---|---|---|---|---|---|
| | Rank documents | Web of Science Documents | Category Normalized Citation Impact | Times Cited | Rank documents | Web of Science Documents | Category Normalized Citation Impact | Times Cited |
| Instituto Gulbenkian de Ciencia | 21 | 1,246 | 1.38 | 28,312 | 10 | 99 | 0.31 | 862 |
| Polytechnic Institute of Bragança | 22 | 1,163 | 1.24 | 14,534 | | | | |
| University of Madeira | 23 | 1,142 | 1.20 | 12,804 | | | | |
| Instituto Nacional de Saude Dr. Ricardo Jorge | 24 | 1,096 | 1.06 | 13,953 | 20 | 18 | 0.40 | 176 |
| Institute of Hygiene & Tropical Medicine UNL | 25 | 1,019 | 0.96 | 11,230 | 20 | 18 | 1.04 | 178 |
| Portuguese Institute of Oncology | 26 | 926 | 0.99 | 9,638 | 12 | 66 | 0.83 | 821 |
| Fernando Pessoa University | 27 | 917 | 0.95 | 10,130 | | | | |
| Faculdade de Ciencias e Tecnologia (FCT) | 28 | 851 | 1.11 | 5,167 | 23 | 6 | 0.47 | 44 |
| National Civil Engineering Laboratory | 29 | 839 | 1.09 | 5,155 | 14 | 32 | 1.26 | 344 |
| Instituto Superior Psicologia Aplicada (ISPA) | 30 | 787 | 0.76 | 6,741 | 26 | 1 | 1.32 | 17 |
| Laboratorio Nacional de Energia e Geologia IP (LNEG) | 31 | 736 | 1.27 | 7,525 | | | | |
| Centro Hospitalar de Lisboa Ocidental, EPE | 32 | 730 | 0.65 | 5,206 | | | | |
| Instituto Superior de Ciencias da Saude Egas Moniz | 33 | 697 | 0.98 | 8,892 | 13 | 36 | 0.51 | 567 |
| Centro Hospitalar de Lisboa Central, EPE | 34 | 659 | 1.41 | 8,804 | | | | |
| Polytechnic Institute of Viseu | 35 | 622 | 0.86 | 4,065 | | | | |
| Egas Moniz Hospital | 36 | 574 | 1.01 | 6,630 | 22 | 9 | 7.17 | 1,317 |

| Institution | 2005/2015 | | | | 1980/1990 | | | |
|---|---|---|---|---|---|---|---|---|
| | Rank documents | Web of Science Documents | Category Normalized Citation Impact | Times Cited | Rank documents | Web of Science Documents | Category Normalized Citation Impact | Times Cited |
| Polytechnic Institute of Setubal | 37 | 495 | 0.87 | 3,269 | | | | |
| Champalimaud Foundation | 38 | 471 | 2.09 | 9,684 | 26 | 1 | | |
| Hospital Professor Doutor Fernando Fonseca, EPE | 39 | 456 | 0.62 | 1,932 | | | | |
| Portuguese Institute of Sea & Fisheries Research (IPIMAR) | 40 | 450 | 1.04 | 7,553 | 26 | 1 | 0.60 | 16 |
| Hospital de Braga | 41 | 431 | 0.31 | 952 | | | | |
| Institute of Telecommunications - Coimbra | 42 | 414 | 1.56 | 5,816 | | | | |
| Polytechnic Institute of Viana do Castelo | 43 | 390 | 0.76 | 2,554 | | | | |
| International Iberian Nanotechnology Laboratory | 44 | 382 | 1.23 | 4,834 | | | | |
| Universidade Aberta | 45 | 371 | 0.78 | 1,783 | | | | |
| Polytechnical Institute of Coimbra (IPC) | 46 | 367 | 0.91 | 1,704 | 26 | 1 | 1.66 | 15 |
| Polytechnic Institute of Castelo Branco | 47 | 354 | 0.79 | 1,809 | | | | |
| Bial Group | 48 | 321 | 6.66 | 3,034 | | | | |
| Polytechnic Institute of Leiria | 49 | 290 | 0.82 | 1,599 | | | | |
| Instituto Portugues do Mar e da Atmosfera | 50 | 257 | 1.29 | 1,819 | | | | |
| Polytechnic Institute of Tomar | 51 | 256 | 0.89 | 1,901 | | | | |
| Polytechnic Institute of Cávado and Ave | 52 | 236 | 0.71 | 1,039 | | | | |
| Catholic University of Portugal Porto | 53 | 235 | 1.26 | 1,504 | | | | |

