GREEK SCIENTIFIC PUBLICATIONS 2000-2014

A Bibliometric Analysis of Greek Publications in International Scientific Journals

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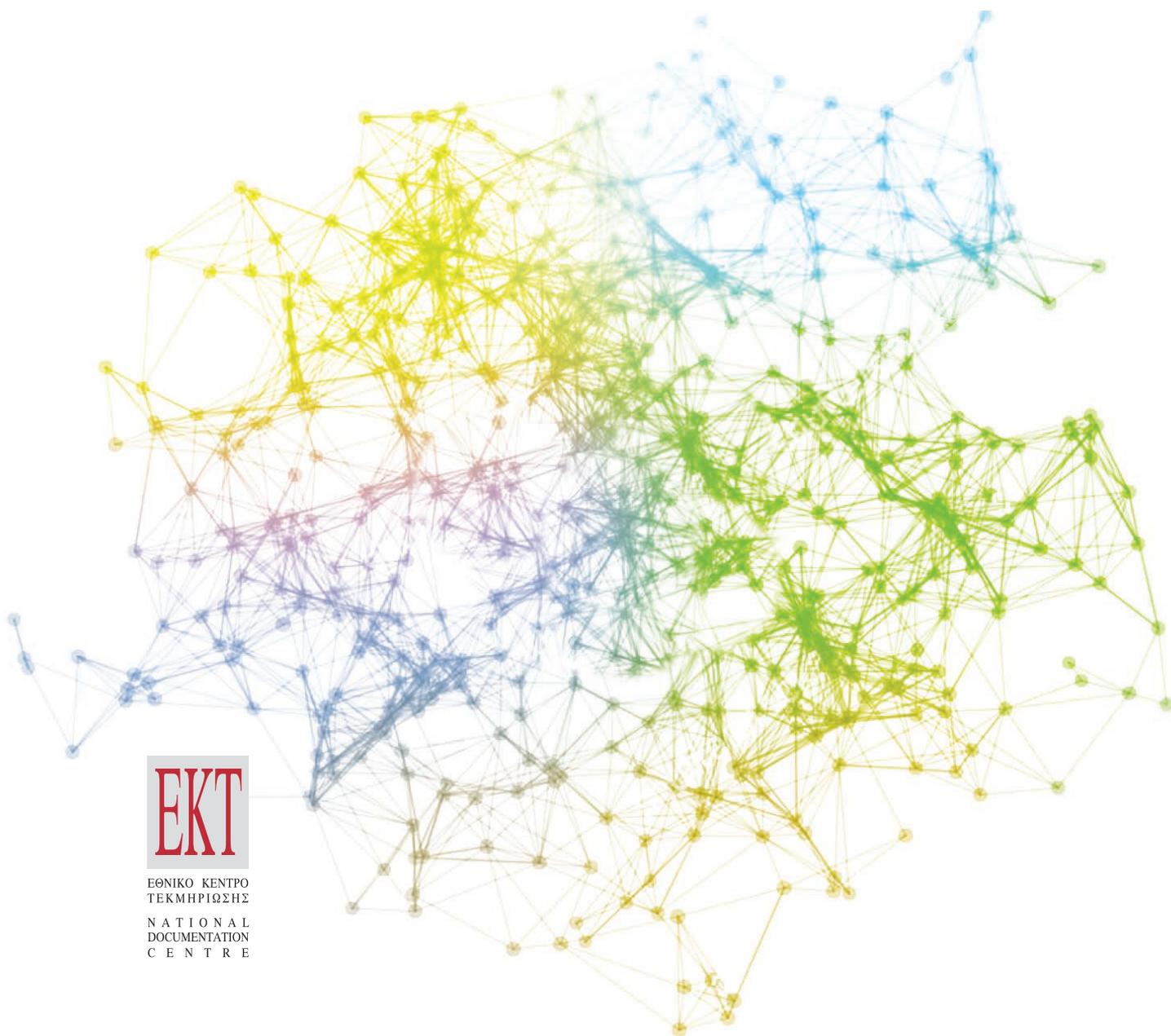# GREEK SCIENTIFIC PUBLICATIONS 2000-2014

A Bibliometric Analysis
of Greek Publications
in International Scientific Journals – Web of Science

Online version is available here http://metrics.ekt.gr/en

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Contributors

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Data processing was enabled by software solutions which EKT developed to meet the requirements of this study. The software makes uses of a set of tools that allowed the calculation of bibliometric indicators as well as the presentation of data in a user friendly format. Dr Nikos Katsarakis was the supervisor of a team comprised of the following members:

• Nikolaos Katsarakis - software developer
• Costas Stamatis - data cleaning and control techniques
• Andreas Kalaitzis - developer of the study's electronic edition

PREFACE

This publication concerns the bibliometric data and relevant analysis of the Greek scientific publications in international journals for the period 2000-2014. The data were drawn from Thomson Reuters Web of Science database. It is the latest example of the National Documentation Center's (EKT) data documentation activities, launched in 2010, with the aim of shedding light on major aspects of the national research system. In-depth presentation, periodicity and the inclusion of not only existing but also new indicators has established this publication as a major reference point for both the research community and policymakers in Greece. The publication and a similar study based on the Elsevier Scopus database provides full-scale mapping of the Greek scientific community's publication activities.

The use and exploitation of bibliometric data in the production of evidence-based science and technology policy is continuously expanding, justifying the choice of EKT to invest in the development of know-how and information systems for presenting and disseminating this kind of research production. This is in tune with international and supranational organizations, such as the EU and OECD which make use of bibliometric indicators in order to compare different countries' research systems, while at the same time lay emphasis on relevant emerging indicators – see for example, the Experts Forum for measuring science, technology and innovation organized by the OECD at the recent Blue Sky Forum of 2016.

EKT is following international trends integrating the publication of bibliometric analyses in EKT's future Strategy as part of the services provided to engage such stakeholders as the research community, policy makers, and the wider public. Lastly, EKT is in support of open access policies since the latter can significantly further the exploitation of scientific results. The data in this publication is also available in csv files to enable further analysis.

Dr. Evi Sachini

Director of EKT

CONTENTS

The study "Greek Scientific Publications 2000-2014: Bibliometric Analysis of Greek Publications in International Scientific Journals – Web of Science" is part of a series of studies undertaken by EKT with the 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 produce 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 2000 to 2014 on a national and per-institutional category level. In addition, it focuses on the latest 5-year period (2010-2014) in order to highlight recent trends and developments.

1. Overview

Bibliometric indicators provide significant information and contribute to a measurable and objective picture of the Research & Development systems. They are commonly used 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 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.

EKT has applied a robust methodological approach and validation techniques, and has 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 studies published by EKT 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.

1.1 Indicators

Overall indicators

In 2014, 10,793 Greek scientific publications were recorded. This number is slightly lower than the all-time high score recorded in 2012 (11,178). In recent years, the rate of increase in Greece has been slightly lower than the EU and OECD countries. However, if the number of publications is viewed in relation to the national R&D spending, Greece tops the relevant EU rankings indicating the high 'productivity' of the domestic research system in terms of scientific publications.

Number of citations

In relation to impact, innovativeness, quality and visibility, Greek scientific publications are dynamically placed within the international environment, since citation of Greek publications continued to increase. For 2014, Greek publications received 334,992 citations. Moreover, the country's citations increased at higher rates than the EU and OECD countries. Likewise, the country's contribution to the number of EU and OECD citations con-

tinued to increase. The same applies to citation percentages. In fact, the share of Greek scientific publications that receive a citation surpassed the EU and OECD average for the 2010-2014 period by 1.5 per cent.

Impact factor

Similarly, the impact factor of the Greek scientific publications continued to rise at a rate higher than the EU and OECD countries. It was in 2014 that, for the first time, the rate surpassed the EU and OECD average. Also, the relative citation impact - indicating the distance between the average citation received by Greek publications to the EU and OECD average - not only continued to rise for the entirety of the 2000-2014 period, but incrementally surpassed the EU and OECD in 2014.

In relation to bibliometric indicators recording the highly cited publications (a number or percentage of publications that were ranked among the top 1%, 5%, 10%, 25% and 50% of the most cited publications worldwide per year and per thematic area), the respective ranking of Greek publications was 1.6%, 6.4%, 11.7%, 26.7 and 49.7%. The above indicate that in four out of five cases (except 50%) the most cited production of the domestic science base exceeded the world average, something of great importance.

Equally, the participation/first authoring of Greek scientists was significant. 28.5% of the most cited publications belonging in the top 1% scale were authored by authors employed by a Greek institution. In the top 5% scale, the rate was 42.0%, whereas in the top 10% it was 62.5%.

Most important contributor

For the 2010-2014 period, the three most important institution categories in relation to the number of publications were the "Universities", "Research Centers supervised by GSRT" and "Public Health Institutions". In relation to cited publications "Research Centers supervised by GSRT" topped the rankings, followed by "Private Health Institutions", "Other Public Research Institutions", and "Private Non For Profit Organizations".

Citation higher than the world average was scored by "Private Health Institutions", "Research Centers supervised by GSRT", "Private Non For Profit Organizations", "Other Public Research Institutions" and "Universities".

In relation to the six main scientific fields, in "Natural Sciences" the highest impact was scored by "Private Health Institutions", in "Engineering & Technology" the "Other Education Institutions", in "Medical & Health Sciences" the "Private Health Institutions", in "Agricultural Sciences" the "Research Centers supervised by GSRT", in "Social Sciences" the "Private Non For Profit Organizations", and in "Humanities" the "Research Centers supervised by GSRT".

Scientific fields of excellence

In relation to the 2008-2012 period and with the exception of "Engineering and Technology", the relative citation impact of Greek scientific publications in all other scientific fields for the 2010-2014 period increased (or, remained the same), while publications that scored a higher impact than the global average (i.e. scoring higher than 1) are located in 29 specialized scientific fields of "Medical & Health Sciences", 26 in "Natural Sciences", 17 in "Engineering & Technology", 9 in "Social Sciences", 5 in "Agricultural Sciences" and 4 in "Humanities".

Collaborations

In relation to scientific collaborations for the production of Greek scientific publications, for the 2000-2014 period a continuous drop in publications produced by a sole institution was recorded, while a continuous rise was recorded in relation to collaboration with the international scientific community. The highest score of collaborations was recorded with the USA, UK, Germany, France and Italy. In all scientific fields, the relative impact factor was significantly higher in those publications that were produced as a result of international collaboration.

1.2 Institution categories

The following section briefly presents the key characteristics and bibliometric indicators for eleven Institution Categories, as well as the institutions that achieved the highest values. The data refers to the last 5-year period of this study 2010-2014.

Universities

Number and share of (%) publications: The National and Kapodistrian University of Athens and the Aristotle University of Thessaloniki produce the greatest number of publications in the category "Universities" with 14,415 (30.2%) and 10,357 (21.7%), respectively.

Percentage (%) of cited publications: A percentage higher that 71.1% (the Greek average) is accomplished by Harokopio University of Athens (77%) and the University of Crete (76.9%). These are followed by University of Ioannina (74.8%), the National and Kapodistrian University of Athens (72.8%), and the Agricultural University of Athens (71.1%).

Number and share (%) of citations: The higher number of citations was attributed to Universities with the higher number of publications for 2010-2014 - the National and Kapodistrian University of Athens and the Aristotle University of Thessaloniki. The former had 108,276 citations and a share of 38.3% within the category, while the latter had 60,327 citations and a share of 21.3%.

Relative citation score: Publications by 10 universities exceed the world average in terms of citations. In 2010-2014, a small number of publications from the University of Peloponnese, the University of Western Macedonia, the University of Ioannina and the Harokopio University of Athens achieve the highest citation score (respectively, 1.93, 1.48 and 1.43 for the two last). Above the world average are also the University of Crete and the National and Kapodistrian University of Athens (1.29, respectively), the Agricultural University of Athens (1.23), the National Technical University of Athens (1.18), the Aristotle University of Thessaloniki (1.11), and the University of the Aegean (1.08).

