

GREEK SCIENTIFIC PUBLICATIONS 1998-2012

A Bibliometric Analysis of Greek Publications in International Scientific Journals

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A Bibliometric Analysis
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Data processing was enabled by software solutions which EKT developed to meet the requirements of this study developed by:

- Dr Dimitris Karaiskos - data processing & software developer
- Costas Stamatis- data cleaning and control techniques
- Andreas Kalaitzis - developer of the study's electronic edition

PREFACE



The study entitled 'Greek Scientific Publications 1998-2012, a Bibliometric Analysis of Greek Publications in International Scientific Journals' is part of the series of studies carried out by EKT in order to highlight Greek scientific performance on an international level.

The series includes bibliometric analyses which align with the accepted methodological approaches in bibliometric science and uses data from the Web of Science and Scopus databases on alternate years. More specifically, the studies cover a fifteen-year time period and are published annually using the Web of Science every even year and Scopus every odd year.

The current publication covers the fifteen-year period 1998-2012 and uses data from the Web of Science. Along with the previous three studies (two using the Web of Science and one Scopus), it provides a continuous and reliable means of monitoring and presenting the developments connected with Greek publications and their position in the international environment (globally, the OECD and the European Union).

We have added new indicators and figures, while the electronic environment has been enriched with new functionalities and capabilities. In brief, the following new data has been added to the data and indicators to be found in our previous studies:

Figure 2.1.2 and 2.1.3 attempt to give a picture of the productivity of the Greek research system regarding scientific publications in relation to national R&D Expenditure (GERD) and researchers' population.

Figure 2.4.2 presents data highlighting the important contribution/leadership of Greek scientists in the area of publications with high impact.

Figure 2.5.5 records the scientific areas in which Greece displays excellence as well as a greater speciality in producing publications in comparison with global productivity.

Figure 2.6.4 links the impact of publications with the degree of co-operation involved.

Also included in this work is the classification of Greek institutions in accordance with the Frascati manual, whose taxonomy criteria are used internationally to produce official Research and Development (R&D) statistics.

Lastly, the electronic version of the study (<http://report04.metrics.ekt.gr/>) includes a new chapter on 'institution profiles'. All the indicators for each of the 78 Greek institutions which are analysed can be found in the chapter. From this publication onwards you

will be able to download the data presented in each figure as a csv. file so that they can be used for further analysis.

The development of the electronic environment and the completion of the printed edition was carried out using resources from the 'National Information System for Research and Technology/Social Networks-User Generated Content' project.

In tune with findings showing the increasing quality of Greek publications, it is hoped that this study, along with the previous ones, will contribute to a creative dialogue on the recognition and promotion of Greek research work.

Dr. Evi Sachini

A handwritten signature in blue ink, consisting of stylized, overlapping loops and lines, positioned below the name 'Dr. Evi Sachini'.

Director EKT

TABLE OF CONTENTS

1. Introduction	9
2. Greek Scientific Publications: Overall Bibliometric Indicators	11
2.1 Publications	12
2.2 Citations	15
2.3 Citation Impact	17
2.4 Highly cited publications	19
2.5 Scientific Fields of Excellence	20
2.6 Collaboration	26
3. Greek Scientific Publications by Institution Categories	31
3.1 Publications	32
3.2 Citations	33
3.3 Citation Impact	34
3.4 Highly cited publications	35
3.5 Scientific Fields of Excellence	36
3.6 Collaboration	39
APPENDICES	43
APPENDIX I: METHODOLOGY	44
APPENDIX II: INDICATORS	50
APPENDIX III: FIELDS OF SCIENCE	53
APPENDIX IV: INSTITUTION CATEGORIES	61



1. Introduction

The study "Greek Scientific Publications 1998-2012: Bibliometric Analysis of Greek Publications in International Scientific Journals – Web of Science" is part of a series of studies undertaken by EKT with an aim of recording and analysing the Greek scientific activity in international peer-reviewed journals. The study relies on the Web of Science database, one of the largest worldwide abstract and citation database of peer-reviewed literature, to record the performance of the Greek Publications and produces indicators which characterize the country's research activity, describe progress and allow for further correlations with activity at EU and international level. The study records the country's output in scientific publications for the 15-year period ranging from 1998 to 2012 on a national and per-institutional category level. In addition, it focuses on the latest 5-year period (2008-2012) in order to highlight recent trends and developments.

Bibliometric indicators provide significant information and contribute to a measurable and objective picture of the Research & Development systems. They are commonly used as measures of research activity and performance in institutions, research centers, research groups or for individual researchers. Moreover, they provide information about research activity across scientific fields, point to the emergence of new subject areas and map research networks created for the achievement of common scientific goals.

Bibliometric indicators are a valuable tool and form part of a broader system of indicators for the evaluation of research activity. While bibliometric analyses have certain limitations (e.g. differences in publication practices and citations across scientific fields such as for example the differences observed between the fields of medicine and humanities), these limitations can be overcome by placing bibliometric indicators within the appropriate contextual framework, taking into account additional data and statistics as well as qualitative research outcomes.

The National Documentation Centre (EKT) applied a robust methodological approach and validation techniques in bibliometrics. It also developed software tools which enabled the processing of data collected and the calculation of bibliometric indicators (data cleaning, processing and normalisation, distribution of publications across scientific fields and subfields, graphic representation).

The analysis follows the methodological framework (e.g. databases, range of indicators, method of calculations, range of institutions and scientific fields) of the previous study published by EKT in 2014, so as to ensure consistency of calculations and results.

The indicators present the number and share (%) of publications, percentage (%) of cited publications, number and share (%) of citations, citation impact, field normalised citation score, number and percentile breakdown of the highly cited publications.

The edition sets out findings regarding the total output and performance of Greek publications, the main institution categories in which scientific activity is distributed, scientific fields with the greatest share of publications, scientific collaborations, etc. Readers may find detailed information about data and figures throughout the chapters and read about the study's methodological approach in the Appendices.

This chapter presents the bibliometric indicators of the total scientific output of Greece and compares the yield of research publications to that of the EU and the OECD countries. It provides an outlook on the productivity and performance regarding Greece's publications over the 15-year period 1998-2012, and highlights recent growth trends.

The following table (Table 2.1.1) summarises bibliometric indicators for Greek publications for the most recent 5-year period (2008-2012). It also shows their growth compared to the 5-year period, 2006-2010, which was presented in the previous study published by EKT in 2014.

2. Greek Scientific Publications: Overall Bibliometric Indicators

Table 2.1.1 Main Indicators of Greek scientific publications

PUBLICATIONS	2010	2012
Number of Greek publications	10,300	11,138
Share (%) of Greek publications in EU countries	2.40%	2.31%
Share (%) of Greek publications in OECD countries	1.12%	1.09%
CITATIONS	2006-2010	2008-2012
Number of citations to Greek publications	224,633	279,178
Share (%) of Greek citations in EU	2.06%	2.20%
Share (%) of Greek citations in OECD	0.94%	1.03%
CITATION IMPACT	2006-2010	2008-2012
Citation Impact (average number of citations per publication)	4.51	5.23
Relative citation impact of Greek publications compared to EU	0.84	0.92
Relative citation impact of Greek publications compared to OECD	0.83	0.92

2.1 Publications

According to the Web of Science database, there were 11,138 Greek publications registered in international scientific journals in 2012. Greece's yield of research publications overcame the 2010 decreasing trends, and increased from 10,300 publications in 2010 to 10,527 in 2011 and, eventually, to 11,138 in 2012 (Figure 2.1.1).

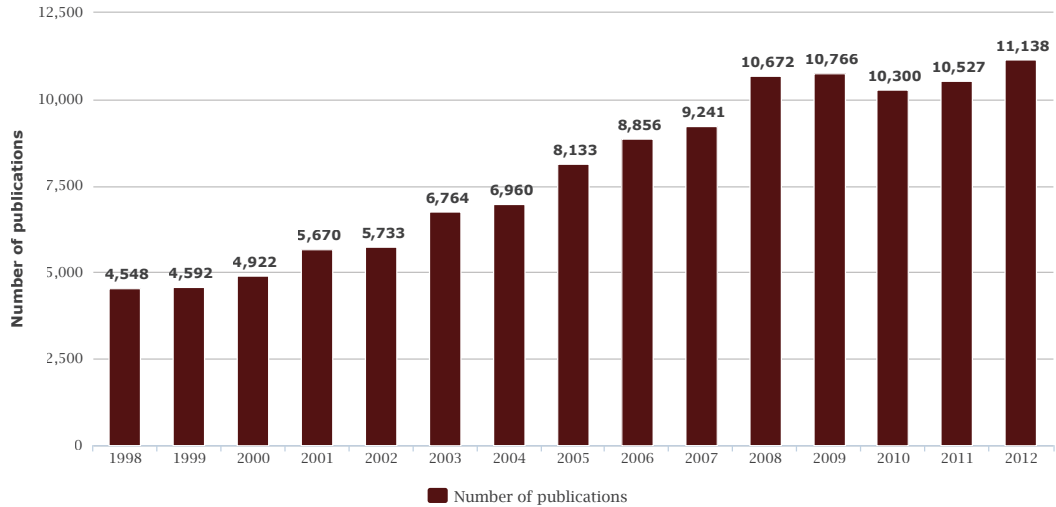


Figure 2.1.1 Development of the number of Greek scientific publications, 1998-2012

Focusing on research productivity, as this is defined by research inputs (R&D Expenditure and human capital) versus research outputs (publications), Figures 2.1.2 and 2.1.3 show that Greece is well placed among European countries. More specifically, if R&D expenditure is taken into consideration (Figure 2.1.2) Greece is ranked 3rd among 24 EU countries.*

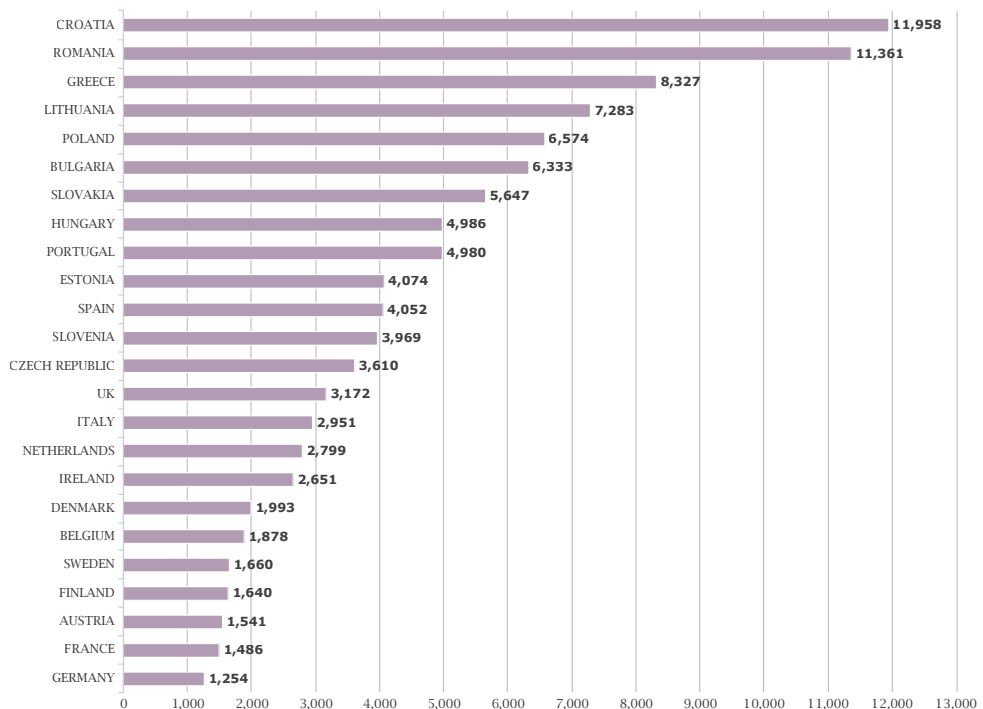


Figure 2.1.2 Number of publications per million Euros of R&D expenditure for EU countries, 2012

* Note: not all EU countries have available data.

Similarly, in Figure 2.1.3 the number of publications in international journals per researcher (as counted in FTE) is expressed. Greece ranks in the 6th place among 24 EU countries.

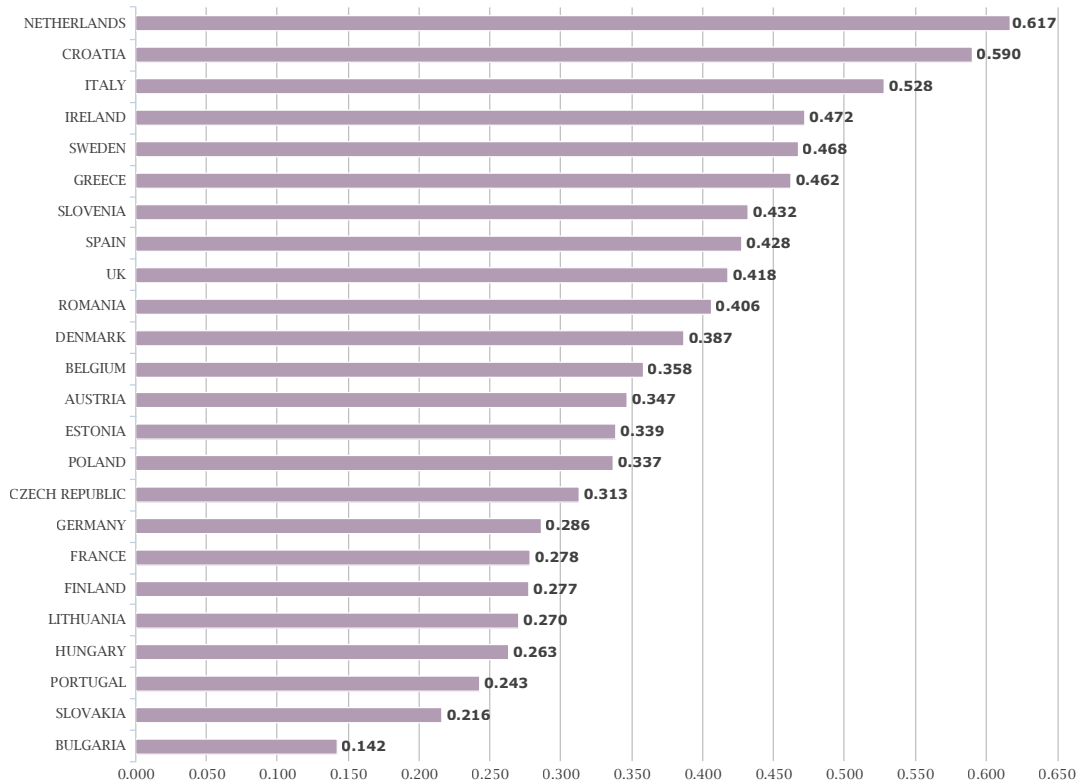


Figure 2.1.3 Number of publications per Researcher (Full Time Equivalents) for EU countries, 2012

The number of Greek publications displayed a steady increase from 1998 until 2008, mostly outpacing annual growth rates of the EU and the OECD (Figure 2.1.4). With the exception of 2009, positive growth rates have been recorded since 2010.

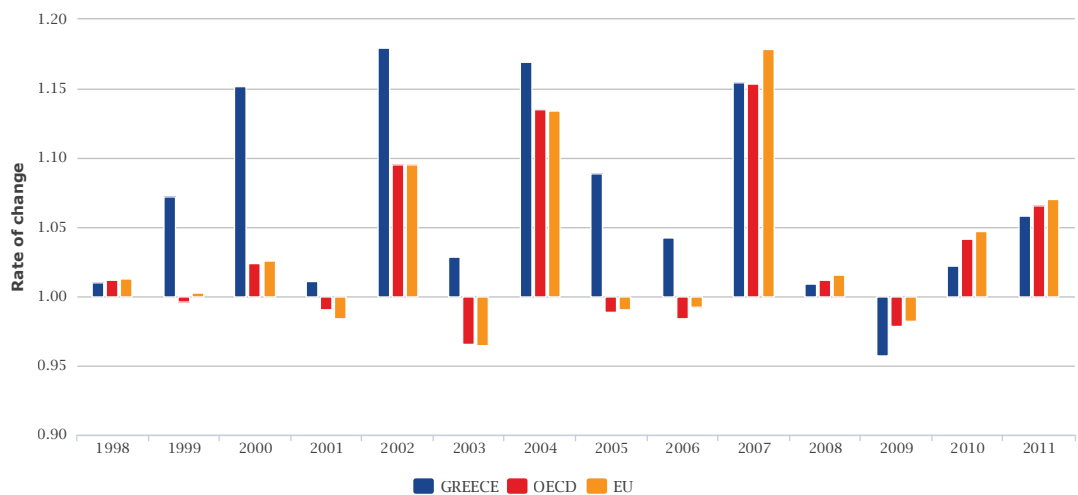


Figure 2.1.4 Change in the number of publications in Greece, EU and OECD, 1998-2012

Greece's share in EU and OECD publications followed a period of constant growth between 1998 and 2009, following a declining trend afterwards (Figure 2.1.5). In 2012, Greece's share in EU publications was 2.31% and its share in OECD publications was 1.09%.

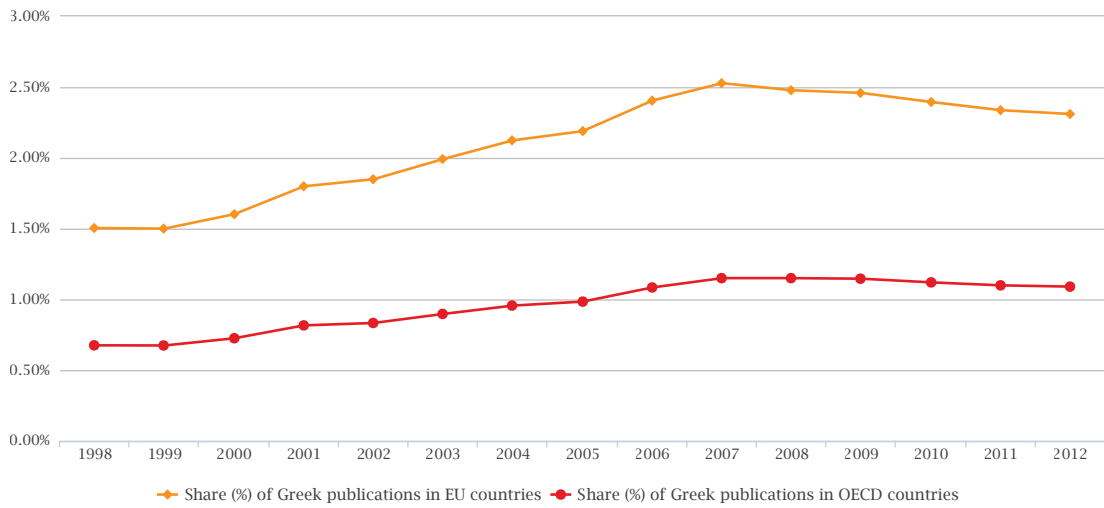


Figure 2.1.5 Share (%) of Greek publications in EU and OECD, 1998-2012

Greece ranked 24th in terms of its share (1.09%) in the OECD (Figure 2.1.6). With a share of 36.7%, USA maintained the leading position among OECD countries, followed by the United Kingdom and Germany, with a share of approximately 10% each.