| Institution | 2005/2015 | | | | 1980/1990 | | | |
|---|---|---|---|---|---|---|---|---|
| | Rank documents | Web of Science Documents | Category Normalized Citation Impact | Times Cited | Rank documents | Web of Science Documents | Category Normalized Citation Impact | Times Cited |
| Instituto Universitario da Maia (ISMAI) | 54 | 234 | 0.98 | 2,573 | | | | |
| Polytechnic Institute of Guarda | 55 | 161 | 0.82 | 778 | | | | |
| Banco de Portugal | 56 | 158 | 1.12 | 1,055 | | | | |
| Instituto Nacional de Medicina Legal e Ciencias Forenses, IP | 57 | 141 | 0.67 | 1,045 | | | | |
| National Institute for Agricultural Research Portugal | 58 | 135 | 1.21 | 1,890 | 17 | 22 | 0.33 | 144 |
| Instituto Nacional de Investigacao Agraria e Veterinaria, IP (INIAV) | 59 | 132 | 0.89 | 718 | | | | |
| Politechnic Institute of Beja | 60 | 109 | 1.20 | 781 | | | | |
| The Nursing College of Coimbra | 61 | 105 | 0.26 | 169 | | | | |
| Politechnic Institute of Santarem | 62 | 92 | 1.13 | 470 | | | | |
| Politechnic Institute of Portalegre | 63 | 83 | 0.79 | 282 | | | | |
| Portugal Telecom | 64 | 81 | 0.53 | 153 | | | | |
| Universidade Portucalense Infante D. Henrique | 65 | 74 | 0.44 | 74 | | | | |
| Instituto Portugues do Sangue e da Transplantacao, IP | 66 | 71 | 0.34 | 97 | | | | |
| Escola Superior de Enfermagem do Porto (ESEP) | 67 | 65 | 0.77 | 95 | | | | |

| Institution | 2005/2015 | | | | 1980/1990 | | | |
|---|---|---|---|---|---|---|---|---|
| | Rank documents | Web of Science Documents | Category Normalized Citation Impact | Times Cited | Rank documents | Web of Science Documents | Category Normalized Citation Impact | Times Cited |
| Nacional do Medicamento e Produtos de Saude, IP (INFARMED) | 68 | 46 | 1.19 | 242 | | | | |
| Escola Superior de Enfermagem de Lisboa (ESEL) | 69 | 32 | 0.39 | 77 | | | | |
| Escola Superior de Hotelaria e Turismo do Estoril (ESHTE) | 70 | 31 | 0.26 | 80 | | | | |
| Escola Superior Educacao Coimbra | 71 | 26 | 0.31 | 64 | 26 | 1 | 1.66 | 15 |
| Infante D. Henrique Nautical School | 72 | 21 | 1.38 | 166 | | | | |
| Autoridade da Concorrencia | 73 | 16 | 0.69 | 94 | | | | |
| Santa Casa da Misericordia de Lisboa | 74 | 13 | 0.26 | 36 | | | | |
| **TOTAL** | | **234,134** | | **2,582,460** | | **7,037** | | **99,127** |

Source: InCites, Clarivate Analytics. Extracted in 07/12/2017.

The first 10 Portuguese institutions with the greatest number of documents published in the decade 2005-2015 are: University of Lisbon (together with Instituto Superior Técnico), University of Porto, Technical University of Lisbon, University of Coimbra, University of Aveiro, Nova University of Lisbon, University of Minho**,** University of Algarve, University of Trás-os-Montes & Alto Douro and São João Hospital. If we consider the total of 234,134 documents produced by these 74 institutions in the 2005/15 period, the first 10 institutions represent 186,455 documents, 79.64% of the scientific production in Portugal.

Among the 74 institutions, there was an increase in the number of publications in 32 institutions. In descending order, the top 10 were the University of Lisbon (along with the Superior Technical Institute), University of Porto, Technical University of Lisbon, University of Coimbra, Aveiro University, Nova University of Lisbon, University of Minho**,** University

of Algarve, University of Trás os Montes & Alto Douro and São João Hospital. In the periods compared, 42 institutions only published between 2005/2015.

The first 10 Portuguese institutions with the greatest number of citations in the decade 2005-2015 are: University of Lisbon (together with Instituto Superior Técnico), University of Porto, Technical University of Lisbon, University of Coimbra, University of Aveiro, Nova University of Lisbon, University of Minho**,** University of Algarve, University of Trás-os-Montes & Alto Douro and University of Évora. The last one, in terms of publication of documents, is in 14th place. If we consider the total of 2,582,460 citations by these 74 institutions in the 2005/15 period, the first 10 institutions represent 2,149,700 citations, 83.24% of citations of the scientific production in Portugal.

We would like to point out that in 2013 the merger of the Universidades Clássica e Técnica de Lisboa and the IST - Instituto Superior Técnico became part of the University of Lisbon. Some of the IST's scientific indicators have been considered in international rankings as part of the performance of the University of Lisbon, as happened in the 2014 edition of the THE (Times Higher Education). The Web of Science presents these indices separately in the 1980/90 period, but we chose to add them.

In the period 2005-2015, the University of Lisbon (+ Instituto Superior Técnico) is the first with the highest number of citations with 551,512 and 47,858 documents, and we observe the CNCI, it is in 5th place, among 25 institutions that have published over 1,000 documents. The best ranked institution in terms of CNCI, if we consider a minimum production of 1000 documents, was the Instituto Gulbenkian de Ciencia, with a CNCI of 1.38, which in the 1980/90 decade published 99 documents and had a CNCI of 0.31, well below the world average.