TEI

Number and share of (%) publications: The TEIs of Athens and Thessaloniki produced the greatest number of publications (and share) in the category "TEIs" during the 2010-2014 period with 630 (20.1%) and 482 (15.4%) publications, respectively.

Percentage (%) of cited publications: A percentage higher that 71.1% (the Greek average) is accomplished by TEI of Ipeiros (77.1%).

Number and share (%) of citations: Most citations for the 2010-2014 period are received by the publications of the TEIs of Athens and Crete. The former had 1,834 citations and a share of 17.4% within the category, while the latter had 1,766 citations and a share of 16.8%.

Relative citation score: Publications by 5 TEIs exceed the world average in terms of citations. In 2010-2014, the TEI of Ionian Islands achieve a citation of 1.94. Above the world average are also the TEI of Sterea Ellada (1.34), the TEI of Anatoliki Macedonia and Thrace (1.12), the TEI of Crete (1.09) and ASPAITE (1.06).

Research Centers supervised by GSRT

Number and share of (%) publications: the National Center of Scientific Research (NCSR) DEMOKRITOS and the Foundation for Research and Technology – Hellas (FORTH) produced the greatest number of publications (and share) in the category "Research Centers" during the 2010-2014 with 2,384 (30.2%) and 2,294 (29.1%) publications, respectively.

Percentage (%) of cited publications: A percentage higher that 71.1% (the Greek average) is accomplished by the great majority of the Research Centers. Specifically, BSRC FLEMING (87.7%), the Hellenic Pasteur Institute (82.1%), the National Observatory of Athens (78.1%), FORTH (78.3%), NCSR DEMOKRITOS (77.4%), HCMR (75.8%), EEAE (75.0%), NHRF (74.6%) and CERTH (73.0%).

Number and share (%) of citations: Most citations for the 2010-2014 period are received by the publications of NCSR DEMOKRITOS and FORTH. The former had 21,672 citations and a share of 34.0% within the category, while the latter had 20,029 citations and a share of 31.4%,

Relative citation score: Publications by 9 Research Centers exceed the world average in terms of citations. In 2010-2014, ATHENA achieve a citation score of 1.86, BSRC FLEMING (1.76), NCSR DEMOKRITOS (1.52), the Hellenic Pasteur Institute (1.44), HCMR (1.36), FORTH (1.18), CERTH (1.11), the National Observatory of Athens (1.08) and EEAE (1.04).

Other Public Research Institutions

Number and share of (%) publications: The Academy of Athens and the National Agricultural Research Foundation produced the greatest number of publications (and share) in the category "Other Public Research Institutions" during the 2010-2014 with 1,150 and 573 publications, respectively

Percentage (%) of cited publications: A percentage higher than 71.1% (the Greek average) is accomplished by the Academy of Athens (79.7%), MAICH (74.7%), Entities of the Ministry of Health (73.6%) and EKBAA (71.7%).

Number and share (%) of citations: Most citations for the 2010-2014 period are received by the publications of the Academy of Athens (10,786), while the Hellenic Agricultural Organization Demeter has 2,621.

Relative citation score: Publications by 5 Other Public Research Institutions exceed the world average in terms of citations. In 2010-2014, Computer Technology Institute and Press "Diophantus" achieved the highest citation score (1.63). Publications by the Academy of Athens (1.34), by Entities of the Ministry of Culture (1.17), by Entities of the Ministry of Health (1.13) and DEMETER (1.10) achieved higher citation scores than the world average.

Public Health Institutions

Number and share of (%) publications: The IPPOKRATEIO General Hospital of Athens (IPPOKRATEIO ATHENS) and the Evaggelismos Hospital of Athens (EVAGGELISMOS) produced the greatest number of publications (and share) in the category "Public Health Institutions" during the 2010-2014 with 770 (12.1%) and 631 (9.9%) publications, respectively.

Percentage (%) of cited publications: A percentage higher that 71.1% (the Greek average) is accomplished by the IPPOKRATEIO General Hospital of Thessaloniki (79.6%) and the General Hospital of Athens ALEXANDRA (76.2%).

Number and share (%) of citations: Most citations for the 2010-2014 period are received by the publications of IPPOKRATEIO ATHENS and EVAGGELISMOS. The former had 5,497 citations and a share of 14.6% within the category, while the latter had 4,207 citations and a share of 11.2%.

Relative citation score: Publications by 7 Public Health Institutions exceed the world average in terms of citations. In 2010-2014, the THEAGENIO Cancer Hospital of Thessaloniki achieve a citation score of 2.34, SOTIRIA General Hospital of Athens (1.30), LAIKO General Hospital of Athens (1.17), IPPOKRATEIO General Hospital of Thessaloniki (1.08), IPPOKRATEIO ATHENS (1.05), EVAGGELISMOS and G. PAPAGEORGIOU General Hospital (1.01, respectively).

Private Health Institutions

Number and share of (%) publications: HYGEIA Group (Hygeia) and HENRY DUNANT hospital (HENRY DUNANT) produced the greatest number of publications (and share) in the category "Private Health Institutions" during the 2010-2014 with 287 (14.5%) and 243 (12.2%) publications, respectively.

Percentage (%) of cited publications: A percentage higher that 71.1% (the Greek average) is accomplished by HENRY DUNANT (90.5%), Alfa Institute of Biomedical Sciences (AIBS) (85.4%), Metropolitan Hospital (82.6%), and Euroclinic Group (71.8%).

Number and share (%) of citations: Most citations for the 2010-2014 period are received by the publications of HENRY DUNANT and AIBS. The former had 3,160 citations and a share of 22.1%, while the latter 2,189 citations and a share of 15.3%,

Relative citation score: Publications by 5 Private Health Institutions exceed the world average in terms of citations. In 2010-2014, St. Luke's Hospital achieve a citation score of 3.23, AIBS (1.94), Metropolitan Hospital (1.75), HENRY DURANT (1.47), and HYGEIA (1.26).

This chapter presents the bibliometric indicators for the total scientific output of Greece -as recorded in the National Science Indicators database of the Web of Science- 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 2000-2014, and highlights recent growth trends.

The following table (Table 2.1.1) summarizes bibliometric indicators for Greek publications for the most recent 5-year period (2010-2014). It also presents evidence of the 2008-2012 period to allow for a historical comparison with the immediate preceding period.

2. Greek Scientific Publications: Indicators and Characteristics

PUBLICATIOS	2012	2014
Number of Greek publications	11,178	10,793
Share (%) of Greek publications in EU countries	2.28%	2.10%
Share (%) of Greek publications in OECD countries	1.15%	1.06%
CITATIONS	**2008-2012**	**2010-2014**
Number of citations to Greek publications	287,802	334,992
Share (%) of Greek citations in EU countries	2.21%	2.28%
Share (%) of Greek citations in OECD countries	1.10%	1.15%
CITATION IMPACT	**2008-2012**	**2010-2014**
Citation Impact (average number of citations per publication)	5.38	6.13
Relative citation impact of publications from Greece compared to EU	0.93	1.01
Relative citation impact of publications from Greece compared to OECD	0.93	1.02

2.1 Publications

According to the Web of Science database, 10,793 Greek publications in international scientific journals were registered in 2014. While a minor decrease can be noted when compared with the 2012 high of 11,178 publications, the number of yearly publications ranged between 10,500 and 11,000 over the five year period (Figure 2.1.1).
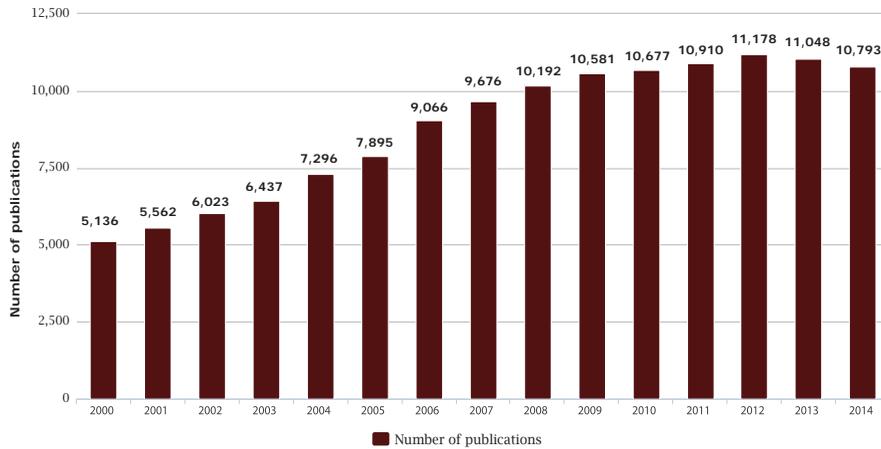
Figure 2.1.1 Development of the number of Greek scientific publications, 2000-2014

Focusing on research productivity, defined as 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.

In Figure 2.1.3 the number of publications in international journals per researcher (counted in FTE) is expressed. Greece ranked 14nth among 24 EU countries.

Figure 2.1.2   Number of publications per million Euros of R&D expenditure for EU countries, 2014*

* No data available for Iceland and Luxembourg (countries with less than 1500 publications)

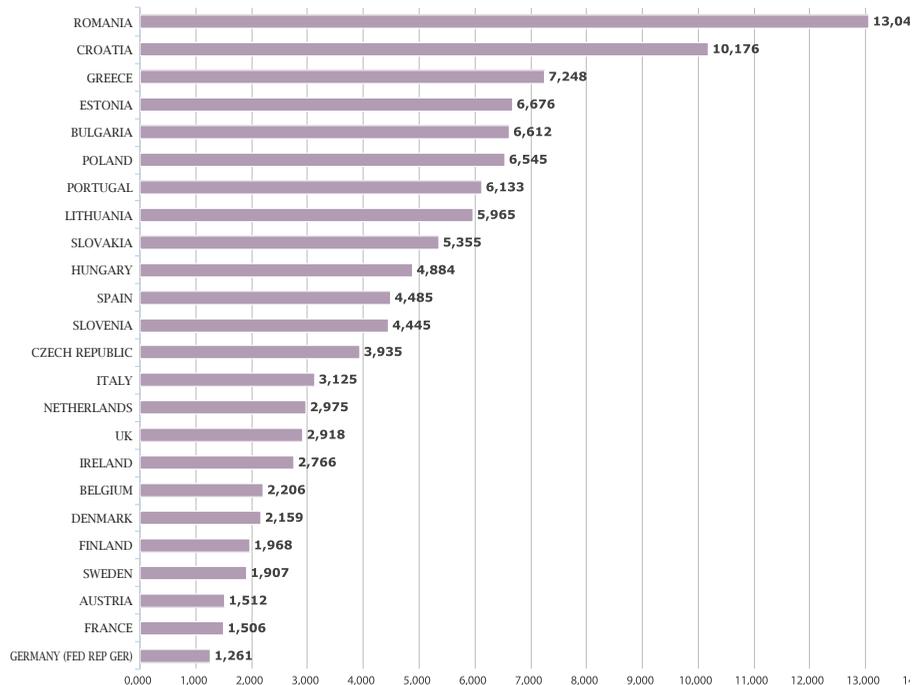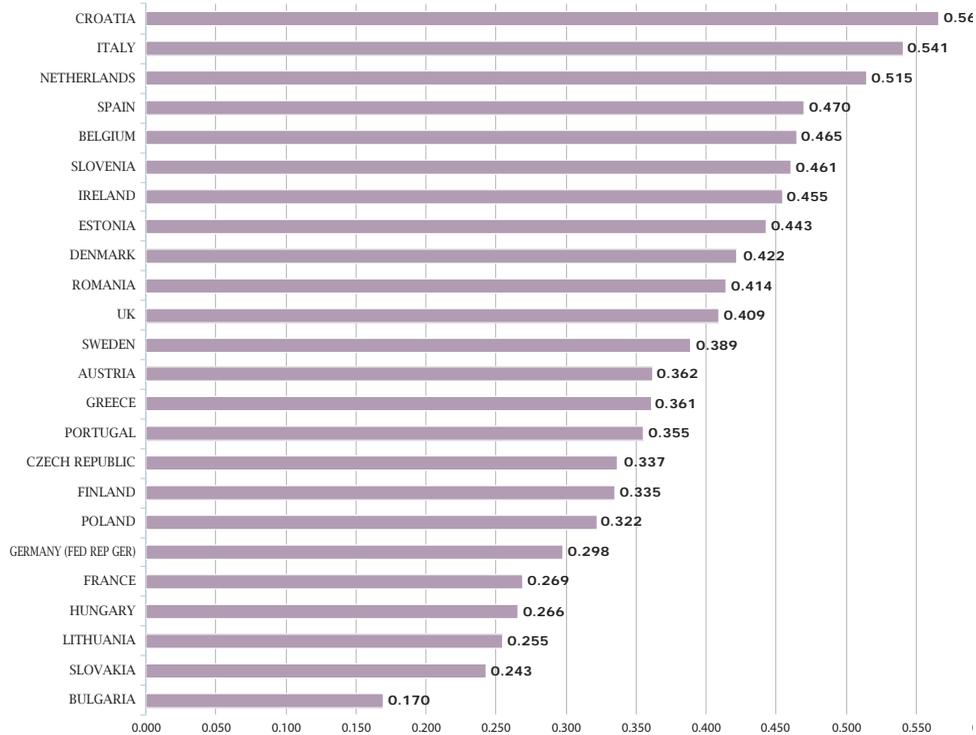|	
CROATIA	0.56
ITALY	0.541
NETHERLANDS	0.515
SPAIN	0.470
BELGIUM	0.465
SLOVENIA	0.461
IRELAND	0.455
ESTONIA	0.443
DENMARK	0.422
ROMANIA	0.414
UK	0.409
SWEDEN	0.389
AUSTRIA	0.362
GREECE	0.361
PORTUGAL	0.355
CZECH REPUBLIC	0.337
FINLAND	0.335
POLAND	0.322
GERMANY (FED REP GER)	0.298
FRANCE	0.269
HUNGARY	0.266
LITHUANIA	0.255
SLOVAKIA	0.243
BULGARIA	0.170