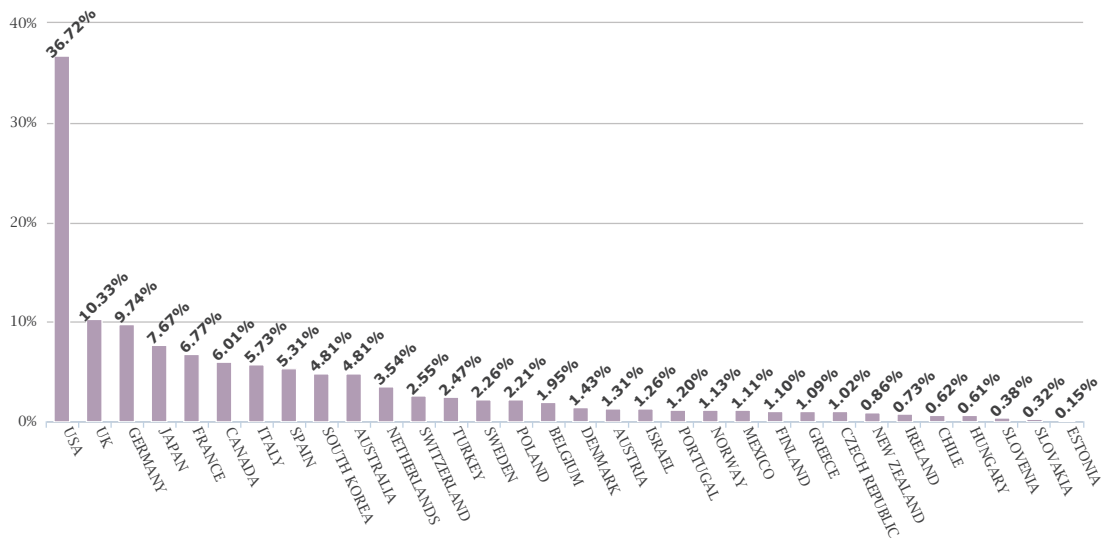


Figure 2.1.6 Share of publications in OECD countries, 2012

In terms of the number of publications per million population, Greece holds the 22nd place in the OECD (Figure 2.1.7) with 1,001 publications per million population. Switzerland maintained the leading position with 3,287 publications.

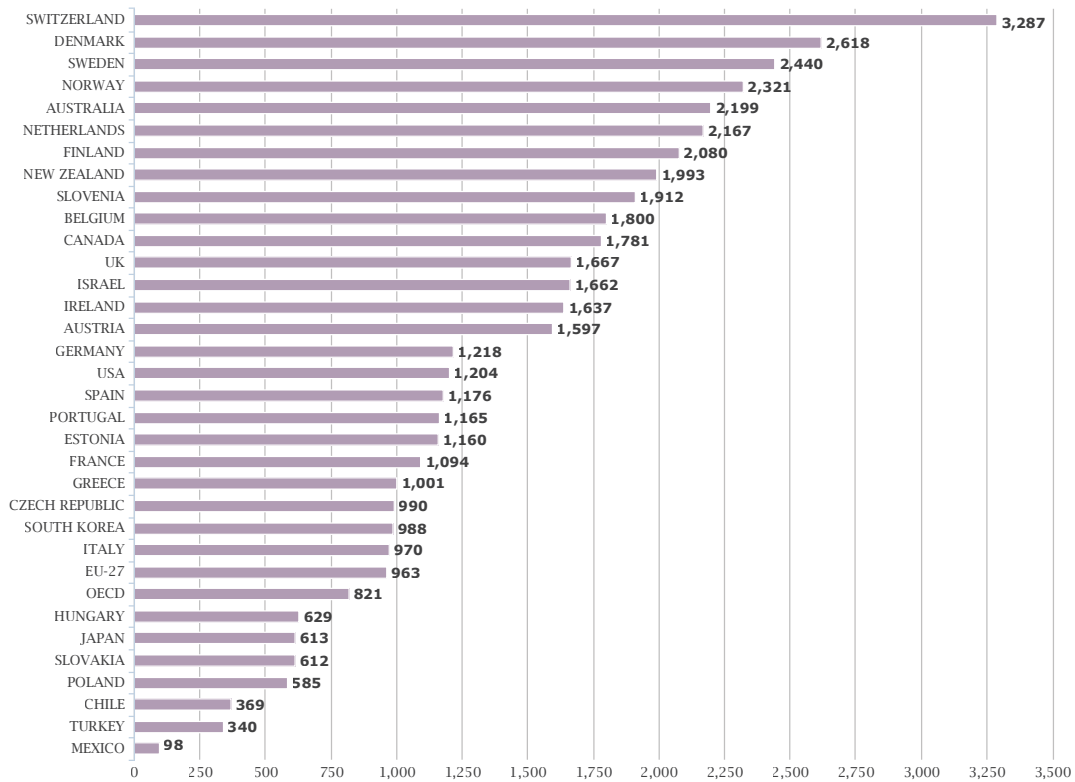


Figure 2.1.7 Number of publications in OECD countries per million of population, 2012

2.2 Citations

Counts of citations to scientific publications are among the most common indicators in bibliometrics and constitute quantifiable evidence of the significance and influence of research. Figure 2.2.1 tracks citations received by Greek publications between 1998 and 2012. According to standard bibliometric practices, data is presented in five-year windows, from 1998 through 2012. Each five-year window displays the number of citations to those publications produced within the designated time.

Between 1998 and 2012, Greece recorded an increasing trend. In the last 5-year window, 2008-2012, Greek publications received 279,178 citations, 4 times more than those received in 1998-2002.

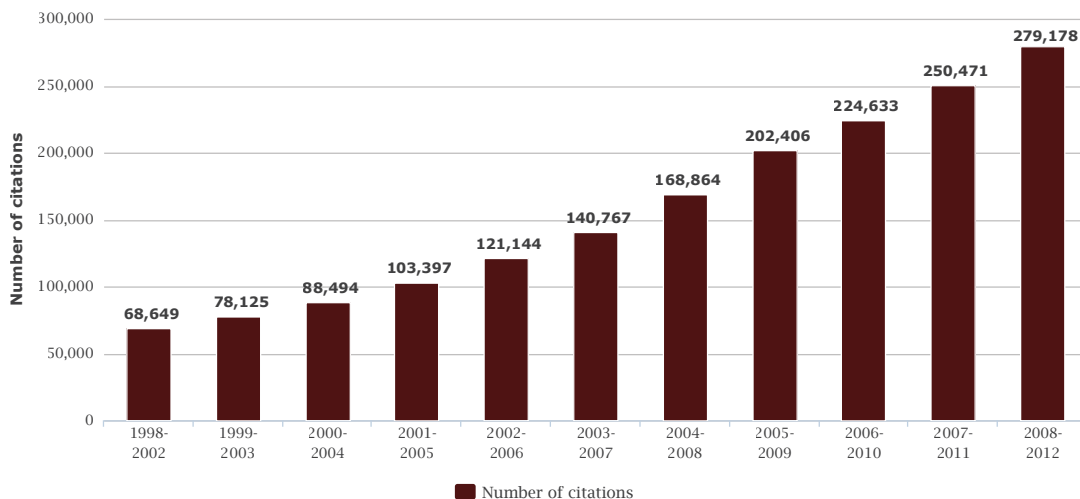


Figure 2.2.1 Development of the number of citations to Greek publications, 1998-2012

Throughout the 1998-2012 period, global trends demonstrated a significant increase in the overall citations counts, both in the EU and the OECD countries. The growth rate of the number of citations to Greek publications surpassed the EU and OECD baseline (Figure 2.2.2).

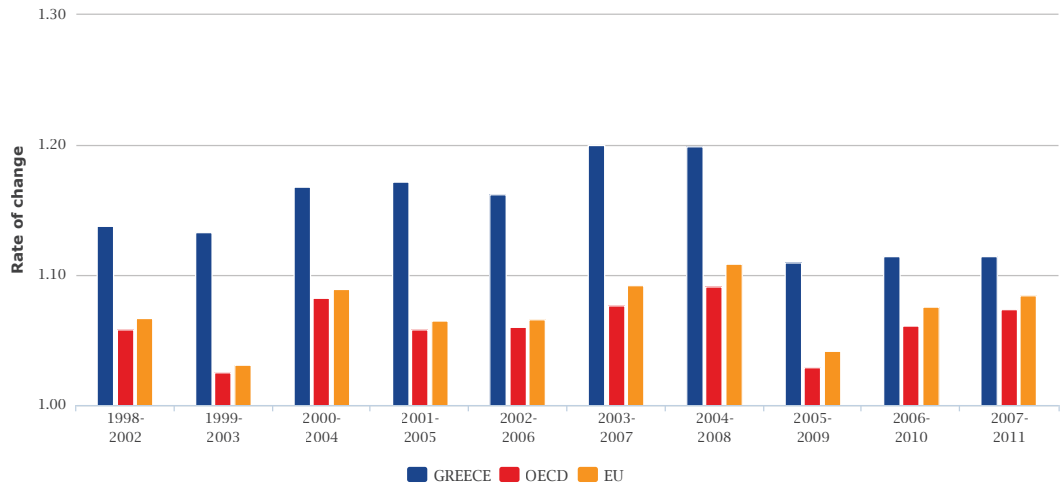


Figure 2.2.2 Change in the number of citations for Greece, EU and OECD, 1998-2012

Accordingly, Greece’s share of EU and OECD citations increased (Figure 2.2.3): for the 2008-2012 period this was equal to 2.20% and 1.03%, respectively.

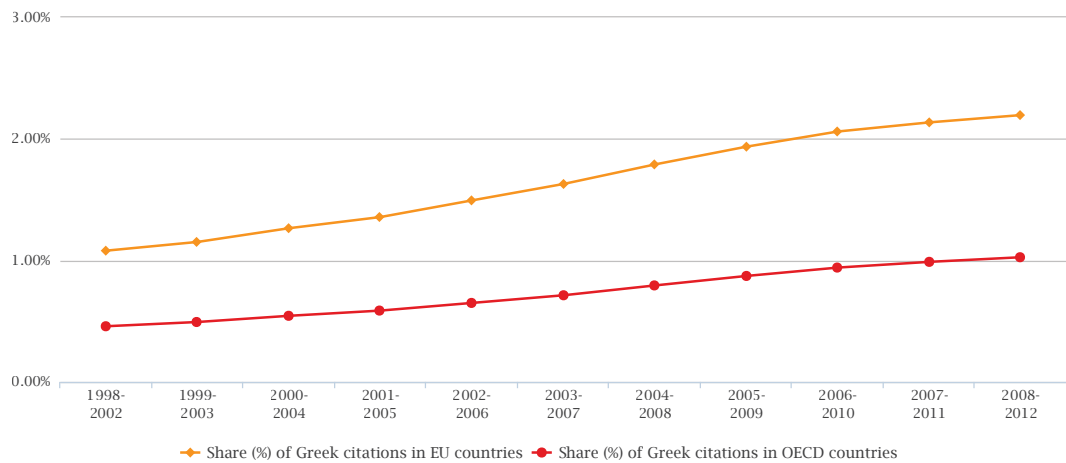


Figure 2.2.3 Share (%) of Greek citations in EU and OECD, 1998-2012

An additional indicator of the visibility and impact of research, is the number of cited publications and its percentage (%) in the total publications output. The percentage (%) of Greek cited publications presented a steady upward trend between 1998-2012, reaching up to 68.3% in 2012, slightly above the EU (67.8%) and the OECD (67.7%) performance (Figure 2.2.4).

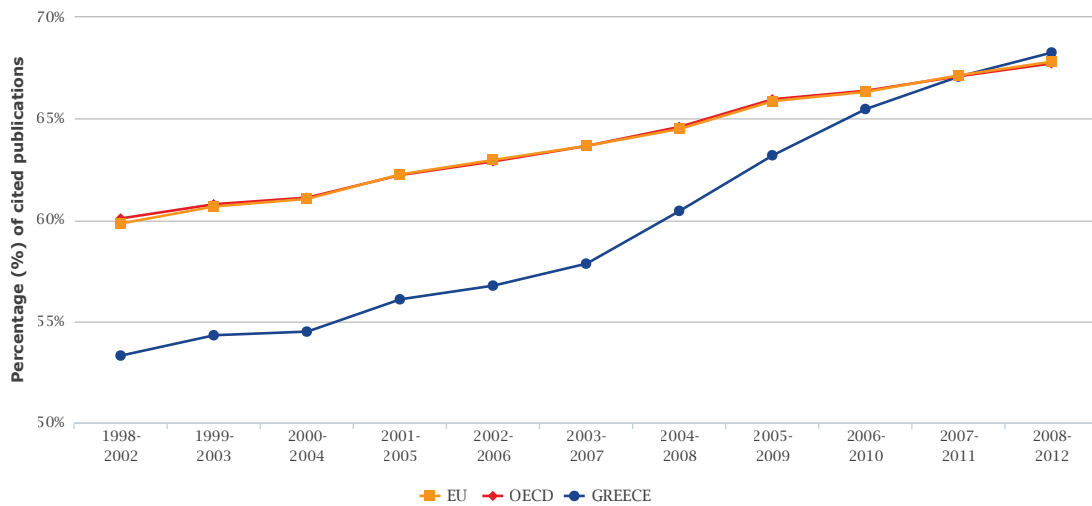


Figure 2.2.4 Percentage (%) of cited publications in Greece, EU and OECD, 1998-2012

2.3 Citation Impact

The average number of citations per publication is used for assessing the scientific impact of publications, especially at a country level. This indicator – henceforth referred to as “citation impact”- is calculated as the ratio of the total number of citations to the total number of publications, without taking into account differences in citation practices among scientific fields.

Figure 2.3.1 presents the citation impact of Greek, EU and OECD publications. In the most recent 5-year period, 2008-2012, Greek publications received 5.23 citations on average, approaching the EU (5.70) and OECD (5.71) average.

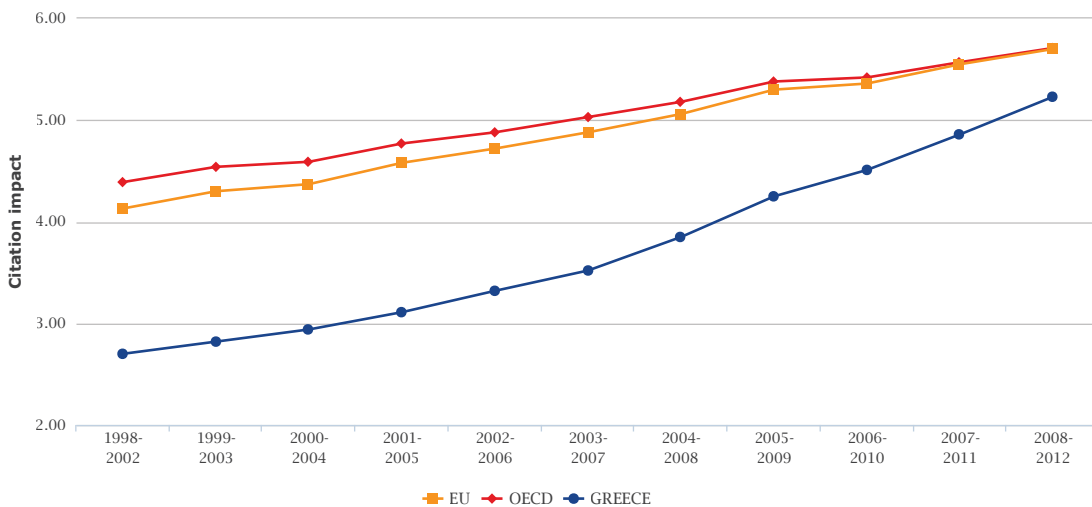


Figure 2.3.1 Citation impact of publications from Greece, EU and OECD, 1998-2012

Notably, over the 1998-2012 period, the growth rate of the citation impact of Greek publications exceeded the corresponding figure for EU and OECD publications. (Figure 2.3.2).

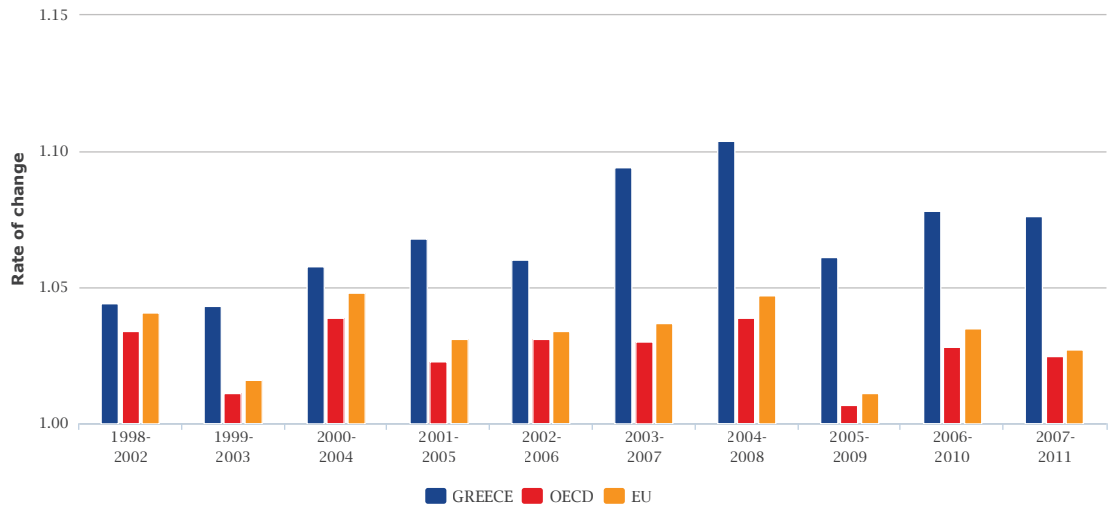


Figure 2.3.2 Change in the citation impact of publications from Greece, EU and OECD, 1998-2012

The “relative impact” indicator, as shown in Figure 2.3.3, compares citations per publication average for Greece against the EU and OECD. Greece’s citation impact relative to the EU and OECD exhibited an ascending trend between 1998 and 2012 and in the most recent 5-year period, 2008-2012, reached 0.92 for both EU and OECD. According to this figure, Greece is ranked 23rd in the OECD (Figure 2.3.4).