## 8. Final Considerations

The data presented show the evolution of Portugal in the panorama of scientific production since 1970. After the period of authoritarian and obscurantist rule, the country experienced a remarkable growth in its scientific production. Between 1980 and 2015 it is in 37th place in the world scientific production considering the number of documents that were published. In this interval a CNCI of 1.07 was registered ahead of Japan, South Korea and Russia, just as some examples of countries considered leaders

Since 1990, already integrated into the European Union, the country has made important leaps in scientific production, from 10.1 publications per 100 thousand inhabitants to 43.5 publications in 2000, 136.2 in 2010 and 206.0 in 2015. We consider that two significant factors have contributed significantly to these leaps: the creation of specific public policies based on the creation of a System of Innovation and Development whose characteristics are internationalization and funding and the other factor that is intrinsically linked to the previous one is joining the European Union from 1985.

The Ministry of Science, Technology and Higher Education of Portugal reports that in 2016 the production of the internationally recognized country multiplied by 35, registered patents 45 times and doctoral professors in public universities exceed the 70% mark, since it portrays the emphasis on capacity building.

Of the areas that most published in the decade 1980-90, namely: Physical Chemistry; Biochemistry & Molecular Biology, Physical Chemistry, Nuclear Physics, Physics Particles & Fields, Inorganic & Nuclear Chemistry, exhibit a strong mastery of the exact sciences. In the 2005/15 decade, the first two areas continued, while we will see a strong presence of Astronomy & Astrophysics, Material Science Multidisciplinary and Genetics & Heredity among the most outstanding. This same role is repeated in the number of published documents with the addition of the areas of Physical Chemistry and Ecology. Among the 50 best ranked is the appearance of Critical Care Medicine with a high CNCI index and the emergence of Biodiversity Conservation.

The areas that obtained the highest number of citations in the 2005/15 decade were: Biochemistry & Molecular Biology; Materials Science, Multidisciplinary; Chemistry, Physical; Environmental Sciences; Astronomy & Astrophysics; Engineering, Electrical & Electronic; Physics, Particles & Fields; Physics, Applied; Ecology and Chemistry, Multidisciplinary.

When we look at the first 5 areas of the indicators of quantity of published documents, teams cited and CNCI, we find an intersection set and two sub-sets. The first brings together the three indicators. It consists of the areas of Astronomy & Astrophysics and Physics, Particles & Fields. A sub-set gathers the indicators of quantity of published documents and times cited. This is composed of the areas of Chemistry, Physical and Materials Science, Multidisciplinary. Another subset consisting of the number of citations and the CNCI brings together Astronomy & Astrophysics and Physics, Particles & Fields.

The institutions that are in the first 5 places in the ranking, considering the number of documents, are: University of Lisbon + Instituto Superior Técnico; University of Porto; Technical University of Lisbon; University of Coimbra; University of Aveiro.

Considering the indicator of number of citations, we have: University of Lisbon + Instituto Superior Técnico; University of Porto; Technical University of Lisbon; University of Coimbra and University of Aveiro.

If the indicator is the CNCI, we verify that the first 5 are Instituto Gulbenkian de Ciências; Technical University of Lisbon; University of Minho; Polytechnic Institute of Bragança; University of Lisbon + Instituto Superior Técnico. In the ranking by CNCI 3 institutions appeared that were not present in the two previous indicators: first place in the ranking, Instituto Gulbenkian de Ciências; the University of Minho and the Polytechnic Institute of Bragança.

Repeating the verification of the intersection between the three indicators, we can observe that between the number of documents and the number of citations, the following appear in common: University of Lisbon + Instituto Superior Técnico; University of Porto; Technical University of Lisbon; University of Coimbra; University of Aveiro, repeating, moreover, the same positions in the two rankings.

Sharing the rankings, number of citations and CNCI we find two institutions: Technical University of Lisbon and University of Lisbon + Instituto Superior Técnico. Crossing the results of the number of documents and CNCI, we find the same two institutions.

The best ranked institution in terms of CNCI, if we consider a minimum production of 1000 documents, was the Instituto Gulbenkian de Ciencia. The Technical University of Lisbon, the University of Minho, the Polytechnic Institute of Bragança, the University of Lisbon (+ Instituto Superior Técnico) and the University of Madeira are the other 4 institutions.

It is clear that the combination of greater investments in research and the qualification of human resources in conjunction with joining the European Union has been of great benefit to S&T in Portugal. This has led the country to take an increasingly qualitative position in the international scientific landscape, as evidenced by the data presented. It should be noted that growth is largely greater in the exact sciences, as it focuses directly on the material progress of a Nation.

The most important consideration, in our judgment, though redundant, is that it is necessary to combine and coordinate public policies, financing and international collaboration in the long term so that the scientific production, S&T of a country becomes significant in the world context of the production of knowledge.

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