Figure 2.1.3 Number of publications per Researcher (Full Time Equivalents) for EU countries, 2014*

In 2011 the continuous increase in terms of number of Greek publications halted and during 2012 and 2013 the previous upward trend was reversed resulting in a drop as opposed OECD and EU countries (Figure 2.1.4).

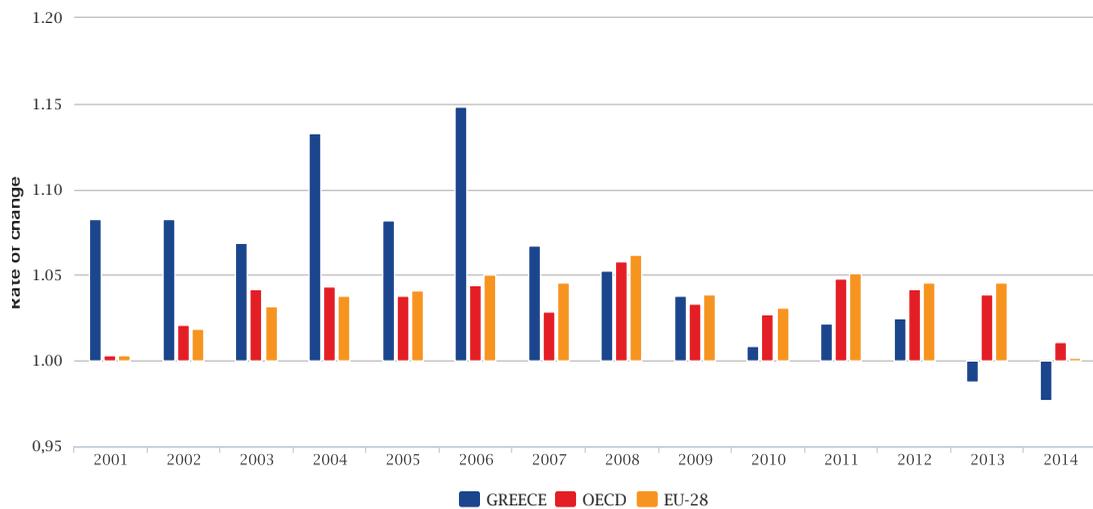**Figure 2.1.4 Change in the number of publications in Greece, EU, OECD, 2000-2014**

In 2014, Greece's share in EU publications reached 2.10% and its share in OECD publications stood at 1.06%. As recorded in Figure 2.1.5, from 2007 the shares of Greek publications in the EU and OECD publications followed a declining trend.

* No data available for Iceland and Luxembourg (countries with less than 1500 publications)
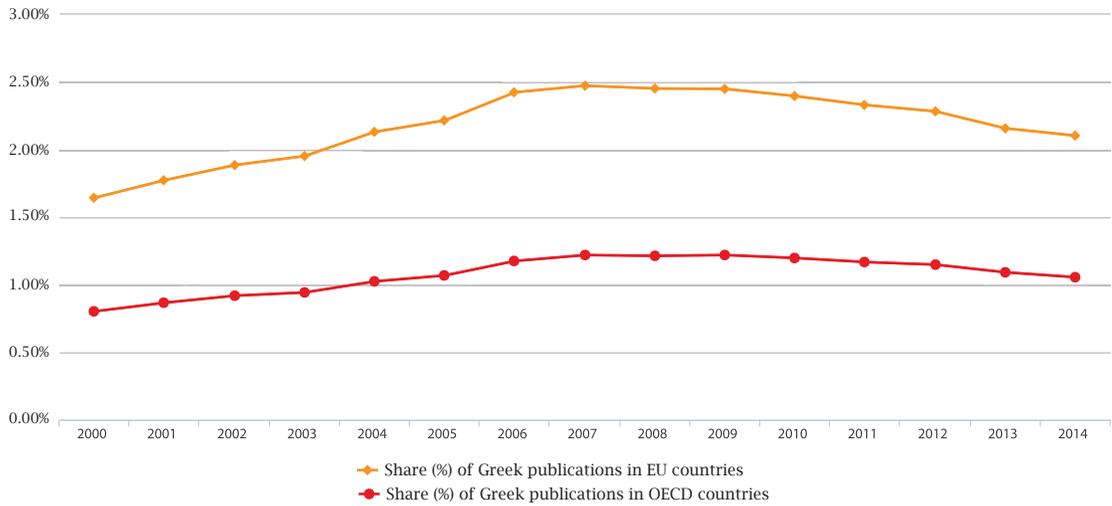
Figure 2.1.5 Share (%) of Greek publications in EU and OECD, 2000-2014

Greece ranked 25th in terms of its share in the OECD (Figure 2.1.6). With a share of 38.8%, USA maintained the leading position among OECD countries, followed by the United Kingdom and Germany, with a share slightly above 10% for each of the two.

Figure 2.1.6 Share of publications in OECD countries, 2014*

In terms of the number of publications per million population, Greece held the 25th place in the OECD (Figure 2.1.7) with 988 publications per million population. Switzerland maintained the leading position with 3,552 publications.

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* No data available for Iceland and Luxembourg (countries with less than 1500 publications)

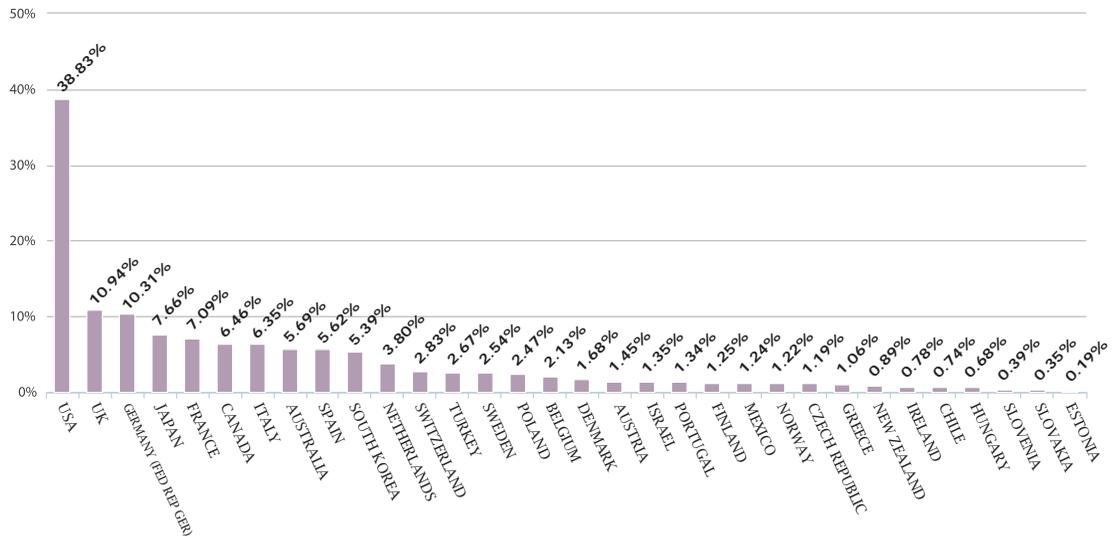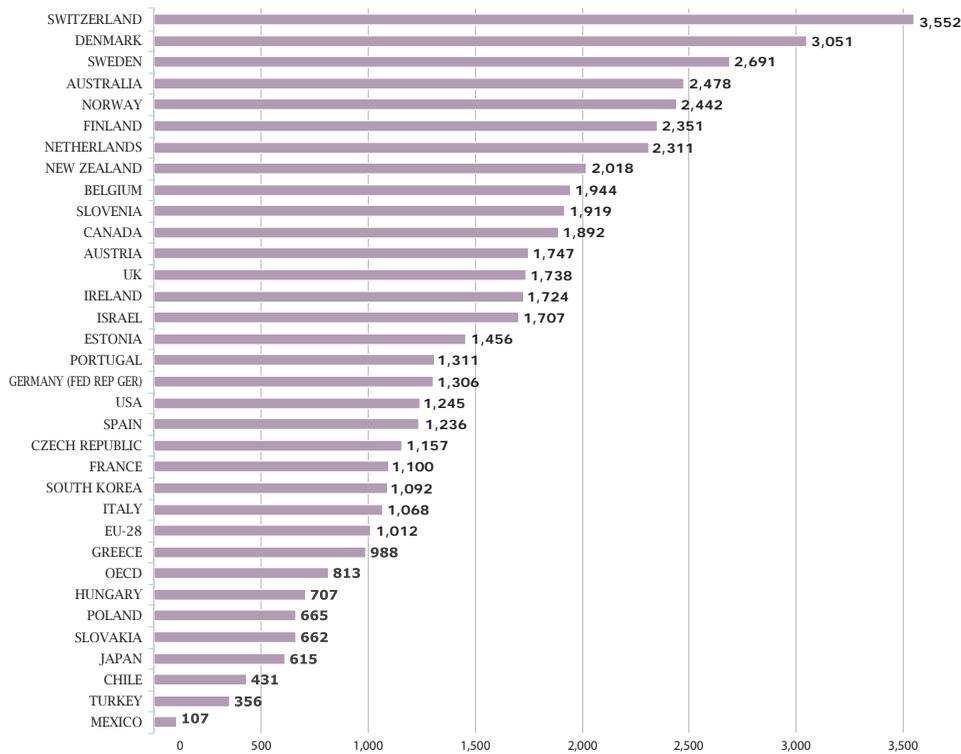**Figure 2.1.7 Number of publications in OECD countries per million of population, 2014***

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 presents the citations received by Greek publications between 2000 and 2014. According to standard bibliometric practices, data is presented in five-year windows, from 2000 through 2014. Each five-year window displays the number of citations to those publications produced within the designated time.