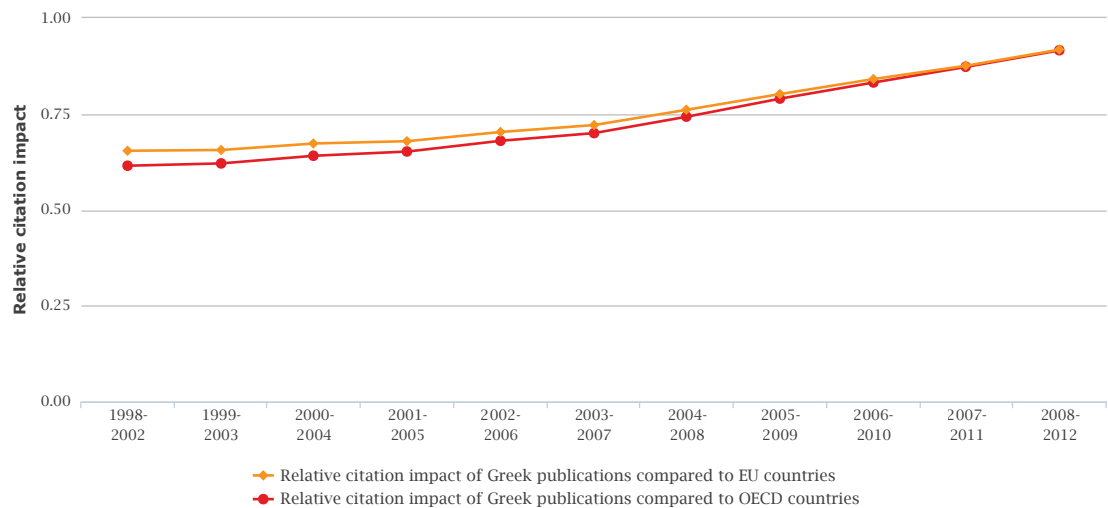


Figure 2.3.3 Relative citation impact of publications from Greece compared to EU and OECD, 1998-2012

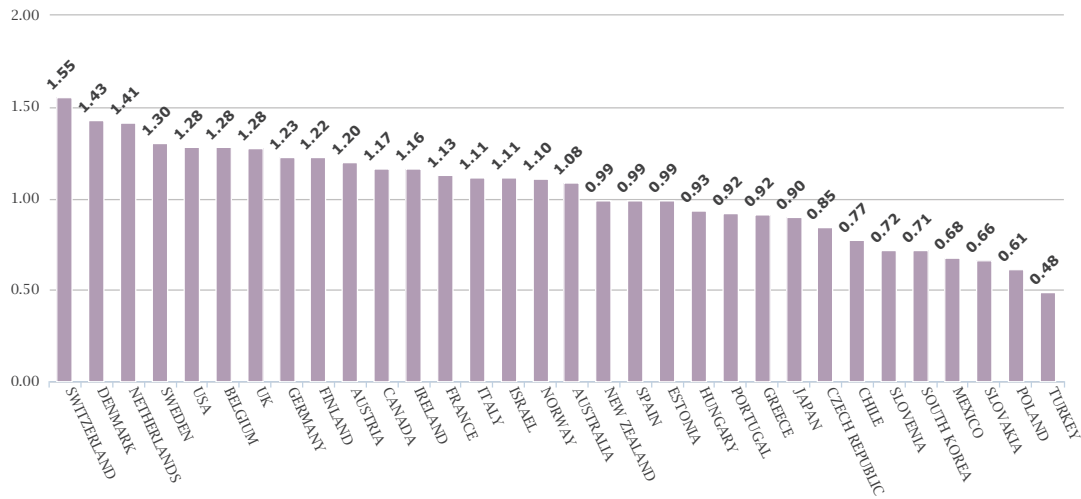


Figure 2.3.4 Ranking of OECD countries by relative citation impact, 2008-2012

2.4 Highly cited publications

A significant criterion for the evaluation of the impact of the scientific publications is their ranking among the most cited publications in the world, published in the same year and the same subject field. The relevant bibliometric indicators refer to the number and the percentile breakdown of publications that were ranked worldwide in the top 1%, 5%, 10%, 25% and 50% of the most cited publications, per year and per scientific field.

During the most recent 5-year period, 2008-2012, 642 Greek publications ranked among the top 1% of the most cited publications worldwide, 2,888 publications in the top 5%, 5,442 publications in the top 10%, 12,347 publications in the top 25% and 23,142 in the top 50% (Figure 2.4.1).

The percentile breakdown of top publications for Greece for the 5-year period, 2008-2012, was 1.2%, 5.4%, 10.2%, 23.2% and 43.5% (Figure 2.4.1). Compared to the world average baseline 1%, 5%, 10%, 25% and 50%, Greece is above the world average in the 1%, 5% and 10% percentiles.

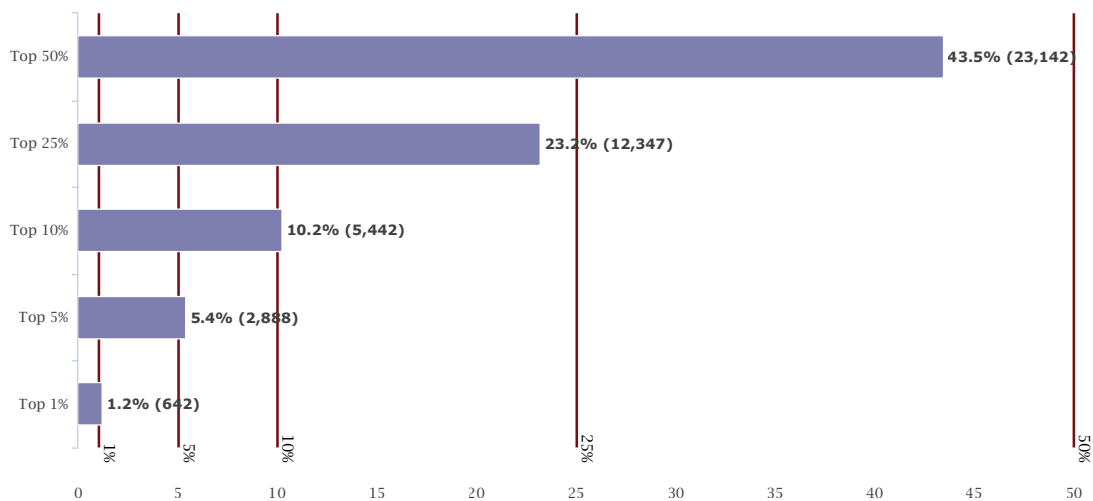


Figure 2.4.1 Number and percentile breakdown (%) of highly cited Greek publications, 2008-2012

The first author’s affiliation was a Greek organisation in 32.6% of the Greek publications ranked worldwide in the top 1% (Figure 2.4.2). This percent increases to 46.4% for the publications ranked worldwide in the top 5% and to 53.5% for those ranked in the top 10%.

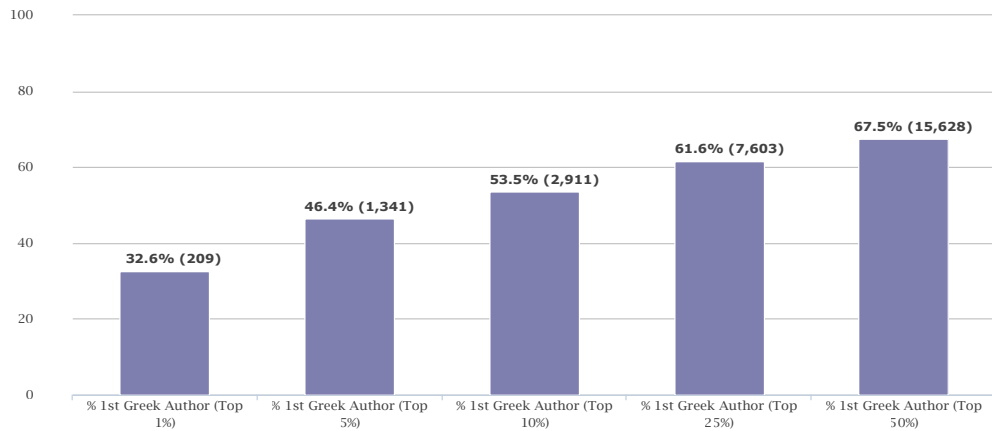


Figure 2.4.2 Number and share (%) of publications by percentile category with 1st author being Greek

2.5 Scientific Fields of Excellence

Aiming at identifying the fields of research where Greek research teams were most active and successful, Greek publications were classified into the six major fields of science “Natural Sciences”, “Engineering & Technology”, “Medical & Health Sciences”, “Agricultural Sciences”, “Social Sciences” and “Humanities” and their subcategories, according to the “Revised Field of Science and Technology Classification” (Frascati Manual, OECD, 2002). The results of this classification corresponding to the entire period between 1998 and 2012, are presented in Figure 2.5.1.

“Natural Sciences” received Greece’s highest representation in the total number of publications, constituting 48.8% in 2012. “Medical & Health Sciences” represented the second highest share, with an increasing trend between 1998 and 2007, and equal to 37.6% of the total publications in 2012.

Publications in “Engineering and Technology” accounted for a more or less stable share, which was equal to 21.9% in 2012. The remaining share of Greek publications was distributed among the “Social Sciences” which had a growing share after 2007 (7.0% in 2012), the “Agricultural Sciences” with a rather stable share (3.3% in 2012), and the “Humanities” with the lowest share (1.3% in 2012). Even though “Humanities” is a significant field of national research, its lowest share of publications was somewhat expected, since scientific production in the field is overwhelmed by monographs and books, as well as them being written in other languages (non-English), publications that are not recorded in the standard bibliometric databases.

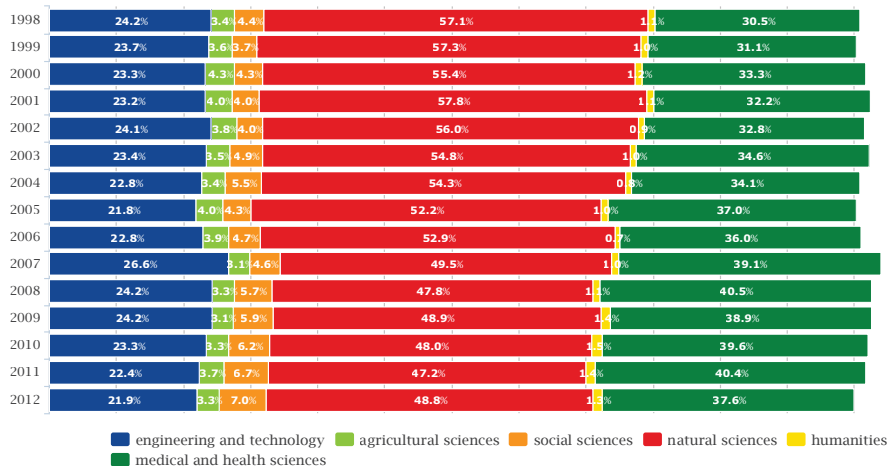
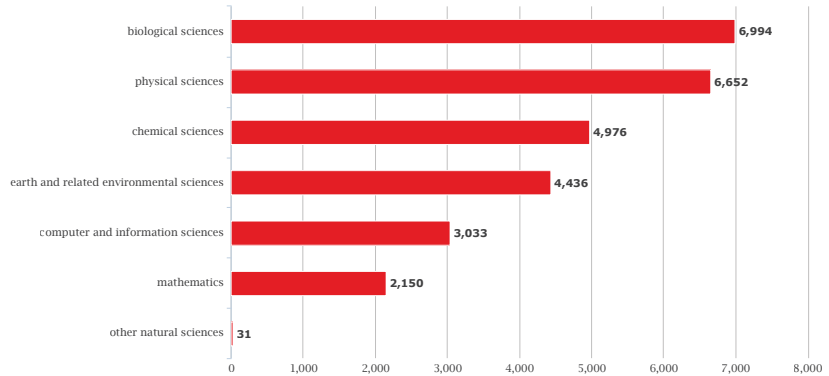


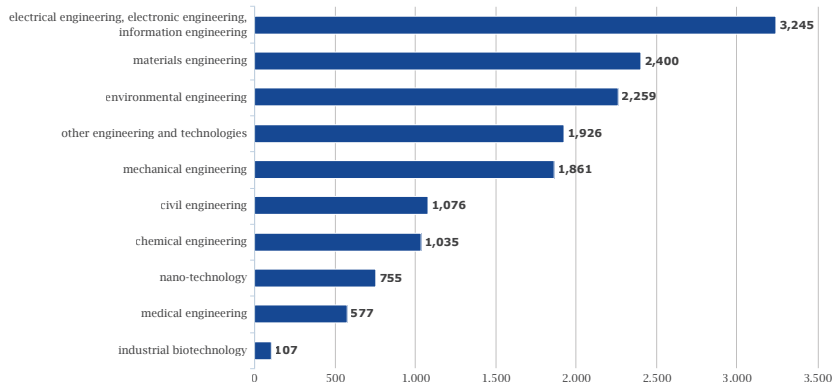
Figure 2.5.1 Distribution (%) of Greek publications across major fields of science, 1998-2012

Figure 2.5.2 tracks the number of Greek publications in the subcategories of the six major fields of science. Data refer to the most recent 5-year period, 2008-2012.

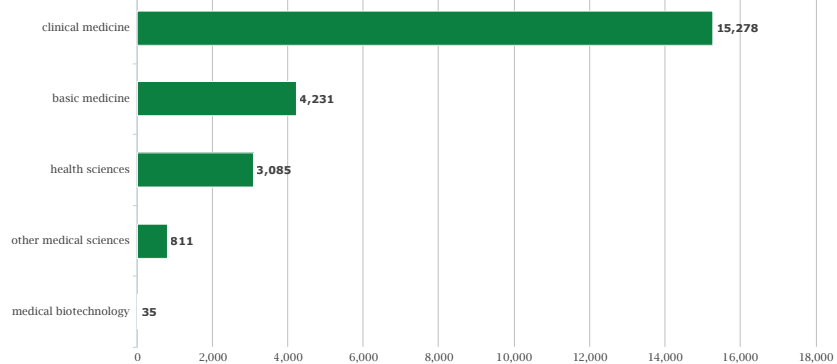
Natural Sciences



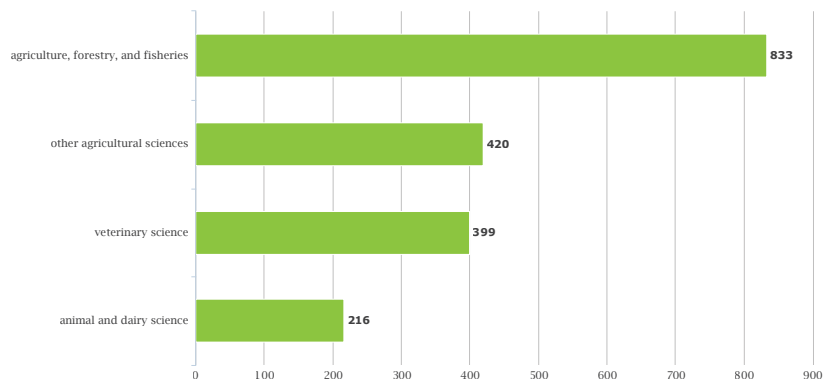
Engineering & Technology



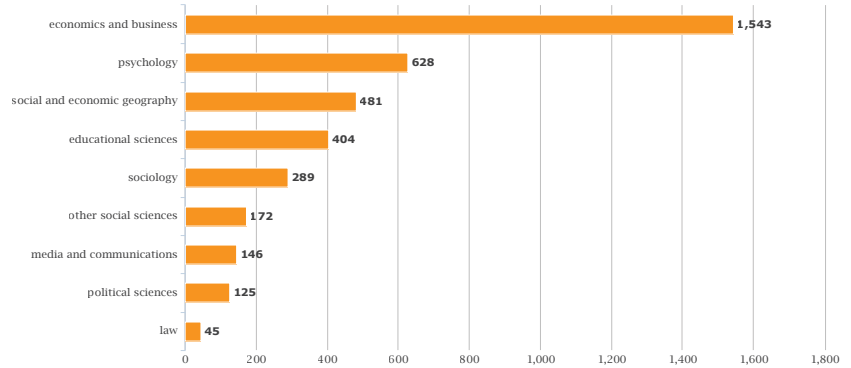
Medical & Health Sciences



Agricultural Sciences



Social Sciences



Humanities

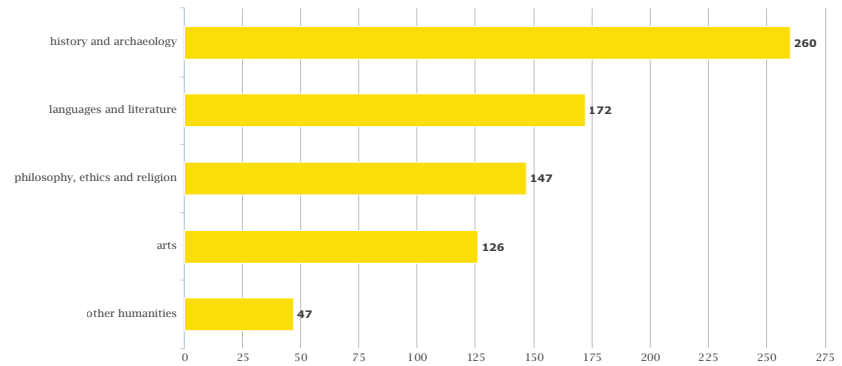


Figure 2.5.2 Number of publications in the 6 major fields of science, 2008-2012

Figure 2.5.3 shows the “field-normalised citation score” of Greek publications for the 5-year period 2008-2012 in the six major fields of science. This indicator is the ratio of the average number of citations received by Greek publications to the world average of citations of the same time period and scientific subject field. The normalisation was carried out at the level of each article/publication according to the Web of Science scientific subject fields. In the case of a publication being attributed to more than one subject field, a mean value of the fields was calculated. The field-normalised citation score or “citation score” was calculated using software developed by EKT. A value greater than 1, indicates that the impact of Greek publications was higher than the world average.

In the period 2008-2012, Greek publications surpassed or approached the world average across all fields, displaying citation scores from 0.81 to 1.09. The field of “Natural Sciences” had the highest citation score 1.09, followed by “Engineering & Technology” (1.06), “Agricultural Sciences” (0.94), “Medical & Health Sciences” (0.93), “Humanities” (0.90) and “Social Sciences” (0.81).

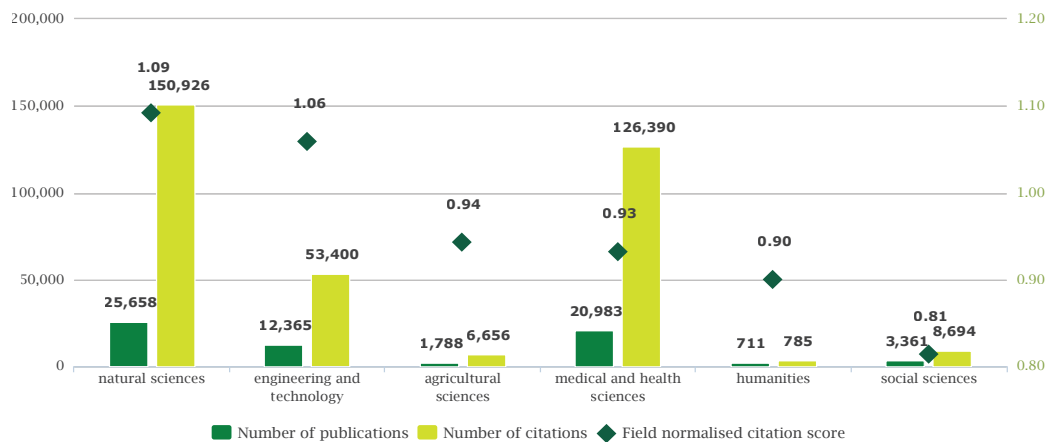


Figure 2.5.3 Publications, citations and field normalised citation score of Greek publications relative to the world, 2008-2012

Focusing on specific thematic areas of the six fields of science (Table 2.5.1), the areas with a citation score ≥ 1 , thus indicating areas of research excellence, are the following: 28 areas “Natural Sciences”, 19 areas in the field “Engineering & Technology”, 14 in “Medical & Health Sciences”, 3 in “Agricultural Sciences”, 6 in “Social Sciences” and 4 in “Humanities”.

Table 2.5.1 Scientific subfields of Greek publications with field normalised citation score ≥ 1 , 2008-2012

Natural Sciences			
Scientific field categories (Frascati classification)	Specific scientific field (WoS)	Field normalised citation score	Number of publications
physical sciences	physics, multidisciplinary	3.40	1,070
biological sciences	genetics & heredity	1.69	633
biological sciences	reproductive biology	1.62	290
physical sciences	physics, particles & fields	1.54	1,006
physical sciences	physics, nuclear	1.28	321
physical sciences	optics	1.27	926
chemical sciences	polymer science	1.22	621
computer and information sciences	computer science, artificial intelligence	1.21	748
biological sciences	microbiology	1.21	767
computer and information sciences	computer science, theory & methods	1.19	555
physical sciences	astronomy & astrophysics	1.18	1,156
earth and related environmental sciences	meteorology & atmospheric sciences	1.18	769
chemical sciences	spectroscopy	1.18	213
chemical sciences	chemistry, inorganic & nuclear	1.16	506
physical sciences	physics, fluids & plasmas	1.14	279
biological sciences	entomology	1.14	311
earth and related environmental sciences	oceanography	1.13	235
physical sciences	physics, mathematical	1.10	423
chemical sciences	chemistry, multidisciplinary	1.09	740
mathematics	mathematics, applied	1.09	1,031
computer and information sciences	computer science, cybernetics	1.07	87
chemical sciences	chemistry, applied	1.07	538
chemical sciences	crystallography	1.06	179
earth and related environmental sciences	geography, physical	1.05	176
chemical sciences	chemistry, physical	1.03	1,477
biological sciences	marine & freshwater biology	1.03	561
physical sciences	physics, applied	1.02	1,511
computer and information sciences	computer science, interdisciplinary applications	1.01	909

Engineering and Technology			
Scientific field categories (Frascati classification)	Specific scientific field (WoS)	Field normalised citation score	Number of publications
other engineering and technologies	instruments & instrumentation	1.46	458
civil engineering	transportation science & technology	1.43	213
mechanical engineering	thermodynamics	1.32	275
medical engineering	neuroimaging	1.32	47
electrical engineering, electronic engineering, information engineering	automation & control systems	1.32	250
medical engineering	medical laboratory technology	1.31	161
environmental engineering	energy & fuels	1.3	1,013
environmental engineering	engineering, environmental	1.23	619
electrical engineering, electronic engineering, information engineering	robotics	1.21	67
electrical engineering, electronic engineering, information engineering	engineering, electrical & electronic	1.17	2,504
mechanical engineering	mechanics	1.13	736
electrical engineering, electronic engineering, information engineering	computer science, hardware & architecture	1.13	404
chemical engineering	engineering, chemical	1.12	1,035
mechanical engineering	engineering, industrial	1.1	190
electrical engineering, electronic engineering, information engineering	telecommunications	1.1	1,084
industrial biotechnology	materials science, biomaterials	1.07	107
environmental engineering	mining & mineral processing	1.05	59
materials engineering	materials science, composites	1.04	173
mechanical engineering	engineering, manufacturing	1	167
other engineering and technologies	instruments & instrumentation	1.46	458
civil engineering	transportation science & technology	1.43	213
mechanical engineering	thermodynamics	1.32	275
medical engineering	neuroimaging	1.32	47
electrical engineering, electronic engineering, information engineering	automation & control systems	1.32	250
medical engineering	medical laboratory technology	1.31	161
environmental engineering	energy & fuels	1.3	1,013
environmental engineering	engineering, environmental	1.23	619
electrical engineering, electronic engineering, information engineering	robotics	1.21	67
electrical engineering, electronic engineering, information engineering	engineering, electrical & electronic	1.17	2,504
mechanical engineering	mechanics	1.13	736
electrical engineering, electronic engineering, information engineering	computer science, hardware & architecture	1.13	404
chemical engineering	engineering, chemical	1.12	1,035
mechanical engineering	engineering, industrial	1.1	190
electrical engineering, electronic engineering, information engineering	telecommunications	1.1	1,084
industrial biotechnology	materials science, biomaterials	1.07	107

Medical & Health Sciences

Scientific field categories (Frascati classification)	Specific scientific field (WoS)	Field normalised citation score	Number of publications
clinical medicine	rheumatology	1.60	326
clinical medicine	allergy	1.60	118
clinical medicine	dermatology	1.44	293
health sciences	health policy & services	1.30	65
health sciences	public, environmental & occupational health	1.26	786
health sciences	infectious diseases	1.26	708
health sciences	parasitology	1.25	93
basic medicine	toxicology	1.21	302
clinical medicine	medicine, general & internal	1.18	892
clinical medicine	critical care medicine	1.13	314
health sciences	medical informatics	1.08	195
health sciences	nutrition & dietetics	1.06	644
health sciences	health care sciences & services	1.05	193
clinical medicine	hematology	1.05	618

Agricultural Sciences

Scientific field categories (Frascati classification)	Specific scientific field (WoS)	Field normalised citation score	Number of publications
other agricultural sciences	agricultural engineering	1.32	173
agriculture, forestry, and fisheries	fisheries	1.15	220
animal and dairy science	agriculture, dairy & animal science	1.07	216

Social Sciences

Scientific field categories (Frascati classification)	Specific scientific field (WoS)	Field normalised citation score	Number of publications
social and economic geography	urban studies	1.52	44
sociology	anthropology	1.40	89
economics and business	operations research & management science	1.19	489
psychology	psychology, social	1.08	47
social and economic geography	environmental studies	1.07	229
political sciences	international relations	1.00	30

Humanities			
Scientific field categories (Frascati classification)	Specific scientific field (WoS)	Field normalised citation score	Number of publications
philosophy, ethics and religion	philosophy	1.22	39
arts	art	1.12	49
languages and literature	language & linguistics	1.05	78
languages and literature	linguistics	1.04	93

In addition, by correlating the citation score with the Activity Index (low-to-high volume publication production) a bi-dimensional location of strong versus weak-performing thematic areas is presented in Figure 2.5.4. In the "High activity- High Impact" area, a total of 42 specific scientific fields are displayed: 14 in "Natural Sciences", 14 in "Engineering & Technology", 10 in "Medical & Health Sciences", 2 in Agricultural Sciences and 2 in "Social Sciences".

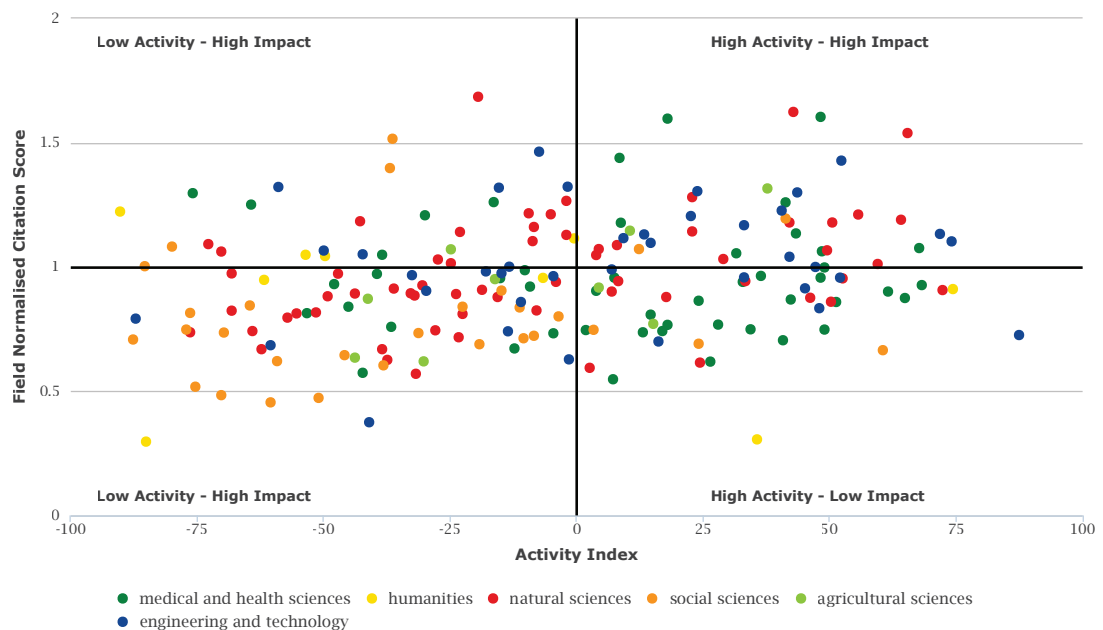


Figure 2.5.4 Plot of Activity Index and field-normalised citation score of Greek publications per specialised thematic areas, 2008-2012

2.6 Collaboration

Collaboration of the scientific community at the national and international level stands as an important factor towards enhanced knowledge production and scientific excellence. Indeed, interactions and scientific relationships across networks, teams, institutions and countries increase the visibility, the number of citations and the impact of publications. The level of international collaboration can be measured by analyzing author institutional affiliations provided on publications.

The collaboration degree in Greek publications* and its evolution over the period 1998-2012, as displayed in Figure 2.6.1, shows a clear increasing trend, both at the national and international level. In 2012, co-publications by Greek researchers accounted for 70.6% of the total publications output, compared to 58.9% in 1998.

* National collaboration: number of publications with at least one national collaboration. International collaboration: number of publications with at least one international collaboration. No collaboration: number of publications with one single institution.

GREEK SCIENTIFIC PUBLICATIONS: OVERALL BIBLIOMETRIC INDICATORS

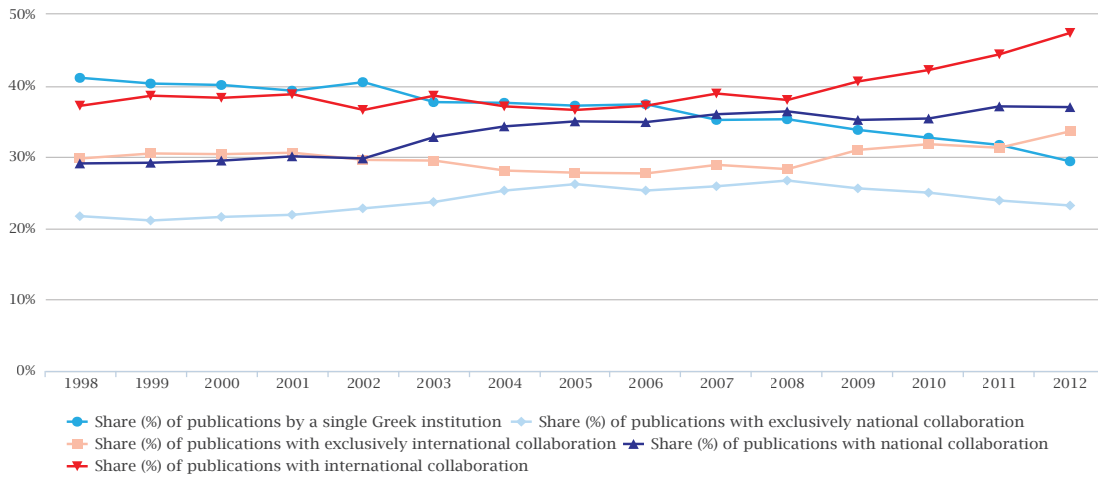


Figure 2.6.1 National and international collaboration in Greek publications, 1998-2012

During the most recent 5-year period, 2008-2012, Greek researchers cooperated with scientists from 154 countries. Figure 2.6.2 highlights these links and regions. Greece’s main publishing partners were the United States, the UK, Germany, France and Italy.

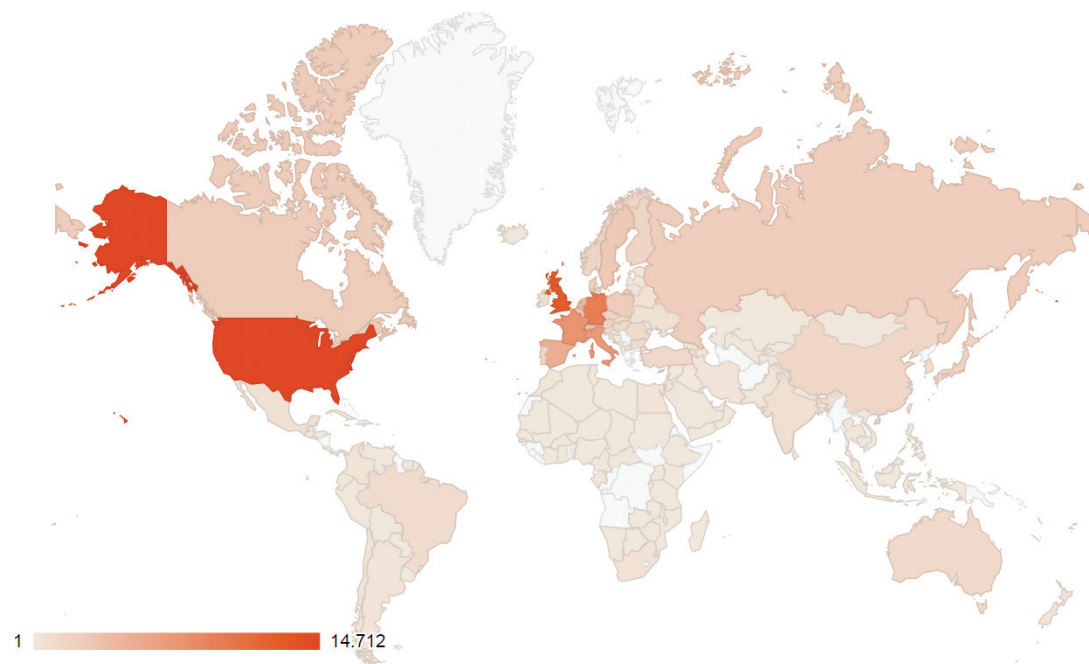


Figure 2.6.2 Countries collaborating in Greek publications, 2008-2012

Figure 2.6.3 illustrates the annual growth in the number of Greek publications with national, international and no collaboration for the period 1998-2012.

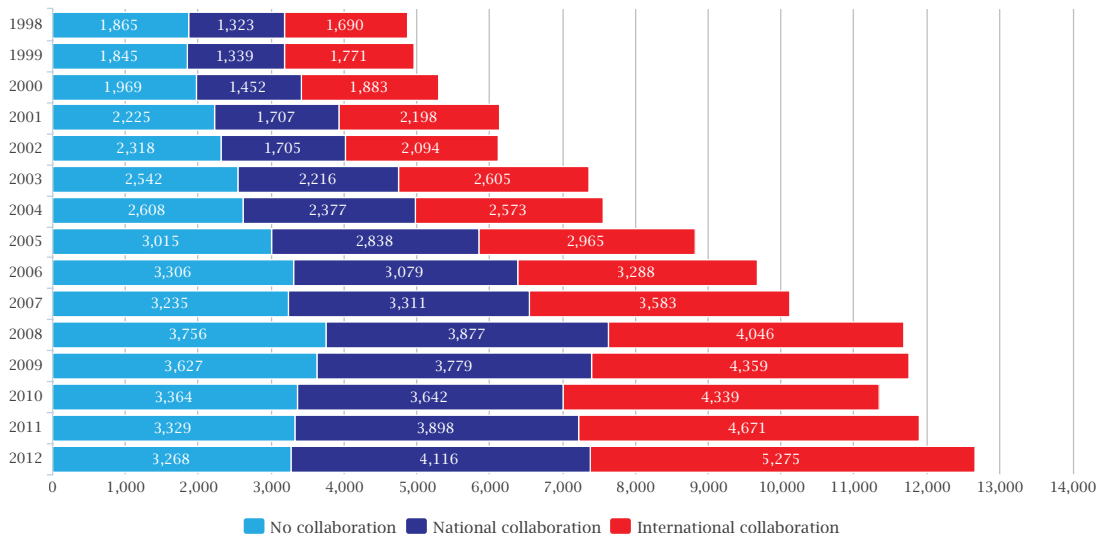


Figure 2.6.3 Distribution of Greek publications by type of collaboration, 1998-2012

Significantly, the type of scientific collaboration is positively correlated with the relative citation impact score of produced publications (Figure 2.6.4). Publications produced by international collaboration feature a higher citation score than those (publications) produced by solely Greek collaboration, and even higher than those (publications) produced without any collaboration. This stands for all scientific fields.

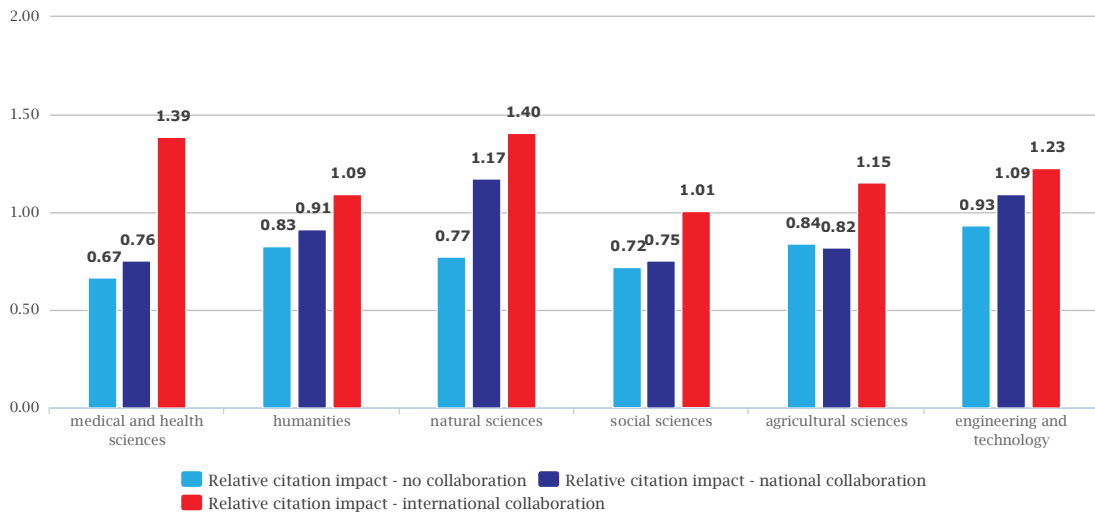


Figure 2.6.4 Field-normalised citation score of Greek publications for the six major fields of science per type of collaboration, 2008-2012

This chapter presents an account of the bibliometric indicators concerning Greek scientific publications at the level of institution category; that is the main institution sectors producing scientific publications.