In the last 5-year window, 2010-2014, Greek publications received 334,992 citations. The number is an all-time high, scoring a 6% increase relative to the immediately preceding 2009-2013 period.

Figure 2.2.1 Development of the number of citations to Greek publications, 2000-2014

* Rate of change: 1 + [(number of publications in year "n" − number of publications in year "n-1")/ number of publications in year "n-1"]. The rate is 1, if the number of publications is the same across the years compared

Throughout the 2000-2014 period, global trends demonstrated a significant increase in the overall citations, both in the EU and the OECD countries. The growth rate of the number o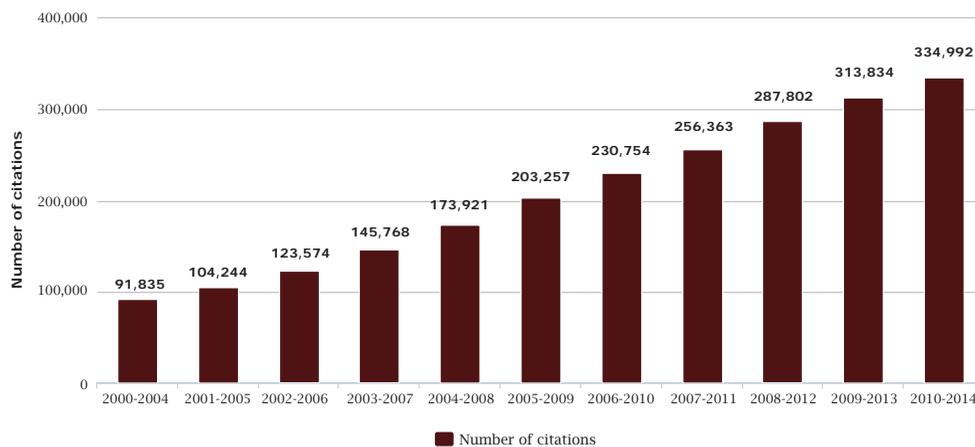f citations received by Greek publications consistently surpassed the EU and OECD baseline, even though with a smaller margin during the more recent 5-year windows (Figure 2.2.2).
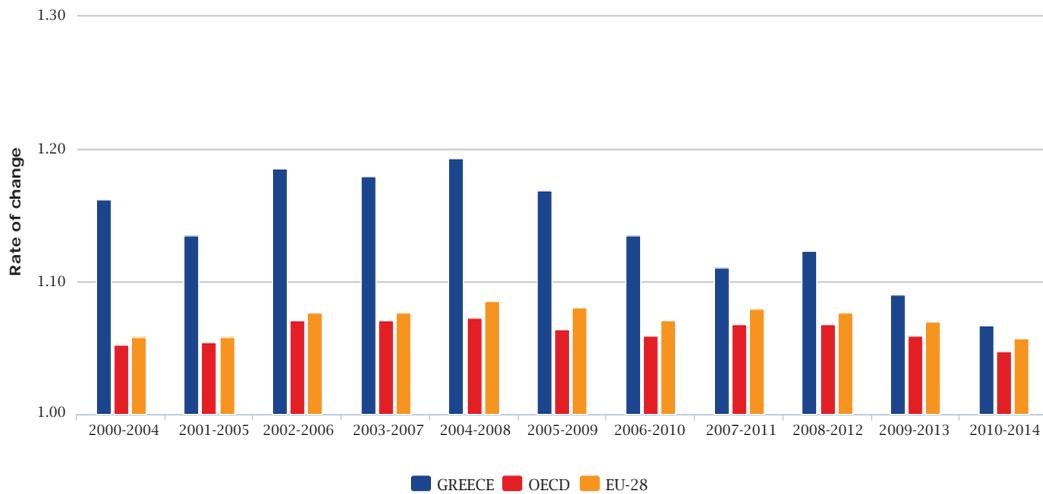
Figure 2.2.2 Change in the number of citations for Greece, EU and OECD, 2000-2014*

Accordingly, Greece's share in the EU and OECD citations increased (Figure 2.2.3). For the 2010-2014 period this was equal to 2.28% and 1.15%, respectively.
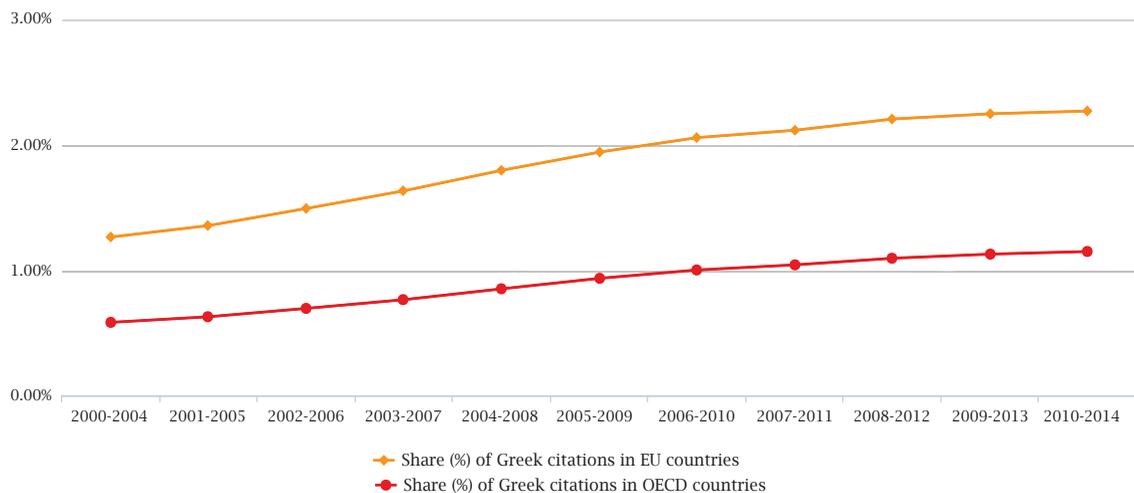
Figure 2.2.3 Share (%) of Greek citations in EU and OECD, 2000-2014

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 2000-2014 reaching 71.1% in 2014. This is well above the EU (69.7%) and the OECD (69.5%) performance (Figure 2.2.4).

* Rate of change: 1 + [(number of publications in year "n" – number of publications in year "n-1")/ number of publications in year "n-1"]. The rate is 1, if the number of publications is the same across the years compared
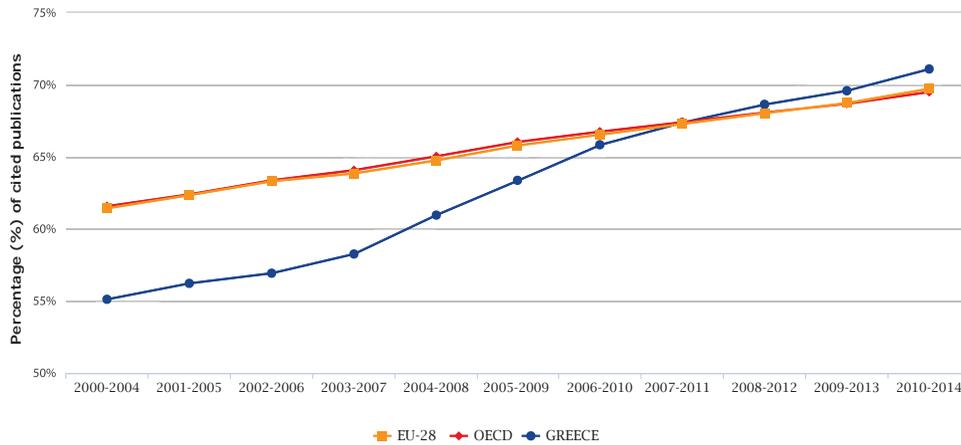
Figure 2.2.4 Percentage (%) of cited publications in Greece, EU and OECD, 2000-2014

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, 2010-2014, Greek publications received 6.13 citations on average, exceeding the EU (6.05) and OECD (6.01) average.

Notably, for the whole 2000-2014 period the rate of the citation impact of Greek publications was consistently above the EU and OECD (Figure 2.3.2).
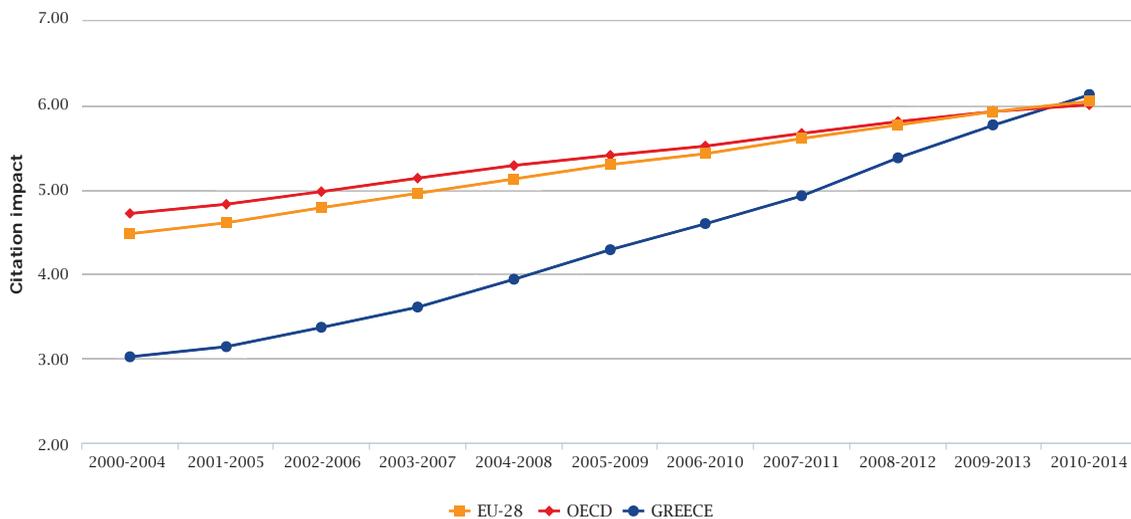
Figure 2.3.1 Citation impact of publications from Greece, EU and OECD, 2000-2014

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* No data available for Iceland and Luxembourg (countries with less than 1500 publications)
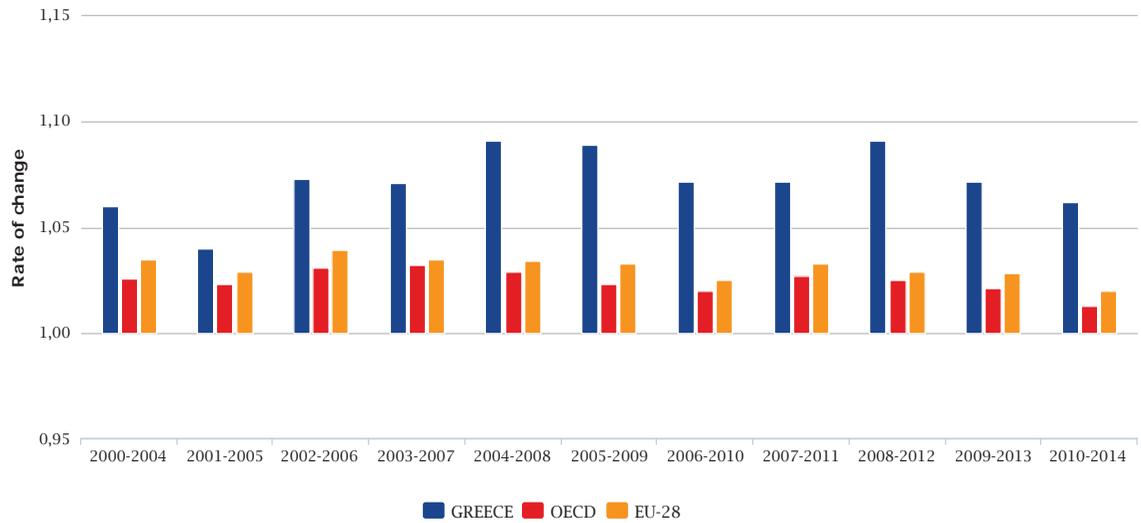
Figure 2.3.2 Change in the citation impact of publications from Greece, EU and OECD, 2000-2014*