Specifically, ten institution categories are presented in the following table. In addition to the number of publications, the number of citations for every institution category is presented. The time series examined includes not only the most recent available 5-year period (2008-2012) of the 15-year period (1998-2012), but also an updated account of the indicators concerning the 2006-2010 5-year period to allow for inter-temporal comparison (Table 3.1.1).

3. Greek Scientific Publications by Institution Categories

Table 3.1.1 Number of publications and number of citations by institution category for the period 2006-2010 and 2008-2012

COLOUR	INSTITUTION CATEGORY	2006-2010		2008-2012	
		NUMBER OF PUBLICATIONS	NUMBER OF CITATIONS	NUMBER OF PUBLICATIONS	NUMBER OF CITATIONS
	Universities	41,092	189,726	44,135	234,903
	Research Centers supervised by the General Secretariat for Research and Technology (RC-GSRT)	6,966	43,424	7,403	52,836
	Public Hospitals (PH)	5,515	25,491	5,738	28,305
	Technological Educational Institutes (TEIs)	2,387	6,565	2,809	8,542
	Other Public Research Institutions	1,970	8,261	2,270	12,135
	Private Health Institutions	1,649	11,401	1,858	12,501
	Enterprises	1,093	3,247	1,196	4,553
	Other Higher Educational Institutions	555	1,418	737	2,336
	Private Non Profit Institutions	656	2,709	686	3,613
	Other Public Institutions	455	1,435	486	1,703

3.1 Publications

The great majority of Greek scientific publications were published by the following three institution categories: "Universities", "Research Centers supervised by the General Secretariat for Research and Technology" (henceforth, "RC-GSRT") and "Public Hospitals". These are followed (ranked by number of publications) by the "Technological Educational Institutes" (henceforth, "TEIs"), "Other Public Research Institutions", "Enterprises", "Private Health Institutions", "Other Higher Educational Institutions", "Private non-for Profit Institutions" and "Other Public Institutions" (Figure 3.1.1.).

For the year 2012, Universities published 9,265 publications continuing their steady increase since 1998. "RC-GSRT" ranked second with 1,552 publications, following a ten-year period of sustained increase. "Public Hospitals" were third with 1,093 publications indicating a continuation of a slight drop since their climax in 2009 (1,274). Both "Other Higher Educational Institutions" and "TEIs" continued their increase –steep in the case of "TEIs"- in the number of publications. Lastly, "Enterprises", despite their increase on an annual basis, the absolute numbers involved (282 in 2012) stand as especially low indicative of the low degree of interconnection with the domestic science base.

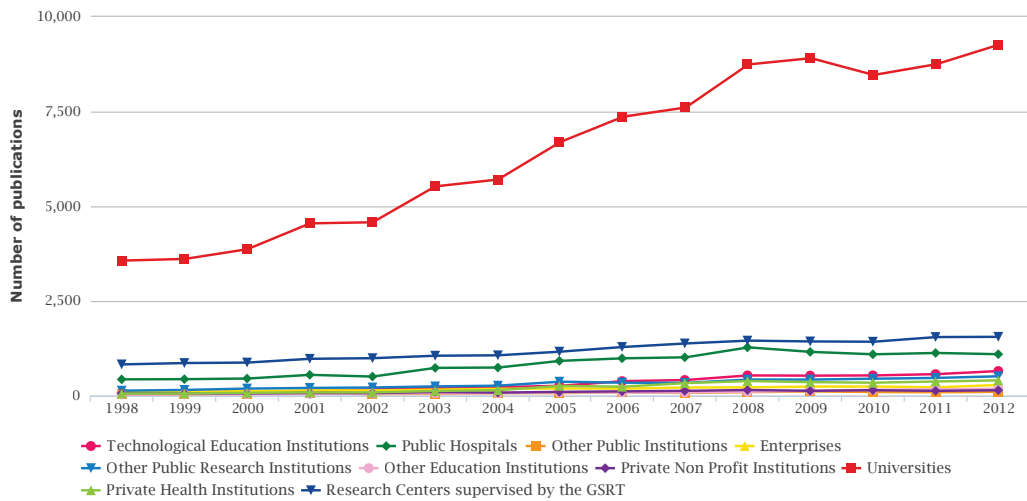


Figure 3.1.1 Development of the number of publications, by institution category, 1998-2012

Viewed in comparison with base year (1998: 100), while all institution categories are recording an increase, it is the TEIs that have been boosting along having reached an index of 866 for 2012 (Figure 3.1.2). They are followed by the "Private Health Institutions" and "Other Higher Educational Institutions" also steadily increasing (733 and 607 for the latest year, respectively).

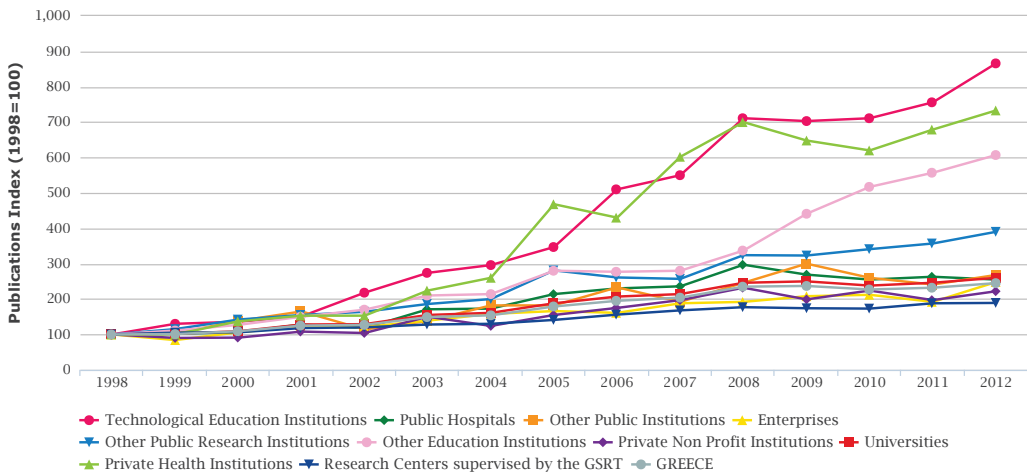


Figure 3.1.2 Publications Index (1998=100), by institution category, 1998-2012

Figure 3.1.3 shows the share of the total number of Greek publications* per institution category for the latest five year period, 2008-2012. "Universities" were ranked first with a share of 82.8%. They were followed by "RC-GSRT" (13.9%), "Public Health Institutions" (10.8%) and "TEIs" (5.3%). The remaining institution categories had shares lower than 5%.

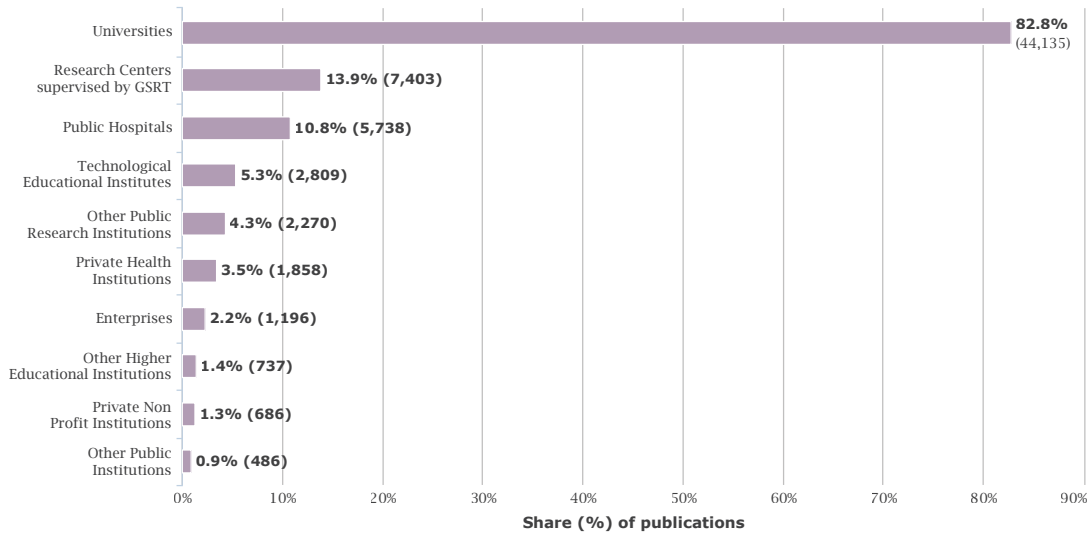


Figure 3.1.3 Number and share (%) of publications, by institution category, 2008-2012

3.2 Citations

Between 1998 and 2012, citation indices grew over time for all institution categories following the growth trend of Greek publications.

"RC-GSRT" and "Private Health Institutions" received the highest percentage (%) of cited publications among all institution categories (Figure 3.2.1). This figure varied from 57.7% for "Other Higher Educational Institutions" to 76.7% for "RC-GSRT" with the average number of publications for Greece and OECD being 68.3% and 67.7% respectively.

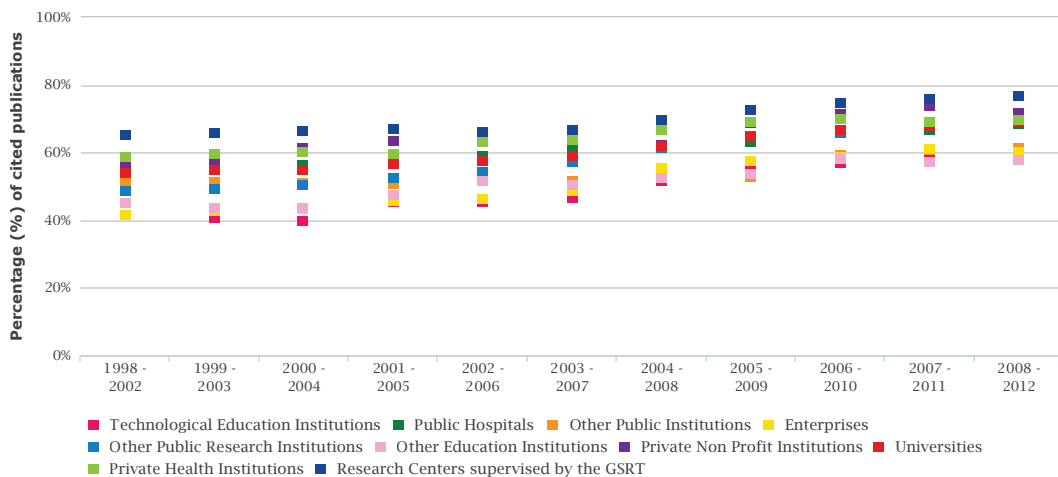


Figure 3.2.1 Percentage (%) of cited publications, by institution category, 1998-2012

* As demonstrated in the Methodology, each institution category received a whole count of the publication (whole counting) for publications produced as a result of collaboration between institutions in different institution categories. The (%) share of publications by institution category was calculated as a proportion of the total number of Greek publications (Figure 3.1.3) and indicates the degree of "participation" of each category to Greece's total publication output. Hence, in the case of Universities, a share of 82.8% means that Universities participated in 82.8% of the total number of Greek publications.

Figure 3.2.2 tracks the number of citations and its growth/evolution between 1998 and 2012. During 1998-2012, the number of citations in all institution categories followed a growth trend.

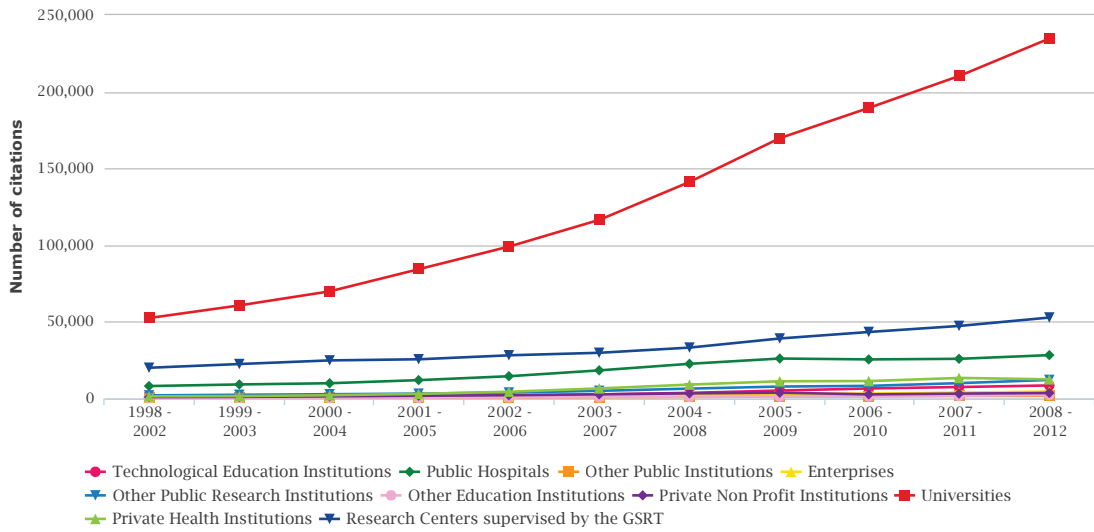


Figure 3.2.2 Number of citations, by institution category, 1998-2012

Apart from the highest representation in the number of publications, «Universities» had also the highest share in the number of citations. More specifically, during 2008-2012, University publications received 234,903 citations or a share of 81.2% in the total number of citations of Greek publications. (Figure 3.2.3).

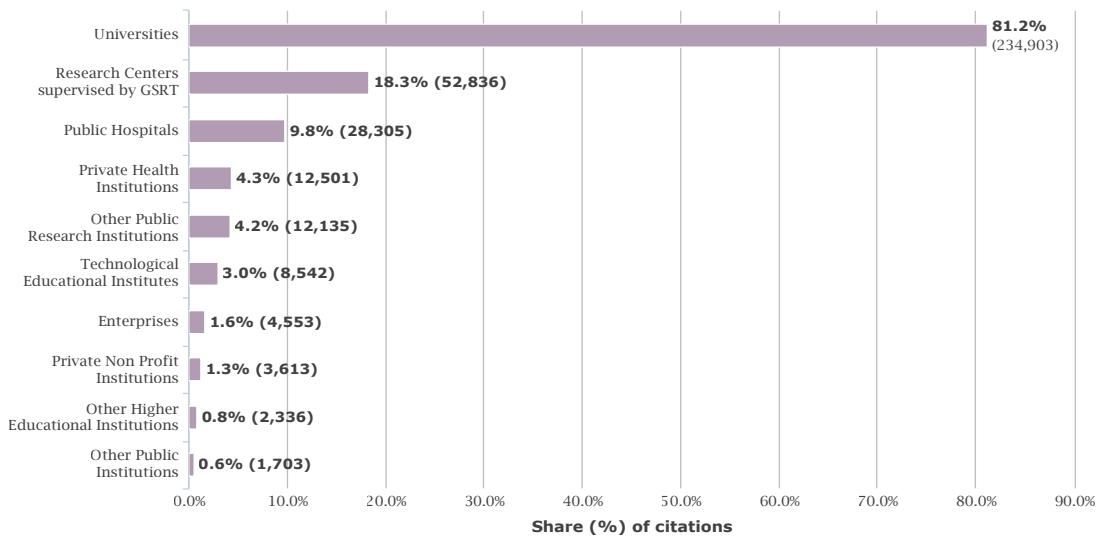


Figure 3.2.3 Number and share (%) of citations by institution category, 2008-2012

3.3 Citation Impact

Figure 3.3.1 shows, for each institution category, the number of publications and citations for the latest 5-year period (2008-2012) and the relevant “field-normalised citation score” (a value greater than 1, indicates that the impact of publications is higher than the world average).

“RC-GSRT” ranked first, with their publications receiving the highest citation score (1.33). “Universities” (1.03), “Other Higher Educational Institutions” (1.02), “Other Public Institutions” (1.02) and “Private Health Institutions” (1.00) had citation scores above the world average.

GREEK SCIENTIFIC PUBLICATIONS BY INSTITUTION CATEGORIES

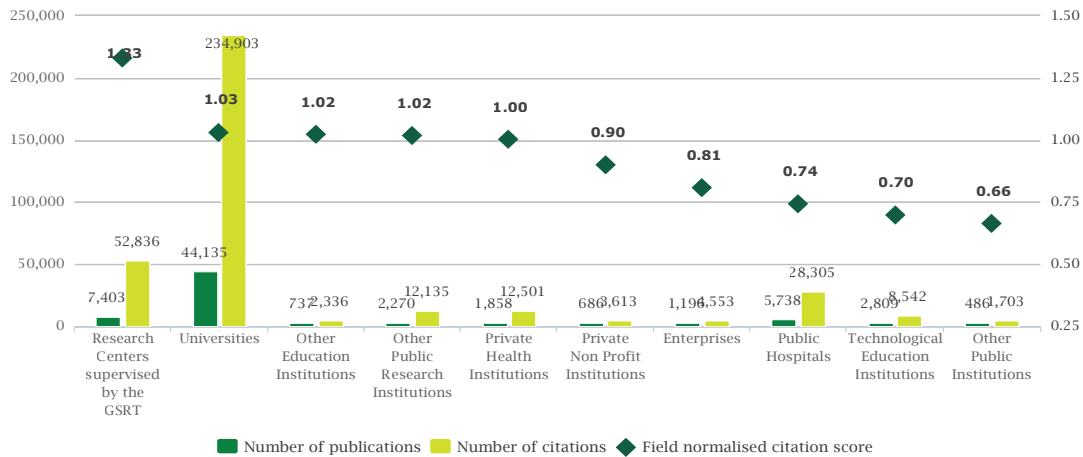


Figure 3.3.1 Publications, citations and field normalised citation score relative to the world, by institution category, 2008-2012. Data refers to the total number of publications in each category for all scientific fields

3.4 Highly cited publications

Figure 3.4.1 illustrates the number of highly cited publications in each institution category for percentile levels 1%, 5%, 10%, 25% and 50%, i.e. the publications attributed to the category that belong respectively to the top 1%, 5%, 10%, 25% and 50% of the most cited publications in the world.

During 2008-2012, the number of top 1% publications for each category was: 511 for «Universities», 131 for «RC-GSRT», 44 for «Public Hospitals», 24 for «Other Public Research Institutions», 18 for «Private Health Institutions», 12 for «TEIs» and for «Enterprises». The remaining institution categories had less than 10 publications in the top 1% publications.

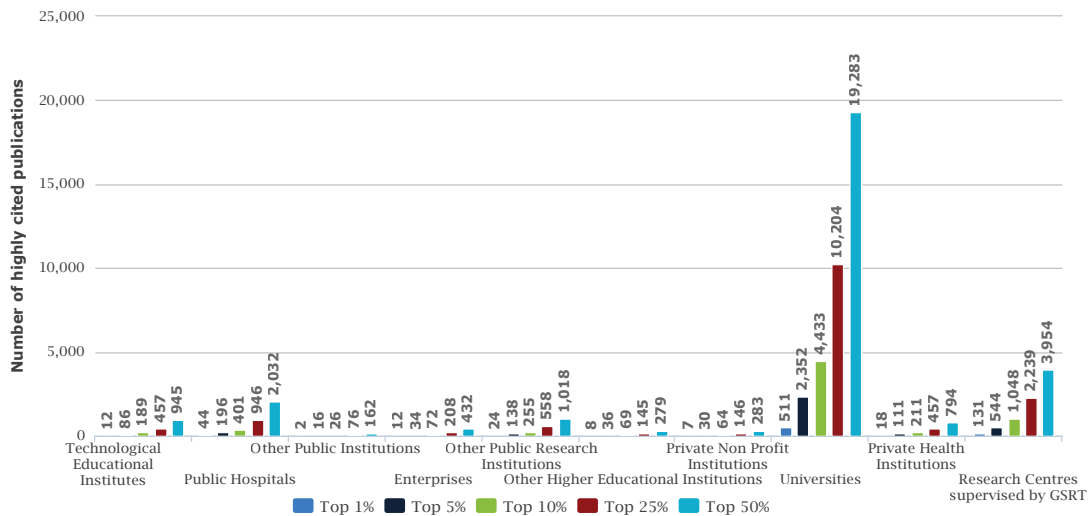


Figure 3.4.1 Number of highly cited publications, by institution category, 2008-2012

Figure 3.4.2 displays the percentage of the highly cited publications in each institution category for percentile levels 1%, 5%, 10%, 25% and 50%. Data refers to the latest 5-year period, 2008-2012. Values above the percentile levels indicate a better performance compared to the world average.

«RC-GSRT» showed a better performance than the world average for all percentile levels. «Universities», «Other Public Research Institutions» and «Private Health Institutions» were above the world average for percentile levels 1%, 5% and 10%.

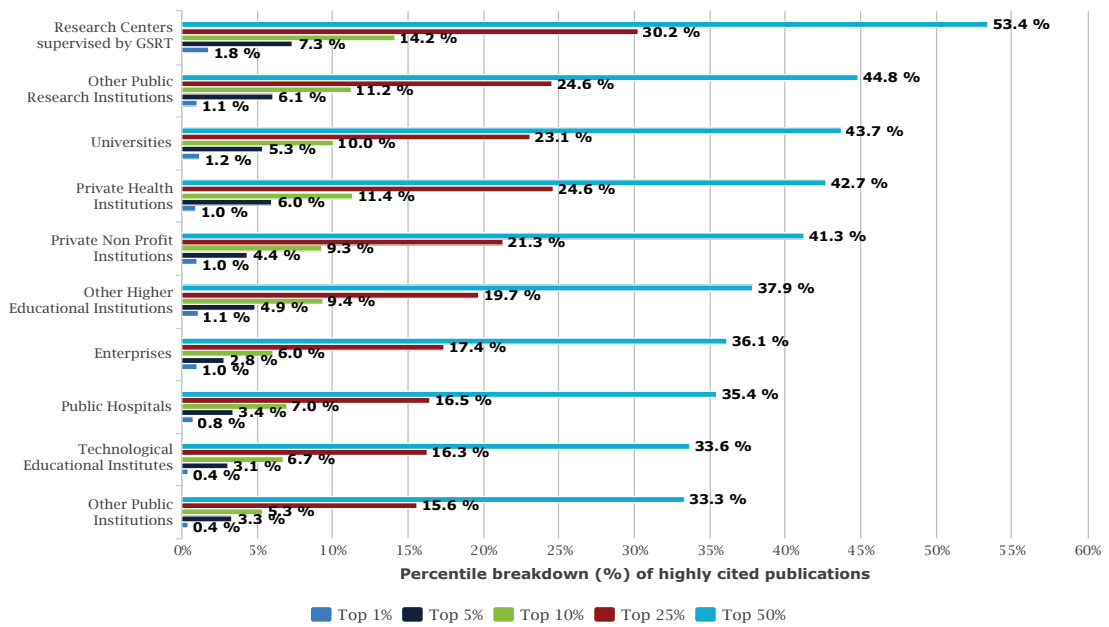


Figure 3.4.2 Percentile breakdown (%) of highly cited publications, by institution category,

3.5 Scientific Fields of Excellence

The citation scores of publications across the six major fields of science for all institution categories* appear in Figure 3.5.1 The Figure also displays the number of publications and citations. Data refers to the most recent 5-year period, 2008-2012.

In "Natural Sciences", a small number of publications attributed to the "Private Health Institutions" recorded the highest citation score (1.45). In addition, the citation scores for publications of "RC-GSRT" (1.25), "Other Higher Educational Institutions" (1.22), "Universities" (1.09) and "Private Non profit Institutions" (1.07) were above world average.

In "Engineering and Technology" the highest citation score was 1.48 and was attributed to the publications of "Other Higher Educational Institutions", followed by "Private Non profit Institutions" (1.20), "RC-GSRT" (1.19), "Other Public Research Institutions" and "Universities" (1.07, respectively).

In "Medical Sciences", publications of three institution categories had a better performance than the world average: "Other Higher Educational Institutions" (1.29), "RC-GSRT" (1.20), and "Other Public Research Institutions" (1.10).

In "Agricultural Sciences" the highest citation score was attributed to the publications of "RC-GSRT" (1.26).

In "Social Sciences", publications by four institution categories attained a performance better than the world average: "Private Non profit Institutions" (1.30), "Other Public Research Institutions" (1.18), "RC-GSRT" (1.08) and "Other Higher Educational Institutions" (1.00).

Finally, in the field of "Humanities", only "Other Public Research Institutions" recorded a citation score above world average (1.16).

* The field normalized citation score is provided only for the Institution Categories with more than 75 publications for the period 1998-2012.

GREEK SCIENTIFIC PUBLICATIONS BY INSTITUTION CATEGORIES

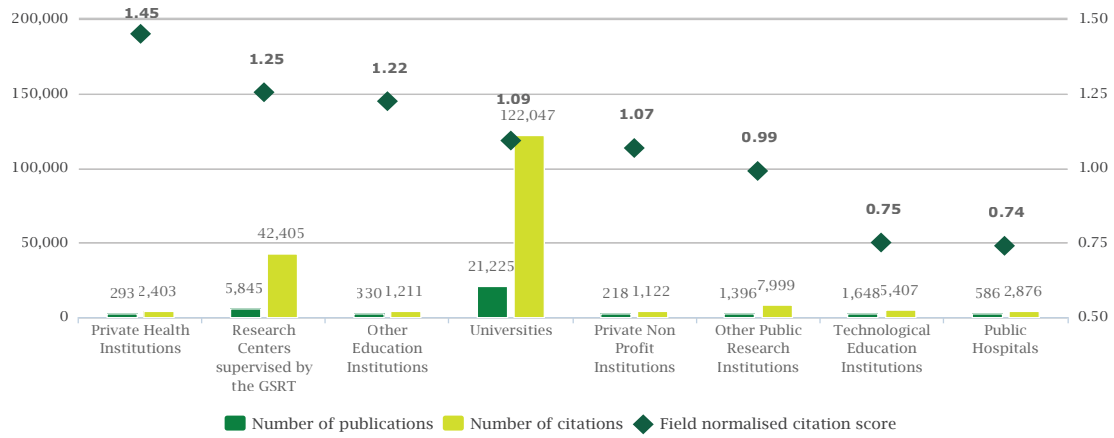


Figure 3.5.1 Publications, citations and field normalised citation score in the major field of «Natural Sciences» relative to the world, by institution category, 2008-2012

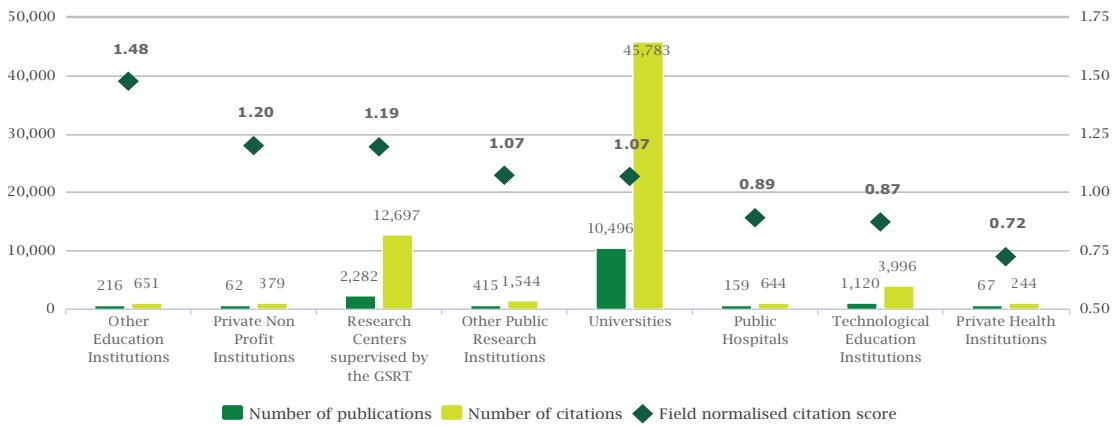


Figure 3.5.1 Publications, citations and field normalised citation score in the major field of «Engineering & Technology» relative to the world, by institution category, 2008-2012

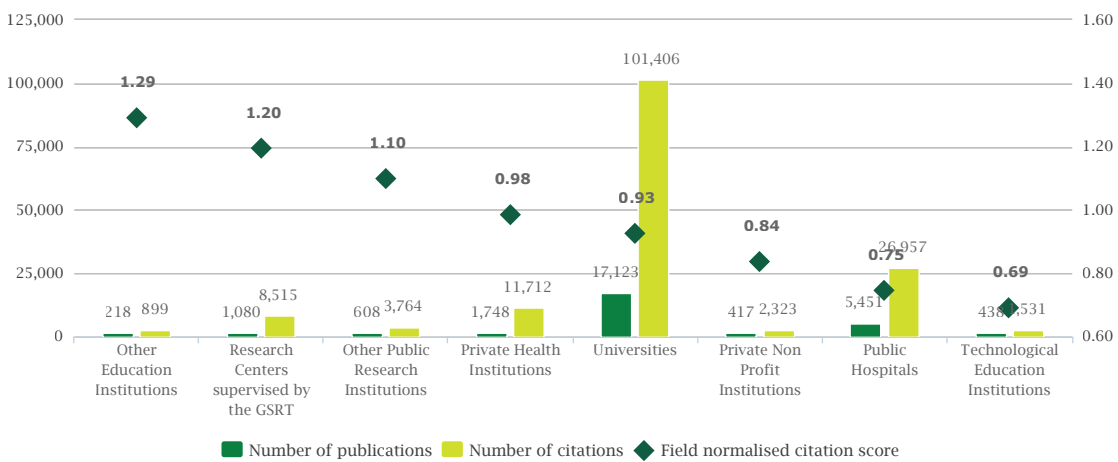


Figure 3.5.1 Publications, citations and field normalised citation score in the major field of «Medical & Health Sciences» relative to the world, by institution category, 2008-2012



Figure 3.5.1 Publications, citations and field normalised citation score in the major field of «Agricultural Sciences» relative to the world, by institution category, 2008-2012

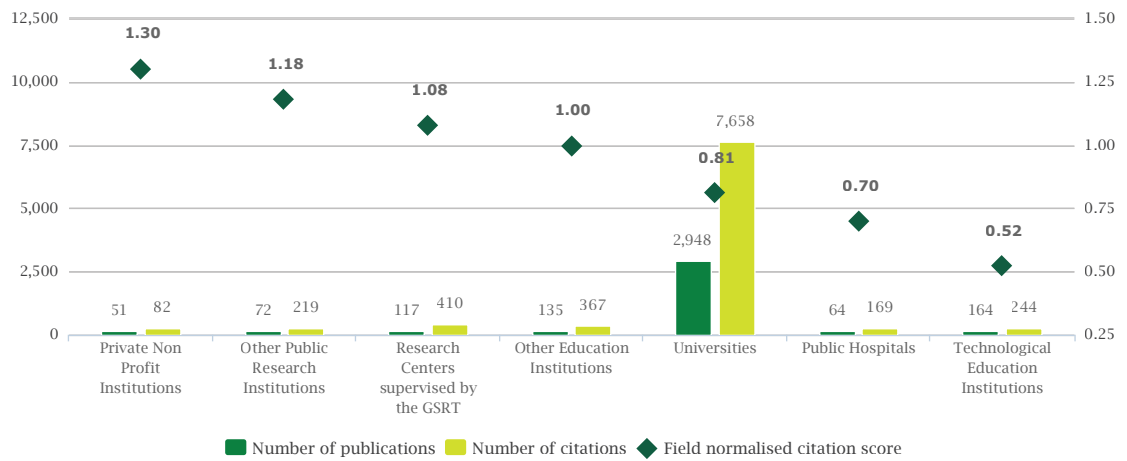


Figure 3.5.1 Publications, citations and field normalised citation score in the major field of «Social Sciences» relative to the world, by institution category, 2008-2012

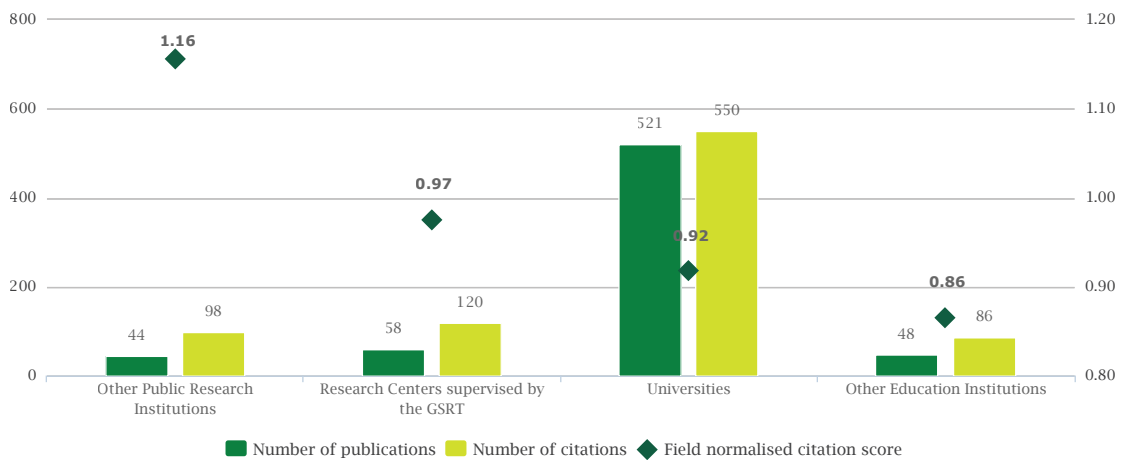


Figure 3.5.1 Publications, citations and field normalised citation score in the major field of «Humanities» relative to the world, by institution category, 2008-2012

3.6 Collaboration

During 1998-2012, all institution categories increased their levels of international and national collaboration.

For example, the publications being a result of national collaboration* rose from 1,167 in 1998 to 3,708 in 2012 for “Universities”, from 438 to 1,008 for “RC-GSRT” and from 41 to 448 for “TEIs” (Figure 3.6.1).

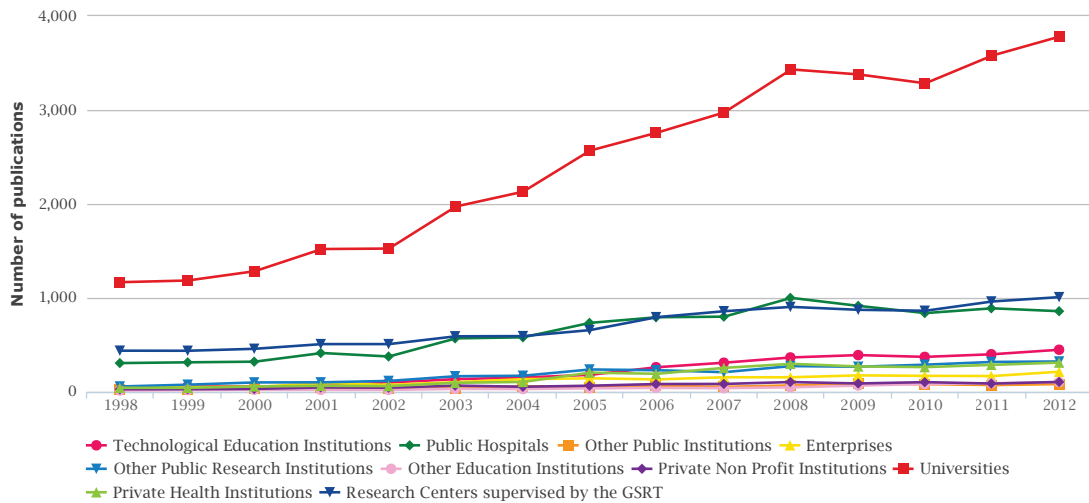


Figure 3.6.1 Number of publications with national collaboration, by institution category, 1998-2012

The number of Greek publications produced with international collaboration also increased. More specifically, the number rose from 1,197 in 1998 to 4,161 in 2012 for “Universities”, from 433 to 955 in “RC-GSRT” and from 24 to 227 for “TEIs” (Figure 3.6.2).

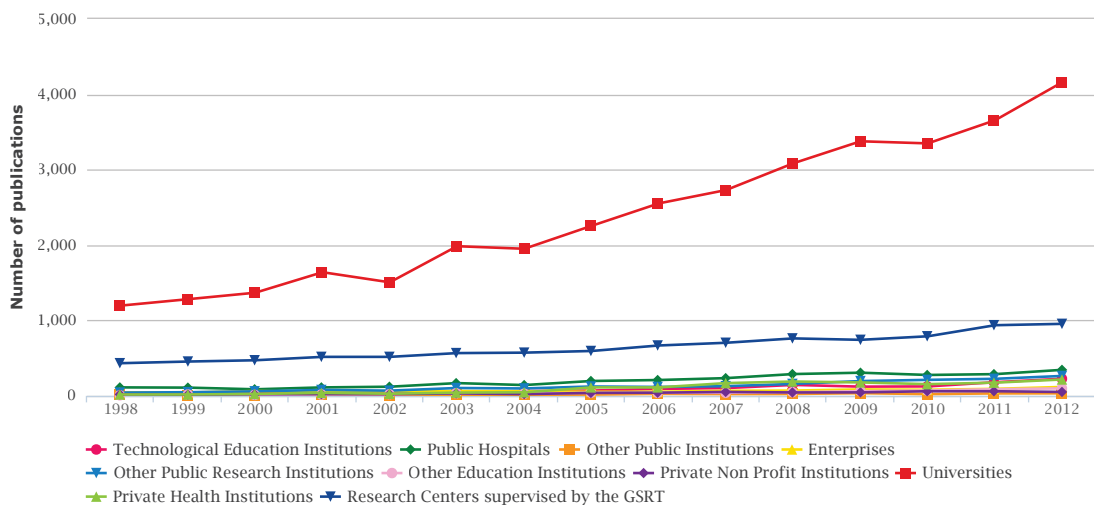


Figure 3.6.2 Number of publications with international collaboration, by institution category, 1998-2012

* National collaboration: number of publications with at least one national collaboration. International collaboration: number of publications with at least one international collaboration. No collaboration: number of publications with one single institution.