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 2000-2014. In the most recent 5-year period, 2010-2014, and for the first time ever, Greece's citation impact overtook that of the EU (1.01) and OECD (1.02).
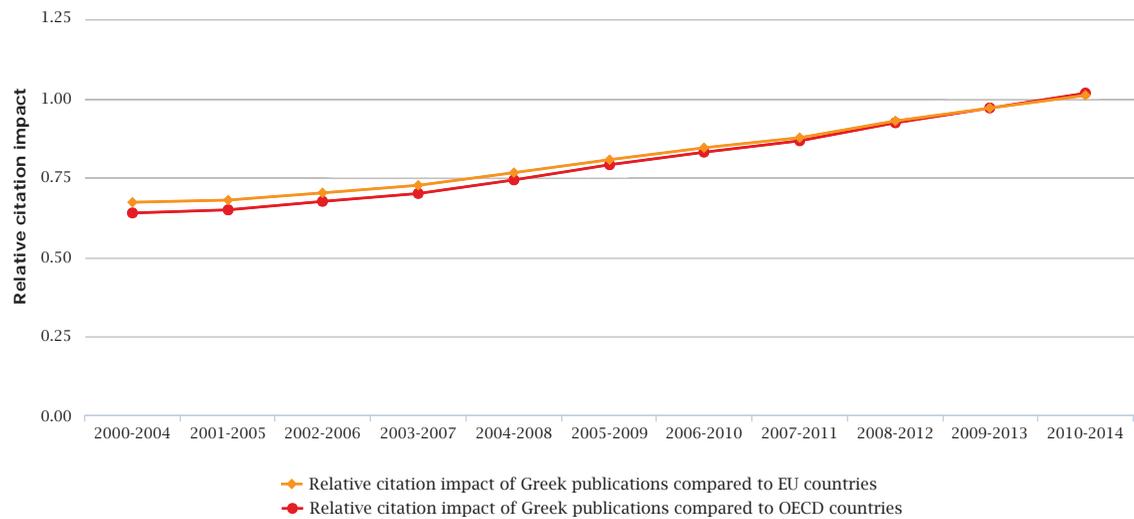
Figure 2.3.3 Relative citation impact of publications from Greece compared to EU and OECD, 2000-2014

In terms of its relative citation impact (1.02) for the 2010-2014 period, Greece was ranked 21st among the 34 OECD countries (Figure 2.3.4).
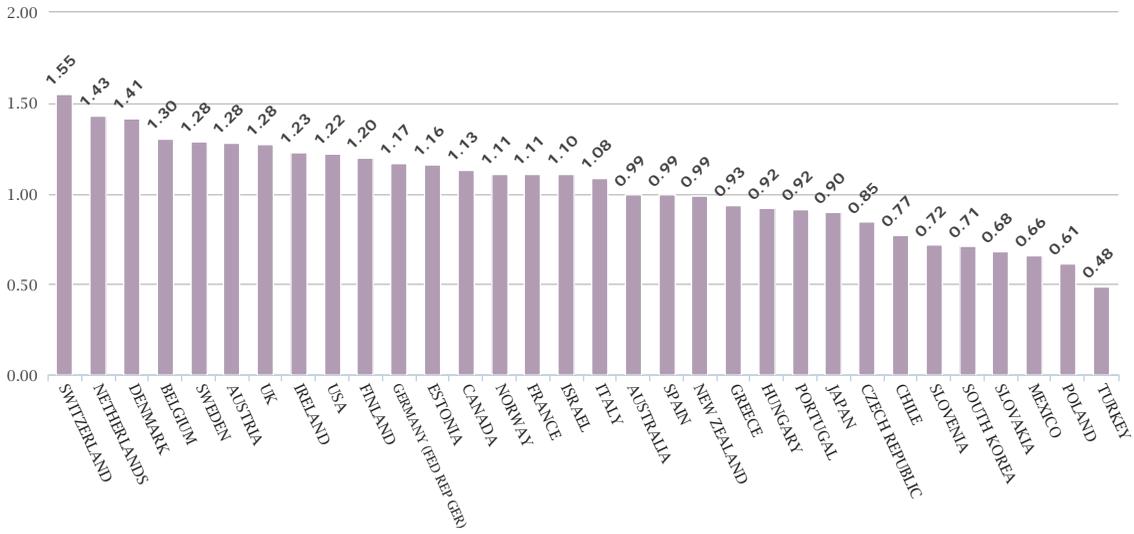
Figure 2.3.4 Ranking of OECD countries by relative citation impact, 2010-2014*

2.4 Highly cited publications

A significant criterion for the evaluation of the impact of 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, 2010-2014, 860 Greek publications ranked among the top 1% of the most cited publications worldwide, 3,488 publications in the top 5%, 6,375 publications in the top 10%, 14,629 publications in the top 25% and 27,212 in the top 50% (Figure 2.4.1).

The percentile breakdown of top publications for Greece for the 5-year period, 2010-2014, was 1.6%, 6.4%, 11.7%, 26.7% and 49.7% (Figure 2.4.1). Compared to the world average baseline, Greece exceeded the world average in all but the 50% percentile.
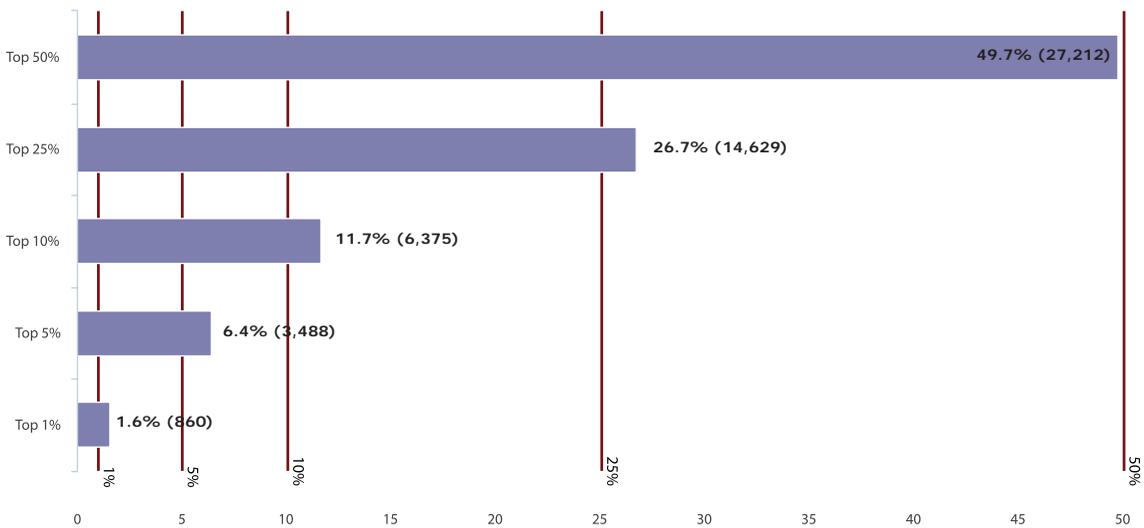
Figure 2.4.1 Number and percentile breakdown (%) of highly cited Greek publications, 2010-2014

23

Greek scientists contributed significantly to high impact publications. 28.5% of the top 1% publications were authored by a Greek scientist as a first author. The same holds for 42.0% of the top 5%. (Figure 2.4.2).
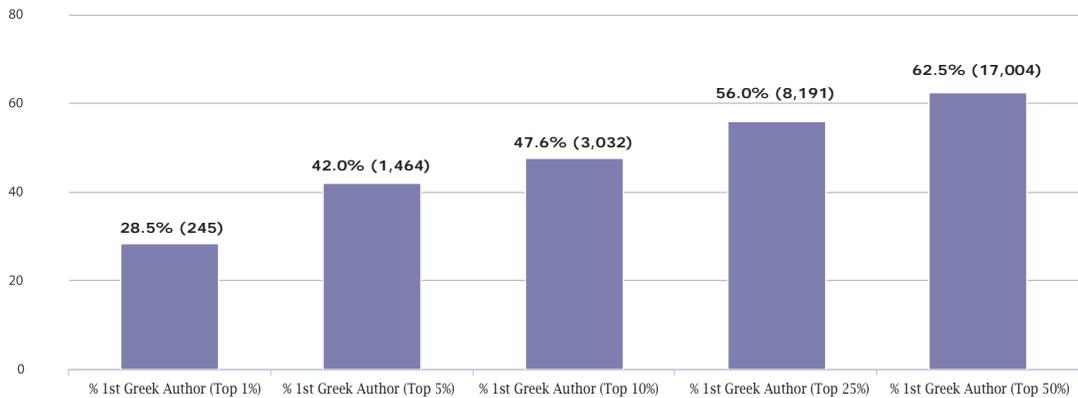
Figure 2.4.2 Number and share (%) of publications by percentile category with 1st author being Greek, 2010-2014

2.5 Major fields of science

Aiming to identify 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 2000 and 2014, are presented in Figure 2.5.1.

"Natural Sciences" received Greece's highest representation in the total number of publications (47.0%) in 2014. "Medical & Health Sciences" stands second (39.4%), followed by "Engineering and Technology" (21.7%). The remaining share of Greek publications was distributed among the "Social Sciences" (7.2%), the "Agricultural Sciences" (3.0%), and the "Humanities" (1.8). Even though "Humanities" was a significant field of national research, low share of publications is to be expected, since scientific production in the field is overwhelmed by monographs and books, as well as the fact that they are written in other languages (non-English). These publications are not recorded in the standard bibliometric databases.
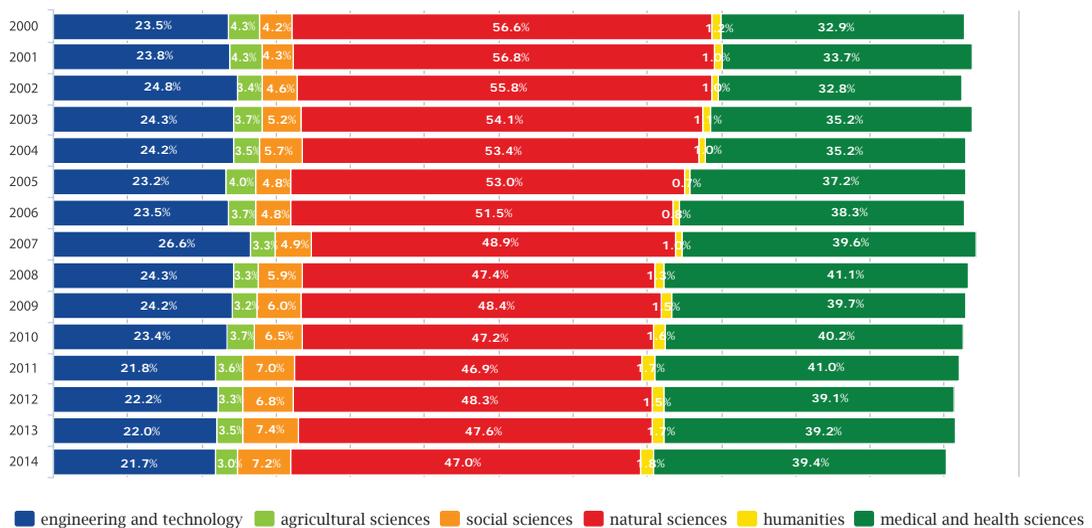
Figure 2.5.1 Distribution (%) of Greek publications across major fields of science, 2000-2014

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, 2010-2014.

Natural Sciences

Subcategory	Value
biological sciences	7,497
physical sciences	6,853
earth and related environmental sciences	5,035
chemical sciences	5,001
computer and information sciences	3,291
mathematics	2,311
other natural sciences	25

Engineering & Technology

Subcategory	Value
electrical engineering, electronic engineering, information engineering	3,355
environmental engineering	2,449
materials engineering	2,341
mechanical engineering	1,931
other engineering and technologies	1,884
civil engineering	1,266
chemical engineering	1,048
nano-technology	738
medical engineering	603
industrial biotechnology	120

Medical & Health Sciences

Subcategory	Value
clinical medicine	16,048
basic medicine	4,749
health sciences	3,496
other medical sciences	932
medical biotechnology	49

25

Agricultural Sciences

agriculture, forestry, and fisheries	1,010
veterinary science	429
other agricultural sciences	415
animal and dairy science	209

Social Sciences

economics and business	1,792
psychology	743
social and economic geography	670
educational sciences	473
sociology	345
other social sciences	211
media and communications	168
political sciences	147
law	55

Humanities

history and archaeology	349
languages and literature	246
philosophy, ethics and religion	221
arts	147
other humanities	48

Figure 2.5.2 Number of publications in the major scientific fields, 2010-2014

Figure 2.5.3 shows the "field-normalised citation score" of Greek publications for the 2010-2014 period 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 2010-2014, Greek publications surpassed or approached the world average across all fields, displaying citation scores from 0.87 to 1.16. The fields of "Natural Sciences", "Medical & Health Sciences" and "Engineering & Technology" exceeded world average (1.16, 1.09 and 1.02, respectively). They were followed by "Agricultural Sciences" (0.94), "Humanities" (0.90) and "Social Sciences" (0.87).
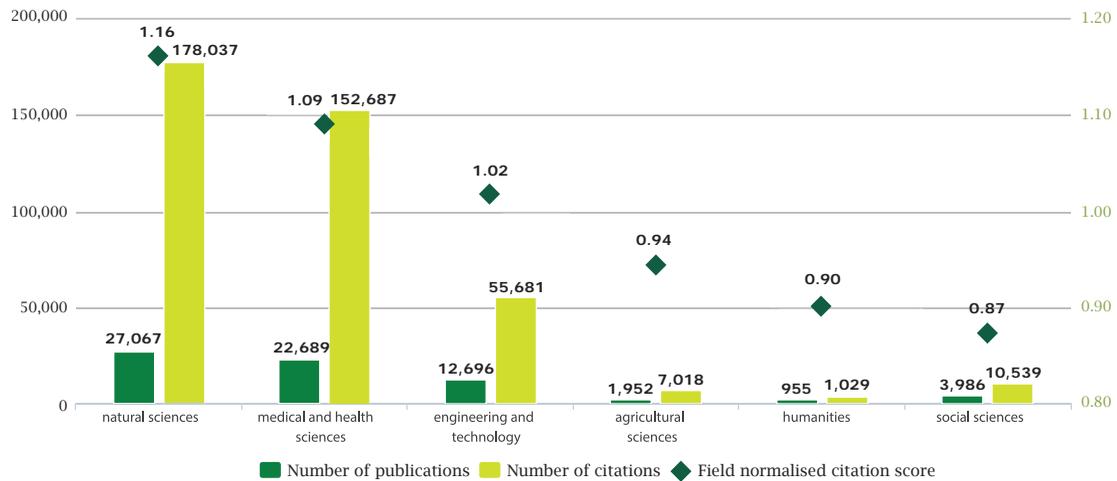
Figure 2.5.3 Publications, citations and field normalised citation score of publications relative to the world, 2010-2014

Table 2.5.1 breaks down the main six fields of science into specialized thematic areas, areas in which Greek publications displaying relative citation scores greater than the world average.

Table 2.5.1 Scientific subfields of Greek publications with field normalised citation score ≥1, 2010-2014

Natural Sciences

Scientific field category	Specific scientific field	Field normalised citation scor	Number of publications
physical sciences	physics, nuclear	3.26	611
physical sciences	physics, multidisciplinary	2.22	903
physical sciences	physics, particles & fields	2.05	1,576
biological sciences	genetics & heredity	1.97	744
physical sciences	astronomy & astrophysics	1.91	1,616
biological sciences	entomology	1.67	315
biological sciences	biodiversity conservation	1.65	124
biological sciences	reproductive biology	1.54	314
biological sciences	microbiology	1.50	825
earth and related environmental sciences	oceanography	1.38	361
physical sciences	physics, mathematical	1.31	341
physical sciences	acoustics	1.31	146
earth and related environmental sciences	meteorology & atmospheric sciences	1.27	781
chemical sciences	chemistry, inorganic & nuclear	1.25	466
biological sciences	marine & freshwater biology	1.24	596
biological sciences	ecology	1.21	436
chemical sciences	chemistry, applied	1.16	472
chemical sciences	spectroscopy	1.14	201

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Natural Sciences

Scientific field category	Specific scientific field	Field normalised citation scor	Number of publications
physical sciences	optics	1.12	915
chemical sciences	chemistry, multidisciplinary	1.07	861
computer and information sciences	computer science, information systems	1.06	1,056
chemical sciences	polymer science	1.06	588
earth and related environmental sciences	geography, physical	1.06	202
biological sciences	limnology	1.06	38
physical sciences	physics, fluids & plasmas	1.04	275
chemical sciences	chemistry, physical	1.02	1,619
earth and related environmental sciences	geosciences, multidisciplinary	1.02	1,187
computer and information sciences	computer science, interdisciplinary applications	1.01	909

Engineering and Technology

Scientific field category	Specific scientific field	Field normalised citation scor	Number of publications
environmental engineering	engineering, environmental	1.44	642
electrical engineering, electronic engineering, information engineering	telecommunications	1.22	1,200
environmental engineering	energy & fuels	1.17	1,120
chemical engineering	engineering, chemical	1.16	1,048
civil engineering	transportation science & technology	1.15	252
materials engineering	materials science, ceramics	1.15	87
materials engineering	materials science, composites	1.13	168
electrical engineering, electronic engineering, information engineering	computer science, hardware & architecture	1.09	434
civil engineering	construction & building technology	1.07	388
environmental engineering	mining & mineral processing	1.07	58
mechanical engineering	thermodynamics	1.06	361
civil engineering	engineering, civil	1.04	1,038
other engineering and technologies	food science & technology,	1.01	1,036
medical engineering	neuroimaging	1.01	50
electrical engineering, electronic engineering, information engineering	engineering, electrical & electronic	1.01	2,541
environmental engineering	engineering, ocean	1.55	58
medical engineering	medical laboratory technology	1.45	160
environmental engineering	engineering, environmental	1.44	642
electrical engineering, electronic engineering, information engineering	telecommunications	1.22	1,200
environmental engineering	energy & fuels	1.17	1,120
chemical engineering	engineering, chemical	1.16	1,048
civil engineering	transportation science & technology	1.15	252
materials engineering	materials science, ceramics	1.15	87

Engineering and Technology

Scientific field category	Specific scientific field	Field normalised citation scor	Number of publications
materials engineering	materials science, composites	1.13	168
electrical engineering, electronic engineering, information engineering	computer science, hardware & architecture	1.09	434
civil engineering	construction & building technology	1.07	388
environmental engineering	mining & mineral processing	1.07	58
mechanical engineering	thermodynamics	1.06	361
civil engineering	engineering, civil	1.04	1,038
other engineering and technologies	food science & technology	1.01	1,036
medical engineering	neuroimaging	1.01	50
electrical engineering, electronic engineering, information engineering	engineering, electrical & electronic	1.01	2,541

Medical & Health Sciences

Scientific field category	Specific scientific field	Field normalised citation scor	Number of publications
health sciences	public, environmental & occupational health	2.15	934
clinical medicine	respiratory system	1.67	666
clinical medicine	rheumatology	1.66	347
clinical medicine	dermatology	1.49	368
basic medicine	toxicology	1.44	362
health sciences	infectious diseases	1.41	816
health sciences	parasitology	1.41	112
clinical medicine	allergy	1.40	147
clinical medicine	gastroenterology & hepatology	1.31	822
clinical medicine	critical care medicine	1.30	374
health sciences	health policy & services	1.24	96
health sciences	health care sciences & services	1.23	232
clinical medicine	hematology	1.21	650
health sciences	nutrition & dietetics	1.17	710
clinical medicine	cardiac & cardiovascular systems	1.15	1,828
clinical medicine	peripheral vascular disease	1.14	1,108
clinical medicine	dentistry, oral surgery & medicine	1.13	574
clinical medicine	psychiatry	1.12	547
clinical medicine	ophthalmology	1.10	481
basic medicine	pharmacology & pharmacy	1.09	1,743
clinical medicine	endocrinology & metabolism	1.08	1,303
clinical medicine	oncology	1.07	2,302
health sciences	substance abuse	1.05	54
basic medicine	immunology	1.05	945
clinical medicine	geriatrics & gerontology	1.04	221

Medical & Health Sciences

Scientific field category	Specific scientific field	Field normalised citation scor	Number of publications
clinical medicine	urology & nephrology	1.04	726
health sciences	nursing	1.03	164
basic medicine	pathology	1.01	377
basic medicine	chemistry, medicinal	1.00	511

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Agricultural Sciences

Scientific field category	Specific scientific field	Field normalised citation scor	Number of publications
agriculture, forestry, and fisheries	fisheries	1.28	321
other agricultural sciences	agricultural engineering	1.11	169
other agricultural sciences	agriculture, multidisciplinary	1.02	237
other agricultural sciences	agricultural economics & policy	1.02	34
animal and dairy science	agriculture, dairy & animal science	1.00	209

Social Sciences

Scientific field category	Specific scientific field	Field normalised citation scor	Number of publications
sociology	anthropology	1.75	119
sociology	social issues	1.53	40
political sciences	international relations	1.48	40
political sciences	political science	1.47	104
social and economic geography	urban studies	1.25	59
social and economic geography	environmental studies	1.13	293
economics and business	business, finance	1.10	185
economics and business	business	1.04	201
Psychology and cognitive sciences	psychology, social	1.02	48

Humanities

Scientific field category	Specific scientific field	Field normalised citation scor	Number of publications
arts	art	1.32	56
languages and literature	linguistics	1.09	120
other humanities	humanities, multidisciplinary	1.05	48
philosophy, ethics and religion	philosophy	1.03	68

Figure 2.5.4 presents an activity index of fields of science and specialized thematic areas of the Greek publications in the form of a bi-dimensional location of strong versus weak-performing thematic areas. The index compares the Greek production to the world performance in a ranking ranging from -100 to +100. 0 indicates absolute balance, while positive scores indicate greater Greek production and negative scores indicate the opposite. Broken in four squares, the following four combinations are represented (starting from top left and in a clock-wise manner): low activity-high impact, high activity-high impact, high activity-low impact, low activity-low impact.