The level and the type of collaboration –national or international- varied significantly within institution categories (Figure 3.6.3). “Universities” had the highest share of publications without collaboration, which was equal to 32.9% during the 5-year period 2008-2012. “RC-GSRT” had the highest share of publications with international collaborations (56.6%). Finally, “Other Public Institutions” had the highest share of publications with national collaborations (81.1%).

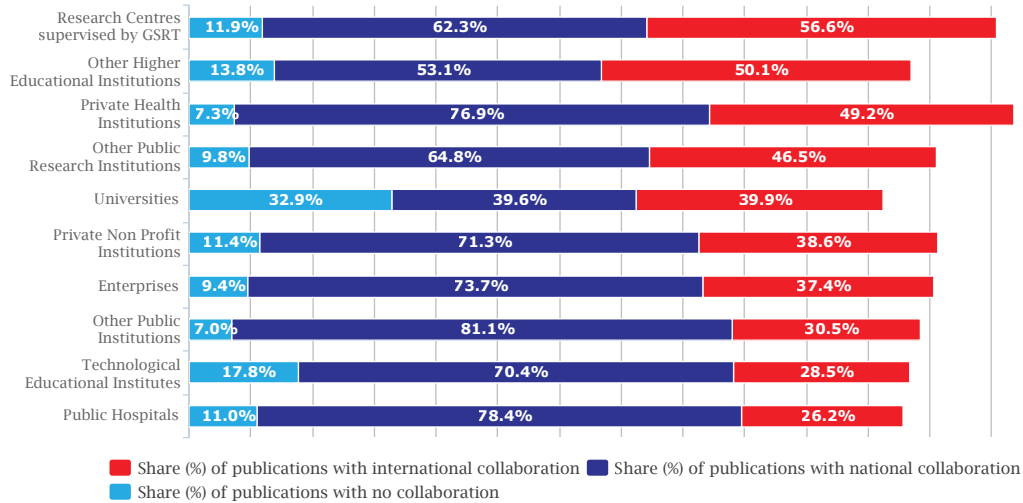


Figure 3.6.3 Share (%) of publications with national, international and no collaboration, by institution category, 2008-2012



APPENDICES

APPENDIX I: METHODOLOGY

APPENDIX II: INDICATORS

APPENDIX III: FIELDS OF SCIENCE

APPENDIX IV: INSTITUTION CATEGORIES

APPENDIX I: METHODOLOGY

Introduction

Bibliometrics deal with the quantitative analysis of scientific literature and particularly with the analysis of citations that scientific publications receive within the international research community. Bibliometric indicators include publication and citation counts, scientific impact indices, collaboration degree, scientific fields of excellence etc.

Bibliometric analysis is a significant tool for the evaluation of research activity, for individual institutions as well as for national research systems or sectors. Bibliometrics offers a sound basis to measure scientific output and performance, its international impact, the research networks among institutions and nations, the knowledge flows and links among scientific disciplines. The number of studies using bibliometric analysis is constantly growing at international level.

Within this context, EKT has launched a study series based on bibliometric analyses of Greek publications in international scientific journals.

The present study is the fourth in the Series and it is based on data from the Web of Science Database. The presentation of indicators from the two internationally established databases (Web of Science and Scopus), provides a fuller picture of significant indicators for Greek publications and scientific fields covered.

The following paragraphs present the study's methodological framework in detail:

Bibliometric Indicators

The study presents the following bibliometric indicators that are widely used throughout international literature:

- Number of publications
- Share (%) of publications
- Percentage (%) of cited publications
- Number of citations
- Share (%) of citations
- Citation impact
- Relative citation impact
- Field normalised citation score
- Number of highly cited publications (Top X%)
- Share (%) of highly cited publications (P Top X%)

For detailed information on bibliometric indicators and methods of their calculation see Appendix II.

Bibliometric Databases

Web of Science (from Thomson Reuters), Scopus (from Elsevier) and Google Scholar are among the most well recognised and internationally established publication and citation databases.

Google Scholar offers access to a huge number of digital sources including scientific articles, conference proceedings, reports etc. Nonetheless, it is not recommended for bibliometric analysis since it lacks detailed metadata necessary for the attribution of publications to research organisations, scientific fields or countries. In addition, it does not offer quality criteria for the inclusion of the different scientific items presented.

Both Web of Science and Scopus ensure the availability of detailed metadata and the quality of publications they include. The Web of Science system (WoS) is the oldest database, including scientific publications from as early as 1900. It extracts data from more than 12,000 peer-review journals. In the newer Scopus database, over 18,500 titles of scientific journals are indexed, with the number continuously expanding, but without data on citations before 1996.

The present study is based on data from the Web of Science international database.

More specifically, data was drawn from the following databases of Thomson Reuters:

- National Science Indicators (NSI): a database with publication and citation statistics for 194 countries and seven geopolitical regions, covering the thirty years between 1981 and 2010. Publications are divided into 253 fields. The information reflects the total number of publications and citations by country, year and scientific field. However, analysis per publication is not provided.
- InCites™ - Greece: a customized citation based research evaluation tool on the web. It uses publication and citation data from Thomson Reuters (<http://incites.isiknowledge.com/>), allowing for systematic and reliable analysis of Greek scientific publications. Within the framework of this study, the relevant data was processed in collaboration with Thomson Reuters so as to ensure consistency with NSI database.

Data for indicators related to the total number of Greek publications and their benchmark worldwide, was drawn from the NSI database. The Incites databases served as a source for data pertaining to indicators such as research collaborations, the distribution of publications by institution or category of institutions and by field of science.

Fields of Science

Web of Science database allows for categorization of publications in 253 scientific subject fields. The database allocates each publication to a specific subject field according to the journal in which the publication appears. It should be noted that a journal may be classified in more than one scientific subject field and so is the case for its publications.

The classification of Greek publications provided by the WoS database, was used in this study for the calculation of bibliometric indicators such as field normalization citation score (normalization process). It was also used to present the specific subject fields where Greek institutions excelled.

Furthermore, Greek publications were classified into 6 major scientific fields and their 42 sub-fields, according to the revised version of the Frascati Manual of OECD. The Frascati classification scheme of fields of science and technology allows for data comparability with standard practices in an international context. It also provides a more consistent framework for the identification of major fields of science in which Greek Institutions were active.

To this end, the 253 subject fields of the WoS database were mapped and included in the following major fields and sub-fields of science of the Frascati Manual:

Natural Sciences (Mathematics / Computer and information sciences / Physical sciences / Chemical sciences / Earth and related environmental sciences / Biological sciences / Other natural sciences)

Engineering & Technology (Civil engineering / Electrical engineering - electronic engineering - information engineering / Mechanical engineering / Chemical engineering / Materials engineering / Medical engineering / Environmental engineering / Environmental biotechnology / Industrial Biotechnology / Nano-technology / Other engineering and technologies)

Medical & Health Sciences (Basic medicine / Clinical medicine / Health sciences / Health biotechnology / Other medical sciences)

Agricultural Sciences (Agriculture, forestry, and fisheries / Animal and dairy science / Veterinary science / Agricultural biotechnology / Other agricultural sciences)

Social Sciences (Psychology / Economics and business / Educational sciences / Sociology / Law / Political Science / Social and economic geography / Media and communications / Other social sciences)

Humanities (History and archaeology / Languages and literature / Philosophy, ethics and religion / Art (arts, history of arts, performing arts, music) / Other humanities)

The detailed mapping of the 253 subject fields of the Web of Science database with the 6 major fields and 42 sub-fields of science of the Frascati Manual is provided in Appendix III.

Types of publications

This study was based on data related to articles, research notes and reviews and we excluded editorials, letters, correction notes and abstracts. Throughout international literature, the types of scientific publications studied -articles, research notes and reviews- are treated as the most important sources for knowledge production and science development.

Time frame for analysis of citations

The number of citations that a publication is likely to receive depends on its impact in the research community but also on the time period that has passed since it was first published. Older publications usually have more citations.

To normalize differences observed between high numbers of citations received by older publications and low in the latest publications, citation counting in this study was made using overlapping 5-year windows. In particular, we recorded citations received in a certain 5-year period for publications edited within the same 5 year period.

As a result, trends in the number of citations and relevant bibliometric indicators were presented on the basis of 11 overlapping 5 year periods throughout the overall period of analysis (1998-2012).

Since the author's practice of citing her/his previous work in a publication is a common practice among authors, we included self citations in the overall number of citations per publication.

Counting of publications

In most cases, publications have more than one authors. Their authors are likely to be affiliated with different institutions in different countries. In addition, in bibliometric databases a journal is usually classified under more than one scientific field. As a result, the distribution of publications into 6 major fields of science and their sub-fields, may cause overlapping.

Publication counts presented in this study are «whole counts» i.e. in the case of multi authored publications each participating institution or country received a whole count and not a fraction of the publication. Similarly, in the case of a publication classified in more than one scientific field, each scientific field or sub-field received a whole count of the publication.

As a result, within a given frame of reference, the sum of publications compiled from different unit of analysis -institutions, institution categories or scientific fields -was higher than the actual total numbers of publications. The "share" (%) of publications of each analytical unit was calculated as the number of its publications divided by the actual total number of publications of the frame of reference and not by the sum of individual units. Consequently, "shares" express the participation of a given unit of analysis in the total output of its frame of reference and not its contribution to it. For example, a publication share of 80% for the institution category "Universities" means that in the 80% of Greek publications we record Universities as participating organisations.

The same rule applies when calculating the share (%) of citations and the share of scientific fields.

Finally, the same methodology is used for calculating the number of collaborations at national and international level. Collaboration is defined as co-authorship involving different institutions. International collaboration refers to Greek publications co-authored with institutions in another country (-ies). Exclusively international collaboration refers to Greek publications co-authored only with institutions in another country (-ies). National collaboration refers to Greek publications co-authored with Greek institutions. Exclusively national collaboration refers to Greek publications co-authored only with Greek institutions. No collaboration refers to Greek publications not involving co-authorship across institutions and includes articles either by only one author or articles being the product of intra-institutional collaboration.

Citation Impact Indicators

In bibliometric analysis, a range of indicators are used for evaluating the impact (or influence) of the published work on the scientific community. These indicators are principally based on the number of citations of publications for a specific time period.

The citation impact, –a widely used indicator–, is the average number of citations per publication. The indicator is calculated as the ratio of the number of citations recorded for a specific time period to the total number of publications of the same time period. The relative citation impact is used for comparative analysis of publications and compares the citations to publications per unit of analysis (e.g. Greece) in relation to the citations to publications within a certain frame of reference (e.g. OECD countries). The relative citation impact is calculated as the ratio of the corresponding citation impacts. When the value of the relative citation impact is greater than 1, the publications of the analysed unit have a greater impact than those within the reference frame.

A number of scientific studies have confirmed that factors such as the different citation practices in various scientific fields or the type of publication significantly affect the citation indicators.

Indeed, publication and citation practices vary among disciplines. There often exist differences between fields of research in terms of citation practices, the life-span of publications, publishing and citation patterns.

For instance, in medicine and molecular biology the annual publication output is high and the level of citations increases significantly within a relatively short time period following the publication. In contrast, in the Social Sciences the publication rate is rather low and many studies may still be cited decades after their release. In the Humanities, the greatest part of publications is books, monographs and articles usually published in national journals, which affects citation patterns. Other scientific areas, such as the ICT, have conference proceedings as their main publication source. Hence, comparison between indicators of different scientific fields and sub-fields may lead to misleading results.

To tackle the issue of different citation practices, it was decided to use the **field normalised citation score**, which is an incremental improvement of the Crown indicator.

The field normalised citation score or citation score is the key indicator used in this study to estimate the impact of the publications of the analytical units examined (e.g. institution category, institution, subject field etc) in relation to the world. The field normalised citation score was calculated using software developed by the National Documentation Center (EKT) allowing for calculations at the level of each publication for each of the 253 subject fields provided by the Web of Science database.

More specifically, the number of citations of each of the unit's publications is normalised by dividing it with the world average of citations to publications of the same publication year and subject field. The citation score is the mean value of all normalised citation scores for the unit's publications. As an example, the citation score of the institution category "Universities" was the mean value of the citation scores calculated for each of the Universities publications; the citation score of each publication was represented by its citations divided by the world average of citations to publications of the same publication year and the subject field it belonged to.

Growth rates

Rate of Change

The change of indicators throughout the period 1998-2012 was displayed either on an annual basis (Figure 2.1.2 – number of publications) or within rolling 5-year periods (Figure 2.2.2 – number of citations).

The progression and growth for indicators was evaluated using the rate of change determined as follows:

$$\Delta t_2 - t_1 = 1 + \frac{n_2 - n_1}{n_1}$$

where $\Delta t_2 - t_1$ is the rate of change n_1, n_2 are the values of the indicator for the years (or period of years) t_1 and t_2 , respectively.

The indicator is equal to 1 if the values n_1, n_2 remain the same for the years (or period of years) t_1 and t_2 .

Indexes calculated using a base year

In the calculation of an index using index value in base year (e.g. Number of publications (1998 = 100)), the base year is the year with which the values from other years are compared. Using an index makes quick comparisons easy. The index value of the base year is conventionally set to equal 100. The calculation of an index value is as follows:

$$v_{t_1|t=100} = 100 * \frac{v_{t_1}}{v_{t=100}}$$

where $v_{t_1|t=100}$ is the index value in year t_1 using t as the base year, v_{t_1} is the index value in year t_1 and $v_{t=100}$ is the index value in base year t .

Threshold number of publications

Field normalised citation scores were calculated per institution, institution category or scientific field only in the case of a “considerable” number of publications i.e. a number that would ensure the reliability of analysis and minimize the influence of random factors without excluding from the analysis organizations with a rather low publications output. Data analysis showed that a threshold of 75 publications for the period 1998-2012, corresponding to 5 publications per year, constituted a good compromise. Given the low number of publications by Greek institutions in most of the cases, the above threshold aims to ensure the reliability of information about the majority of institutions.

Data Processing

For the purpose of this study, EKT developed its own software which enables data cleaning and integrity check for bibliometric databases, calculation of non-trivial bibliometric indicators and presentation of the results using interactive visualizations.

Specifically, the software enables:

- calculation of complex bibliometric indicators such as the field normalised citation score per scientific field, the count and type of collaborations among institutions etc.
- classification of Greek publications adopting the Frascati/OECD taxonomy for scientific areas and mapping of the Frascati/OECD taxonomy with that employed by bibliometric databases.
- production of analytical customized reports per institution category, per institution etc.
- effective cleaning of data and identification of Greek organizations. Cleaning the provided data was critical. The cleaning process allowed the export of reliable indicators since certain organizations appeared in the bibliometric databases with multiple names and there was a lack of unique identifiers and authority files. The identification problem would pose difficulties when exporting reliable reports at organization level. By developing specialized software for this purpose – to resolve matters related with documentation and information organization- EKT implemented systematic procedures for cleaning the primary data. These procedures included identifying alternative names for Greek organizations and the homogenization of data -resulting in a new database version-. EKT’s previous bibliometric study, describes this procedure in detail.
- automated generation of interactive charts –embedded in the study’s online edition- so that the study’s results could be communicated in a comprehensive way.

The software developed by EKT employed a set of tools that allowed the processing of primary data of different types (XML, relational databases), their representation as an independent data model and their processing and categorization. The data model facilitated the calculation of descriptive and complex bibliometric indicators which were visualized using interactive charts and exported to multiple formats (CSV, Excel, JSON) for use in different media (text files, spreadsheets).

Furthermore, the software was heavily parameterized, in order to allow parallel execution of different data workflows, which significantly accelerated the process of calculating the necessary indicators. Note that the system was designed to be largely independent of specific software and technologies, both in the incorporation of raw data and in the production of intermediate and final results.

Finally, special attention was given to the presentation of Greek bibliometric indicators. Findings are presented in the form of an online book. The selected presentation format enhances accessibility and dissemination of the results and offers a range of navigation, interactive and browsing functions to its readers.

Interpretation of results

To avoid fragmented and invalid comparisons, a combined interpretation of bibliometric indicators is required on the part of the reader. Hence, when interpreting indicators such as the rate of change, the relative citation impact or citation score, the percentage of cited publications or the percentile breakdown of highly cited publications, one has to also consider the number of publications as well as their systematic production over time.

The overall aim of the analysis carried out, was not just to identify trends and tendencies but also to highlight outstanding aspects which characterize the output of Greek publications. To this end, we applied a wide range of indicators to compile a comprehensive picture. In order to minimize the influence of random factors, we adopted the following:

- To reflect information regarding current research activity, figures present information and indicators corresponding to the last 5-year period 2008-2012 so as to control abnormal annual variations.
- We provide a trend analysis, when applicable, throughout the period 1998-2012.
- To ensure the reliability of results, indicators were calculated only for institutions with a publication output above the threshold (75 publications for the period 1998-2012).
- The calculations did not take into account certain extremely random cases. For example, when calculating citation scores per scientific subfield we excluded extremely highly cited publications produced by institutions with a low and unstable number of publications in the field.
- Finally, the analysis was based on robust and appropriate methodological and software tools, which will support future bibliometric studies, in the series. By ensuring consistency in procedures, methodology and software used, we make the accurate mapping of research activity possible and we allow for comparability across data.

Scientific publications in journals are the traditional indicator of research activities. It is customary to evaluate the results of research activities based on the number of scientific articles produced and the share the articles have on the global map, the share of citations the articles received, the collaborations formed to produce them as well as other standard bibliometric indicators.

Within this context, bibliometric data is definitely an important part of the information needed to measure research output, but it is not the only one. Other indicators -such as the number of patents, licenses, research projects, social impact etc- should also be taken into account.

APPENDIX II: INDICATORS

Table of Bibliometric Indicators used

INDICATOR	DESCRIPTION	INTEPRETATION
Number of publications	The number of scientific publications is calculated on the basis of:	An indication of the volume of research output for:
	<ul style="list-style-type: none"> country total. 	<ul style="list-style-type: none"> Greece.
	<ul style="list-style-type: none"> institution category. 	<ul style="list-style-type: none"> each institution category.
	<ul style="list-style-type: none"> scientific field. 	<ul style="list-style-type: none"> each scientific field.
Share of publications (%)	It is calculated as a percentage of:	An indication for the participation of:
	<ul style="list-style-type: none"> Greek publications in relation to EU and OECD publications. 	<ul style="list-style-type: none"> Greece within all EU and OECD publications.
	<ul style="list-style-type: none"> publications per institution category in relation to the total number of Greek publications. 	<ul style="list-style-type: none"> each institution category within all Greek publications.
	<ul style="list-style-type: none"> publications falling under one scientific field in relation to the total number of Greek publications. 	<ul style="list-style-type: none"> each scientific field within all scientific fields.
Percentage of cited publications (%)	The percentage of publications that have received at least one citation. It is calculated using overlapping 5-year periods for the following units of analysis:	An indication for the levels of visibility / recognition of scientific publications produced by:
	<ul style="list-style-type: none"> country total. 	<ul style="list-style-type: none"> Greece.
	<ul style="list-style-type: none"> institution category. 	<ul style="list-style-type: none"> each institution category.
	<ul style="list-style-type: none"> institution. 	<ul style="list-style-type: none"> each institution.
Number of citations	The number of citations within a specific time period to articles published by the analysed unit during the same time period. It is calculated using overlapping 5-year periods on the following levels:	An indication of the influence and visibility of scientific publications produced by:
	<ul style="list-style-type: none"> country total. 	<ul style="list-style-type: none"> Greece.
	<ul style="list-style-type: none"> institution category. 	<ul style="list-style-type: none"> each institution category.
	<ul style="list-style-type: none"> scientific field. 	<ul style="list-style-type: none"> each scientific field.
	<ul style="list-style-type: none"> institution. 	<ul style="list-style-type: none"> each institution.

INDICATOR	DESCRIPTION	INTEPRETATION
Share of citations (%)	It is calculated using overlapping 5-year periods as the percentage of citations received by the publications of:	An indication for the influence and visibility of:
	<ul style="list-style-type: none"> • Greece in relation to the number of citations that EU and OECD's publications received. 	<ul style="list-style-type: none"> • Greece within the EU and OECD.
	<ul style="list-style-type: none"> • citations in one institution category in relation to the total number of citations for Greek publications. 	<ul style="list-style-type: none"> • each institution category within Greece.
	<ul style="list-style-type: none"> • citations found in each scientific field in relation to the total number of citations for Greek publications. 	<ul style="list-style-type: none"> • each scientific field within all scientific fields.
Citation impact	<p>The citation impact is the average number of citations per publication and is calculated as the ratio of the number of citations recorded for a specific time period to the total number of publications of the same time period. Calculations have been performed using overlapping 5-year periods.</p> <p>As this indicator does not take into account the variations of citation practices within the different scientific fields, it was only used for the calculation of the citation impact of all Greek scientific publications.</p>	An indication for the impact of publications.
Relative citation impact	<p>The relative citation impact compares the citations to publications per unit of analysis [e.g. Greece] in relation to the citations to publications within a certain frame of reference [e.g. the EU countries]. It is calculated as the ratio of the corresponding citation impacts.</p> <p>When the value of the relative citation impact is greater than 1, the publications of the analysed unit have a greater impact than those within the reference frame. The indicator does not take into account the variations of citation practices within the different scientific fields.</p> <p>In this study the relative citation impact was only used to establish Greece's place amongst the member countries of the EU and the OECD and was calculated as the ratio of the citation impact for all Greek publications to the citation impact for the countries of the EU and the OECD.</p>	With reference to all Greek publications in all scientific fields, comparison can be made between the impact of Greek publications and those of EU and OECD publications.

INDICATOR	DESCRIPTION	INTEPRETATION
Field normalised citation score (abv: citation score)	<p>This indicator expresses the citation impact normalised according to subject field. It compares the average number of citations to the publications of an analysed unit to the average number of citations to international publications from the same year, in the same research field.</p> <p>The Field Normalised Citation Score or citation score is the key indicator used in this study to estimate the impact of the publications of an analyzed unit in relation to world. It was calculated using software particularly developed by EKT. The specific software permitted normalisation of the citation values on an individual article level on the basis of the distribution of publications over the specific subject fields designated by bibliometric databases.</p> <p>When the value of the citation score is greater than 1, the publications of the analysed unit have a greater impact than the world average.</p> <p>In the study citation scores were calculated after normalisation for:</p>	<p>An indication for the impact of publications taking into account differences in citation practices across scientific fields. The impact of publications relative to world is derived for:</p>
	<ul style="list-style-type: none"> the sum of Greek publications. 	<ul style="list-style-type: none"> Greece.
	<ul style="list-style-type: none"> Greek publications by scientific field. 	<ul style="list-style-type: none"> Greece within the 6 major scientific fields.
	<ul style="list-style-type: none"> the sum of publications for an institution category. 	<ul style="list-style-type: none"> each institution category.
	<ul style="list-style-type: none"> the publications for an institution category by scientific field. 	<ul style="list-style-type: none"> each institution category within the 6 major scientific fields.
	<ul style="list-style-type: none"> the sum of publications for an institution. 	<ul style="list-style-type: none"> each institution.
	<ul style="list-style-type: none"> publications of an institution by scientific field. 	<ul style="list-style-type: none"> each institution within the 6 major scientific fields.
Number of top publications (P Top X%)	<p>It is the number of publications attributed to a unit that belongs to the X% most cited publications in the world from the same year, in the same subject field. The ranking was carried out based on the number of citations.</p> <p>The indicator was calculated for 5-year periods to the percentile levels 1%, 5%, 10%, 25% and 50% [that is the number of publications that were ranked worldwide in the 1%, 5%, 10%, 25% and 50% most cited publications] on the following levels:</p>	<p>An indication of the volume of high impact publications produced by:</p>
	<ul style="list-style-type: none"> for country total. 	<ul style="list-style-type: none"> Greece.
	<ul style="list-style-type: none"> per institution category. 	<ul style="list-style-type: none"> each institution category.
Percentile breakdown of top publications (Top X%)	<p>It is the share (%) of publications attributed to a unit that belong to the X% most cited publications in the world from the same year, in the same subject field. It is calculated at percentile levels of 1%, 5%, 10%, 25% and 50%.</p> <p>When the percentile breakdown of a unit is approximately that of the corresponding world breakdown (or surpasses it) 1%, 5%, 10%, 25% and 50%, then the performance of the unit is considered equal or above the world average. The indicator is calculated over time periods of five years:</p>	<p>Comparison to the world average for percentile breakdown of top publications is made for:</p>
	<ul style="list-style-type: none"> for country total. 	<ul style="list-style-type: none"> Greece.
	<ul style="list-style-type: none"> per institution category. 	<ul style="list-style-type: none"> each institution category.
	<ul style="list-style-type: none"> per institution. 	<ul style="list-style-type: none"> each institution.

APPENDIX III: FIELDS OF SCIENCE

Classification of the Subject fields of the Web of Science database into the six major fields of science and 42 scientific subfields of the Frascati Manual/ OECD

MAJOR FIELDS OF SCIENCE & TECHNOLOGY FRASCATI MANUAL	SCIENTIFIC SUBFIELDS FRASCATI MANUAL	SUBJECT FIELDS - WEB OF SCIENCE DATABASE
Natural Sciences	Mathematics	• mathematics
		• mathematics, applied
		• mathematics, interdisciplinary applications
		• comp critical reviews
		• statistics & probability
	Computer and Information Sciences	• computer science, artificial intelligence
		• computer science, cybernetics
		• computer science, information systems
		• computer science, interdisciplinary applications
		• computer science, software engineering
		• computer science, theory & methods
		• mathematical & computational biology
	Physical Sciences	• acoustics
		• astronomy & astrophysics
		• optics
		• physics, applied
		• physics, atomic, molecular & chemical
		• physics, condensed matter
		• physics, fluids & plasmas
		• physics, mathematical
		• physics, multidisciplinary
• physics, nuclear		
• physics, particles & fields		

MAJOR FIELDS OF SCIENCE & TECHNOLOGY FRASCATI MANUAL	SCIENTIFIC SUBFIELDS FRASCATI MANUAL	SUBJECT FIELDS - WEB OF SCIENCE DATABASE
Natural Sciences	Chemical Sciences	• chemistry, analytical
		• chemistry, applied
		• chemistry, inorganic & nuclear
		• chemistry, multidisciplinary
		• chemistry, organic
		• chemistry, physical
		• crystallography
		• spectroscopy
		• electrochemistry
		• polymer science
	Earth and related Environmental Sciences	• oceanography
		• paleontology
		• geochemistry & geophysics
		• geography, physical
		• geology
		• geoSciences, multidisciplinary
		• meteorology & atmospheric Sciences
		• mineralogy
		• water resources
		• environmental Sciences
	Biological Sciences	• behavioral Sciences
		• biochemical research methods
		• biochemistry & molecular biology
		• biodiversity conservation
		• biology

MAJOR FIELDS OF SCIENCE & TECHNOLOGY FRASCATI MANUAL	SCIENTIFIC SUBFIELDS FRASCATI MANUAL	SUBJECT FIELDS - WEB OF SCIENCE DATABASE
Natural Sciences	Biological Sciences	• biology, miscellaneous
		• biophysics
		• cell biology
		• developmental biology
		• ecology
		• entomology
		• evolutionary biology
		• genetics & heredity
		• limnology
		• marine & freshwater biology
		• microbiology
		• mycology
		• ornithology
		• plant Sciences
	• reproductive biology	
• virology		
	Other Natural Sciences	• microscopy
Engineering & Technology	Civil Engineering	• construction & building technology
		• engineering, civil
		• transportation science & technology
	Electrical Engineering, Electronic Engineering, Information Engineering	• automation & control systems
		• computer science, hardware & architecture
		• engineering, electrical & electronic
		• robotics
	• telecommunications	

MAJOR FIELDS OF SCIENCE & TECHNOLOGY FRASCATI MANUAL	SCIENTIFIC SUBFIELDS FRASCATI MANUAL	SUBJECT FIELDS - WEB OF SCIENCE DATABASE
Engineering & Technology	Mechanical Engineering	• engineering, aerospace
		• engineering, industrial
		• engineering, manufacturing
		• engineering, mechanical
		• mechanics
		• nuclear science & technology
		• thermodynamics
	Chemical Engineering	• engineering, chemical
	Materials Engineering	• materials science, ceramics
		• materials science, characterization & testing
		• materials science, coatings & films
		• materials science, composites
		• materials science, multidisciplinary
		• materials science, paper & wood
		• materials science, textiles
		• metallurgy & metallurgical engineering
	Medical Engineering	• engineering, biomedical
	Environmental Engineering	• energy & fuels
		• engineering, environmental
		• engineering, geological
		• engineering, marine
		• engineering, ocean
		• engineering, petroleum
		• mining & mineral processing
		• remote sensing
	Industrial Biotechnology	• materials science, biomaterials
		• medical laboratory technology
		• neuroimaging
	Nano-technology	• nanoscience & nanotechnology
	Other Engineering and Technologies	• food science & technology microbiology
		• engineering, multidisciplinary
• imaging science & photographic technology		
• instruments & instrumentation		

MAJOR FIELDS OF SCIENCE & TECHNOLOGY FRASCATI MANUAL	SCIENTIFIC SUBFIELDS FRASCATI MANUAL	SUBJECT FIELDS - WEB OF SCIENCE DATABASE
Medical & Health Sciences	Basic Medicine	• anatomy & morphology
		• chemistry, medicinal
		• cytology & histology
		• immunology
		• neuroSciences
		• pathology
		• pharmacology & pharmacy
		• physiology
	Clinical Medicine	• toxicology
		• allergy
		• andrology
		• anesthesiology
		• cardiac & cardiovascular systems
		• clinical neurology
		• critical care medicine
		• dentistry, oral surgery & medicine
		• dermatology
		• emergency medicine
		• endocrinology & metabolism
		• gastroenterology & hepatology
		• geriatrics & gerontology
		• hematology
		• medicine, general & internal
		• obstetrics & gynecology
		• oncology
		• ophthalmology
• orthopedics		
• otorhinolaryngology		
• pediatrics		
• peripheral vascular disease		
• psychiatry		
• radiology, nuclear medicine & medical imaging		

MAJOR FIELDS OF SCIENCE & TECHNOLOGY FRASCATI MANUAL	SCIENTIFIC SUBFIELDS FRASCATI MANUAL	SUBJECT FIELDS - WEB OF SCIENCE DATABASE
Medical & Health Sciences	Clinical Medicine	• respiratory system
		• rheumatology
		• surgery
		• transplantation
		• urology & nephrology
Agricultural Sciences	Agriculture, Forestry, and Fisheries	• agronomy
		• fisheries
		• forestry
		• horticulture
	Animal and Dairy Science	• agriculture, dairy & animal science
	Veterinary Science	• veterinary Sciences
	Other Agricultural Sciences	• agricultural economics & policy
• agricultural engineering		
• agriculture, multidisciplinary		
Social Sciences	Psychology	• ergonomics
		• psychology
		• psychology, applied
		• psychology, biological
		• psychology, clinical
		• psychology, developmental
		• psychology, educational
		• psychology, experimental
		• psychology, mathematical
		• psychology, multidisciplinary
		• psychology, psychoanalysis
		• psychology, social
		Economics and Business
	• business, finance	
	• economics	
	• industrial relations & labor	
	• management	
	• operations research & management science	

MAJOR FIELDS OF SCIENCE & TECHNOLOGY FRASCATI MANUAL	SCIENTIFIC SUBFIELDS FRASCATI MANUAL	SUBJECT FIELDS - WEB OF SCIENCE DATABASE
Social Sciences	Educational Sciences	• education & educational research
		• education, scientific disciplines
		• education, special
	Sociology	• anthropology
		• demography
		• ethnic studies
		• family studies
		• gerontology
		• social issues
		• social work
		• sociology
		• women's studies
	Law	• criminology & penology
		• law
	Political Sciences	• international relations
		• political science
		• public administration
	Social and Economic Geography	• area studies
		• environmental studies
		• geography
		• planning & development
• transportation		
• urban studies		
Media and Communications	• communication	
	• information science & library science	
Other Social Sciences	• history of social Sciences	
	• social Sciences, interdisciplinary	
	• social Sciences, mathematical methods	
Humanities	History and Archaeology	• archaeology
		• history

MAJOR FIELDS OF SCIENCE & TECHNOLOGY FRASCATI MANUAL	SCIENTIFIC SUBFIELDS FRASCATI MANUAL	SUBJECT FIELDS - WEB OF SCIENCE DATABASE
Humanities	Languages and Literature	• classics
		• language & linguistics
		• linguistics
		• literary reviews
		• literary theory & criticism
		• literature
		• literature, american
		• literature, british isles
		• literature, german, dutch, scandinavian
		• literature, romance
	• medieval & renaissance studies	
	Philosophy, Ethics and Religion	• asian studies
		• ethics
		• history & philosophy of science
		• philosophy
		• religion
	Arts	• architecture
		• art
		• dance
		• film, radio, television
		• folklore
		• music
• poetry		
• theater		
Other Humanities	• humanities, multidisciplinary	

APPENDIX IV: INSTITUTION CATEGORIES

Bibliometric indicators for Greek scientific publications were calculated at two different levels of aggregation:

- The total number of Greek publications
- Ten (10) specific categories of institutions

Greek institutions are classified into four sectors (BES, GOV, HES, PNP) according to the sector of activities in which they belong and the classification criteria used in the Frascati Manual (OECD 2002).

Specifically, institutions which produced scientific publications were grouped in the following categories:

SECTOR	INSTITUTION CATEGORY	DESCRIPTION
Higher Education Sector (HES)	Universities	<p>Universities, University research institutes (EPI) and University Hospitals</p> <p>Universities include (in alphabetic order in Greek): Athens School of Fine Arts, Aristotle University of Thessaloniki, Agricultural University of Athens, Demokritos University of Thrace, International Hellenic University, National & Kapodistrian University of Athens, Hellenic Open University, National Technical University of Athens, Ionian University, Athens University of Economics and Business, University of the Aegean, University of Western Greece, University of Western Macedonia, University of Thessaly, University of Ioannina, University of Crete, University of Macedonia of Economic and Social Sciences, University of Patras, University of Piraeus, University of the Peloponnese, University of Central Greece, Panteion University of Social and Political Sciences, Technical University of Crete, Harokopio University of Athens.</p> <p>University research institutes include 15 research institutes operating within Greek Universities such as the Institute of Communications and Computer Systems of the National Technical University of Athens (NTUA), the Research Institute of Procedural Studies of the National & Kapodistrian University of Athens, the Institute of Plasma Physics of the University of Crete, the Research Institute of Neurosurgery of the University of Ioannina etc.</p> <p>University hospitals include (in alphabetic order in Greek): Aretaieio Hospital, Eginition Hospital, General University Hospital of Larissa, General University Hospital of Patras / «Agios Andreas» General Hospital Patras, Univeristy General Hospital of Heraklion / Venizelio-Panakio Hospital of Heraklion, University General Hospital «ATTIKON», University General Hospital of Thessaloniki AHEPA, University Hospital of Alexandroupolis / Academic General Hospital of Alexandroupolis, University Hospital of Ioannina / Hatzikosta General Hospital of Ioannina.</p>
	Technological Educational Institutes (TEI)	<p>Technological Educational Institutes (TEI)></p> <p>TEI include (in alphabetic order in Greek): School of Pedagogical and Technological Education – ASPETE, TEI of Athens, TEI of West Macedonia, TEI of Epirus, Alexandreio Technological Educational Institute) of Thessaloniki, TEI of Ionian Islands, TEI of Kavala, TEI of Kalamata, TEI of Crete, TEI of Lamia, TEI of Larissa, TEI of Messolonghi, TEI of Patras, TEI of Piraeus, TEI of Serres, TEI of Chalkida.</p>
	Other Higher Educational Institutions	<p>Other Higher Educational Institutions include the Private Institutes of Vocational Training (IEK) accredited by the Ministry of Education and Religious Affairs, as well as other HE schools/academies (e.g. Higher Ecclesiastical Schools, Military Academies).</p>

SECTOR	INSTITUTION CATEGORY	DESCRIPTION
Government Sector (GOV)	Research Centres supervised by the General Secretariat for Research and Technology (RC-GSRT)	Public Research Centers that are supervised by the General Secretariat for Research and Technology (GSRT). In alphabetic order in Greek: National Observatory of Athens, National Hellenic Research Foundation, The Centre for Research and Technology, National Center for Scientific Research 'DEMOKRITOS', Hellenic Centre for Marine Research, National Centre for Social Research, Greek Atomic Energy Commission, Hellenic Pasteur Institute, "Alexander Fleming" Biomedical Sciences Research Center, Athena-Research and Innovation Center in Information, Communication and Knowledge Technologies, Foundation for Research & Technology – Hellas, Center for Research and Technology – Thessaly.
	Other Public Research Institutions	Other Public Research Institutions supervised by different Ministries. An indicative and non-exhaustive list of such institutions is the following: Academy of Athens, Biomedical Research Foundation Academy of Athens, Hellenic Agricultural Organisation DEMETRA (former National Agricultural Research Foundation - NAGREF), Benaki Phytopathological Institute, Center for Renewable Energy Sources and Saving, Mediterranean Agronomic Institute of Chania, Computer Technology Institute and Press "Diophantus", Institutions supervised by Ministry of Culture such as archaeological and cultural institutions, Institutions supervised by Ministry of Health other than Public Hospitals, etc.
	Public Hospitals (PH)	Public Hospitals and Hospitals supervised by the Ministry of Defense.
	Other Public Institutions	Ministries. Regional and local authorities and other public institutions.
Business Sector (BES)	Private Health Institutions	Private institutions activating in the Health sector such as private hospitals, clinics, diagnostic centers, Private research centres etc.
	Enterprises	All firms, organisations and institutions whose primary activity is the market production of goods or services (other than higher education and health services) for sale to the general public at an economically significant price. Public companies as well as private non-profit institutions mainly serving enterprises are also included.
Private Non Profit Sector (PNP)	Private Non Profit Institutions	Non-market, private non-profit institutions serving the general public, such as non-market units, professional and learned societies, charities, relief or aid agencies, trade unions, consumers' associations, etc.