In the high activity-high impact category, the thematic area «physics, nuclear» recorded the highest relative citation score (3.26 – not indicated, though, in the Figure for representation purposes) with an activity index of 66.84 (belonging to "Natural Sciences" fields of science). Other areas of the "Natural Sciences" include "Physics, particles & fields", "Astronomy & astrophysics"), of "Medical & Health Sciences" include "Rheumatology", "Respiratory system"', of "Engineering & Technology" include "Engineering, ocean", "Engineering, environmental", of "Social Sciences" include "Business, finance", "Environmental Studies", and of "Agricultural Sciences" include "Fisheries", "Agricultural engineering".
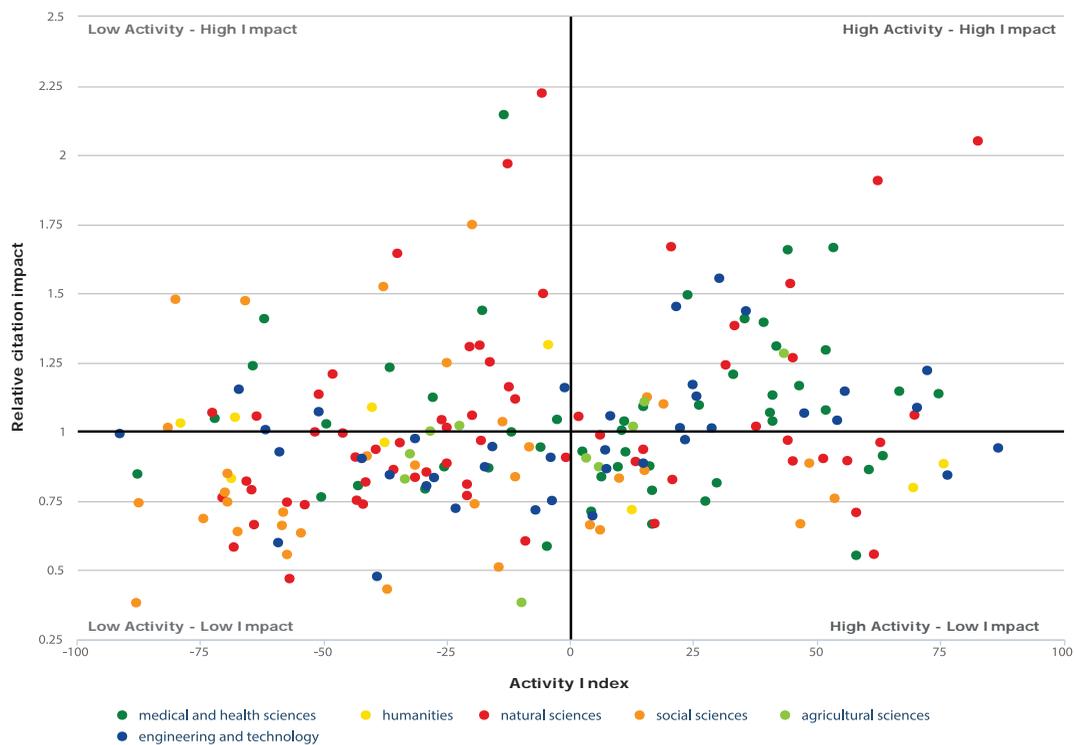
Figure 2.5.4 Plot of Activity Index and field-normalised citation score of Greek publications per specialised thematic areas, 2010-2014

2.6 Scientific collaboration

Collaboration of the scientific community at the national and international level is 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 the author institutional affiliations that are provided on publications.

The collaboration degree in Greek publications[1] and its evolution over the 2000-2014 period, as displayed in Figure 2.6.1, shows a clear upward trend, both at the national and international level. In 2014, co-publications by Greek researchers accounted for 74.6% of the total publications output, compared to 59.8% in 2000.

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

Share (%) of publications by a single Greek institution
Share (%) of publications with exclusively national collaboration
Share (%) of publications with international collaboration
Share (%) of publications with national collaboration
Share (%) of publications with exclusively international collaboration
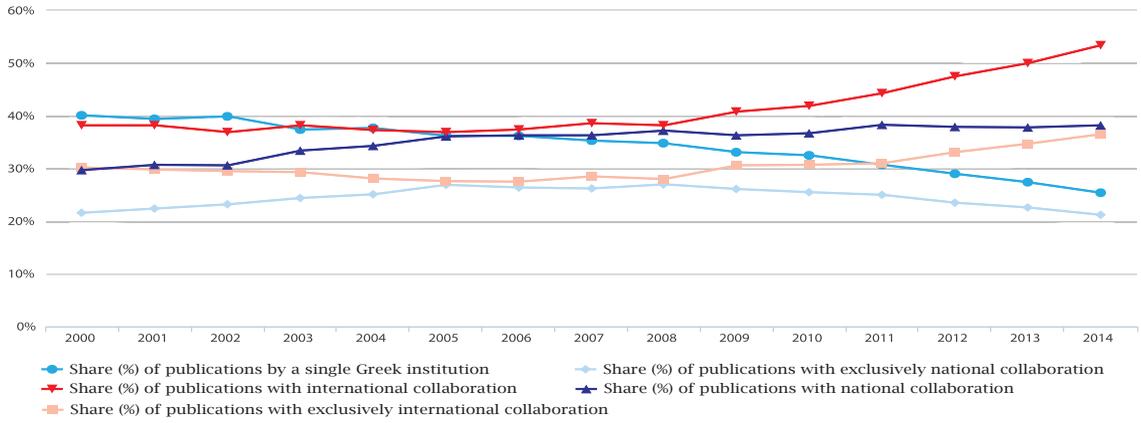
Figure 2.6.1 National and international collaboration in Greek publications, 2000-2014

During the 15-year period, 2000-2014, Greek researchers cooperated with scientists from 174 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.
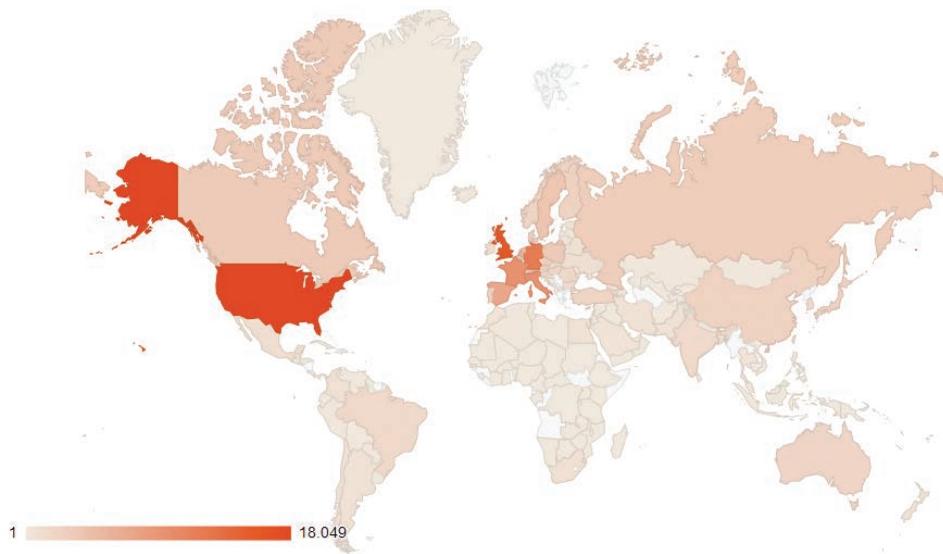
Figure 2.6.2 Countries collaborating in Greek publications, 2000-2014

Figure 2.6.3 illustrates the annual growth in the number of Greek publications that were produced as a result of national and international collaboration as well as without for the period 2000-2014.
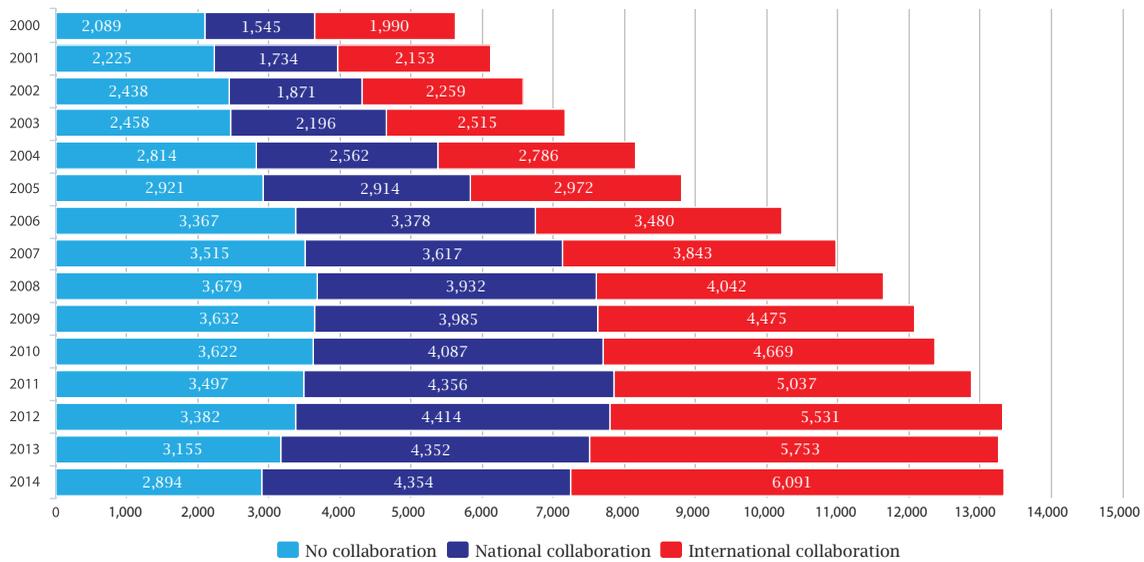
Figure 2.6.3 Distribution of Greek publications by type of collaboration, 2000-2014

Significantly, the type of scientific collaboration is positively correlated with the relative citation impact score of the 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 fields of science.
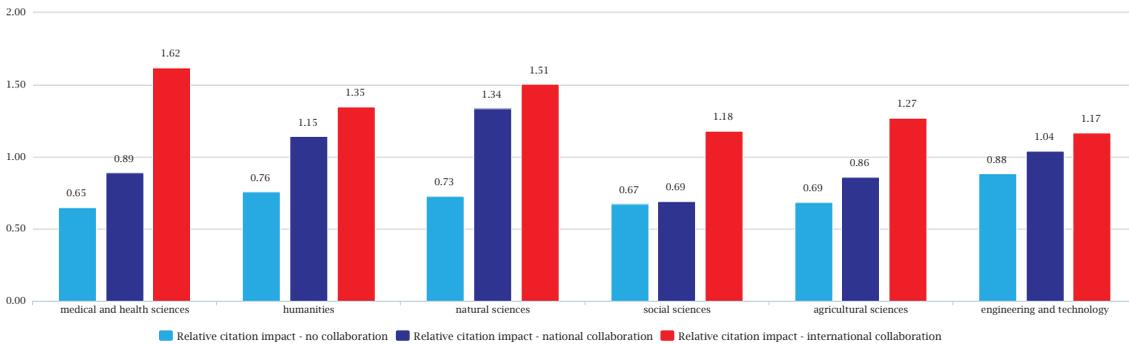
Figure 2.6.4 Distribution of Greek publications by type of collaboration, 2000-2014

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. Greek institutions are classified into three major activity areas (education, research, health), distinguishing public from private entities, and taking into account classification criteria used in the Frascati Manual: Proposed Standard Practice for Surveys on Research Experimental Development (OECD, 2002). The aim is to ensure the comparability across indicators from multiple sources that are presented in this study.

The time series examined includes not only the most recent available 5-year period (2010-2014), but also an updated account of the indicators for the 2008-2012 5-year period to allow for inter-temporal comparison (Table 3.1.1).

3. Scientific Publications by Institution Categories

COLOR	ORGANISATIONS	2008-2012		2010-2014	
		Number of publications	Citations number	Number of publications	Citations number
	Public hospitals	6,525	32,713	6,374	37,620
	Enterprises	1,206	4,424	1,167	4,531
	Research Centers supervised by the GSRT	7,591	53,680	7,888	63,703
	Private Non Profit Institutions	716	3,798	712	5,153
	Private Health Institutions	1,973	12,963	1,984	14,278
	Other Public Research Institutions	2,345	12,288	2,549	17,232
	Other Public Institutions	479	1,656	444	1,547
	Other Education Institutions	578	1,412	622	1,999
	Universities	46,253	239,400	47,678	282,986
	Technological Educational Institutions	2,894	8,340	3,132	10,524

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". They are followed (ranked by number of publications) by the "Technological Educational Institutes" (henceforth, "TEIs"), "Other Public Research Institutions", "Private Health Institutions", "Enterprises", "Private non-for Profit Institutions", "Other Education Institutions", and "Other Public Institutions" (Figure 3.1.1).

For the year 2014, Universities published 9,568 publications. "RC-GSRT" ranked second with 1,594 publications, following a ten-year period of sustained increase. "Public Hospitals" were third with 1,221 publications slightly decreasing since 2011. "TEIs" published 625 publications in 2014, while "Other Public Research Institutions" contributed 533 publications.
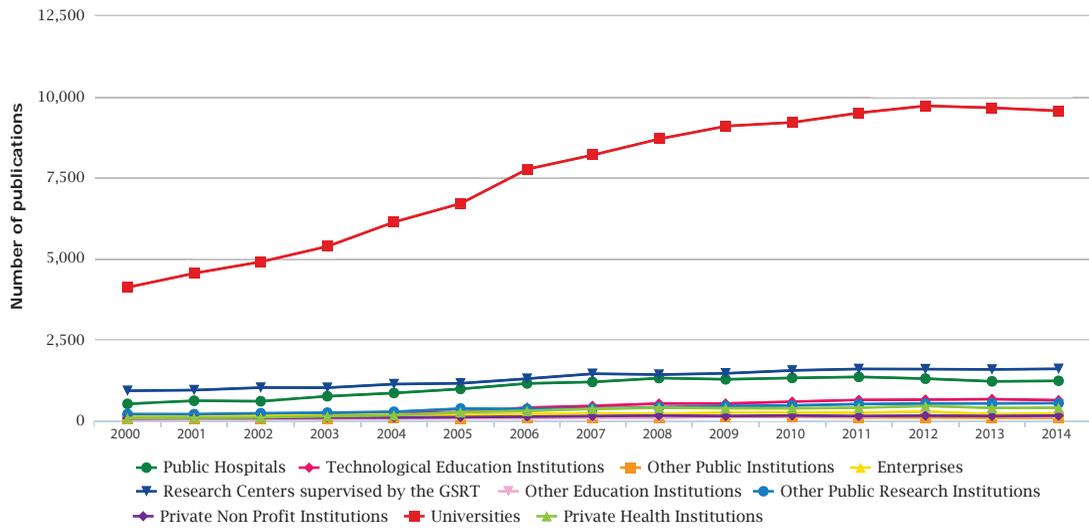
Figure 3.1.1 Development of the number of publications, by institution category, 2000-2014

Viewed in comparison with the base year (2000: 100), while all institution categories have been recording a steady increase, during recent years (since 2012) this has been slightly toned down. For some ("Other Education Institutions", "TEIs", "Private Health Institutions") the trend has reversed (Figure 3.1.2).
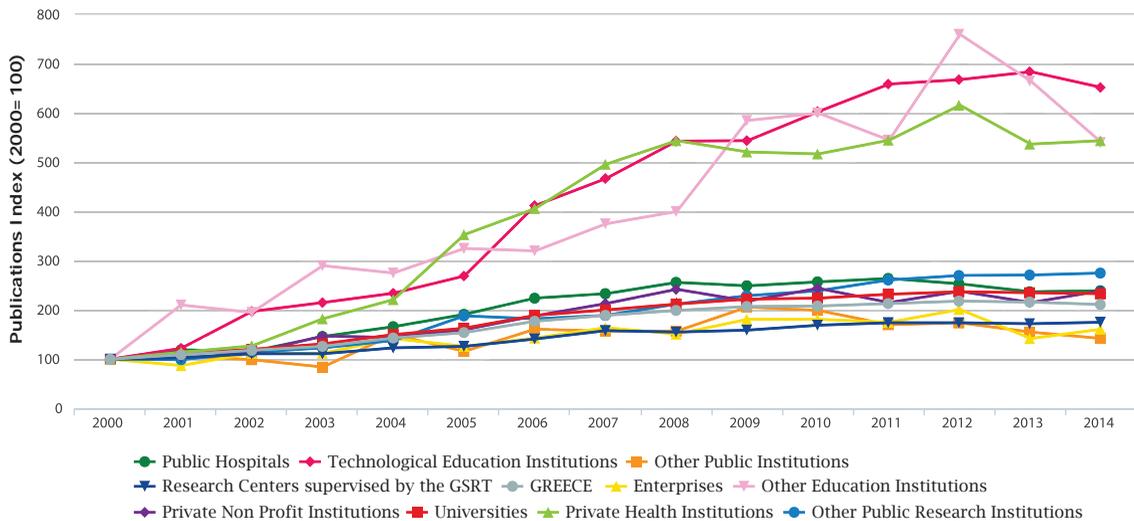
Figure 3.1.2 Publications Index (2000=100), by institution category, 2000-2014

Figure 3.1.3 presents the share of the total number of Greek publications per institution category for the latest five year period, 2010-2014. "Universities" ranked first with a share of 83.5%. They were followed by "RC-GSRT" (13.8%), "Public Health Institutions" (11.2%) and "TEIs" (5.5%). The remaining institution categories have shares lower than 5%.
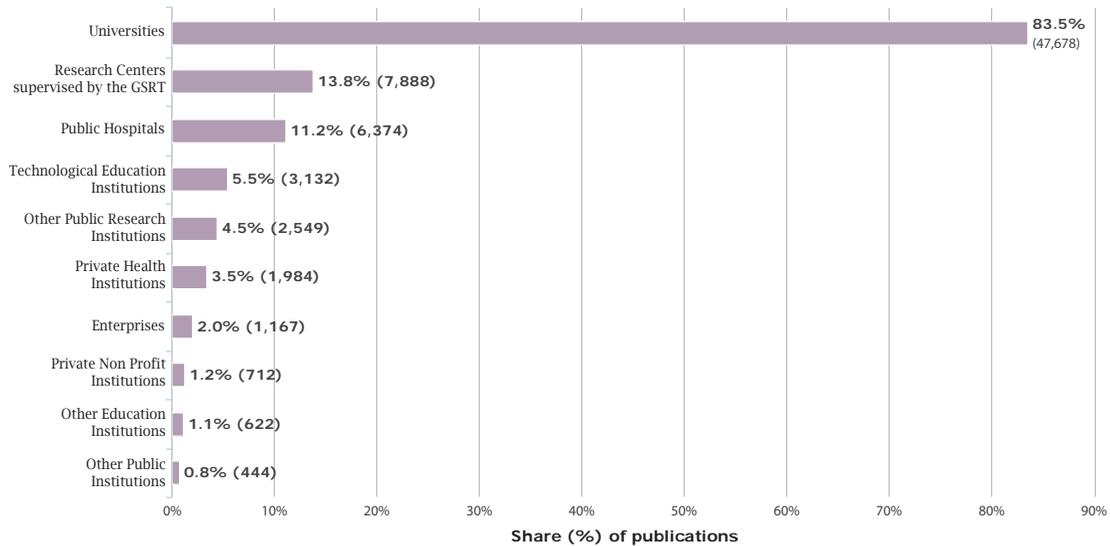
Figure 3.1.3 Number and share (%) of publications, by institution category, 2010-2014

3.2 Citations

Between 2000 and 2014, citation indices grew over time for all institution categories following the growth trend of Greek publications.

For the period 2010-2014, «RC-GSRT» and «Private Health Institutions» received the highest percentage (%) of cited publications among all institution categories (77.0% and 73.3%, respectively) (Figure 3.2.1). These are followed by "Other Public Research Institutions" (73.1%) and "Private non-for Profit Institutions" (71.3%).
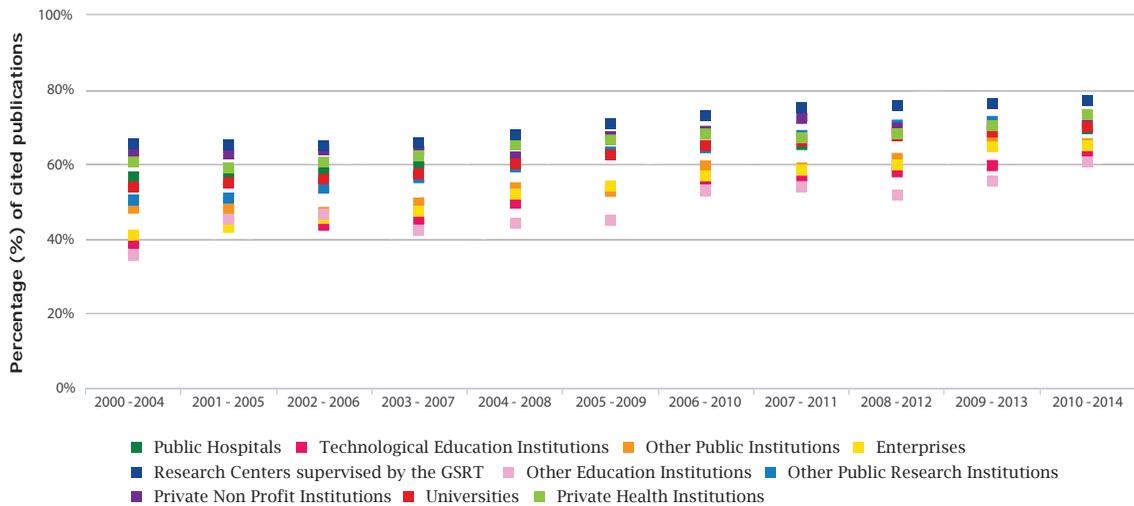
Figure 3.2.1 Percentage (%) of cited publications, by institution category, 2000-2014

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Figure 3.2.2 tracks the number of citations and its growth/evolution for the period 2000-2014. During this period, the number of citations in all institution categories followed an upward trend.
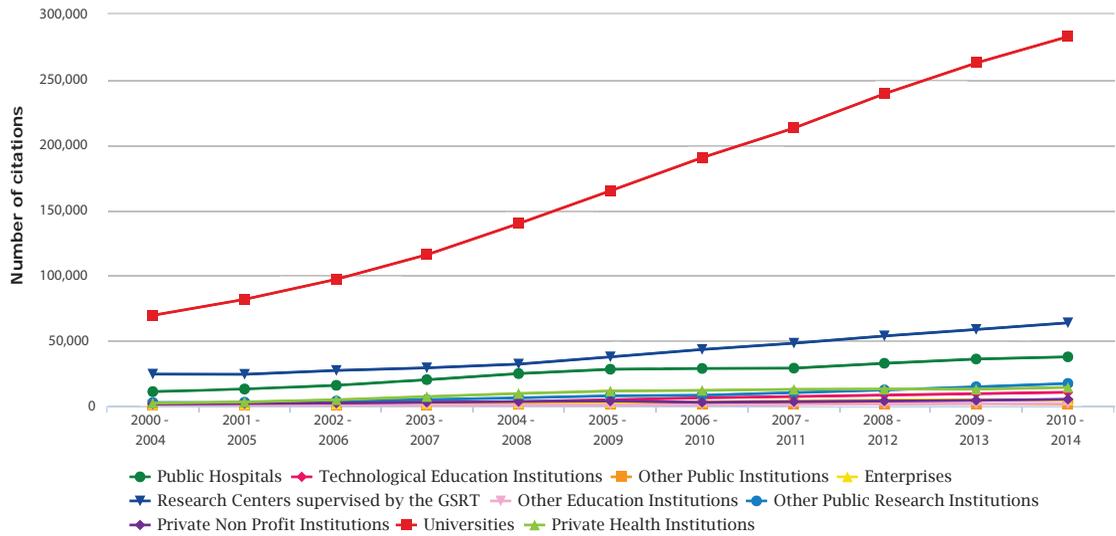
Figure 3.2.2 Number of citations, by institution category, 2000-2014

Apart from the highest representation in the number of publications, «Universities» had also the highest share in the number of citations. More specifically, during the period 2010-2014, University publications received 282,986 citations or a share of 82.8% in the total number of citations of Greek publications. (Figure 3.2.3).
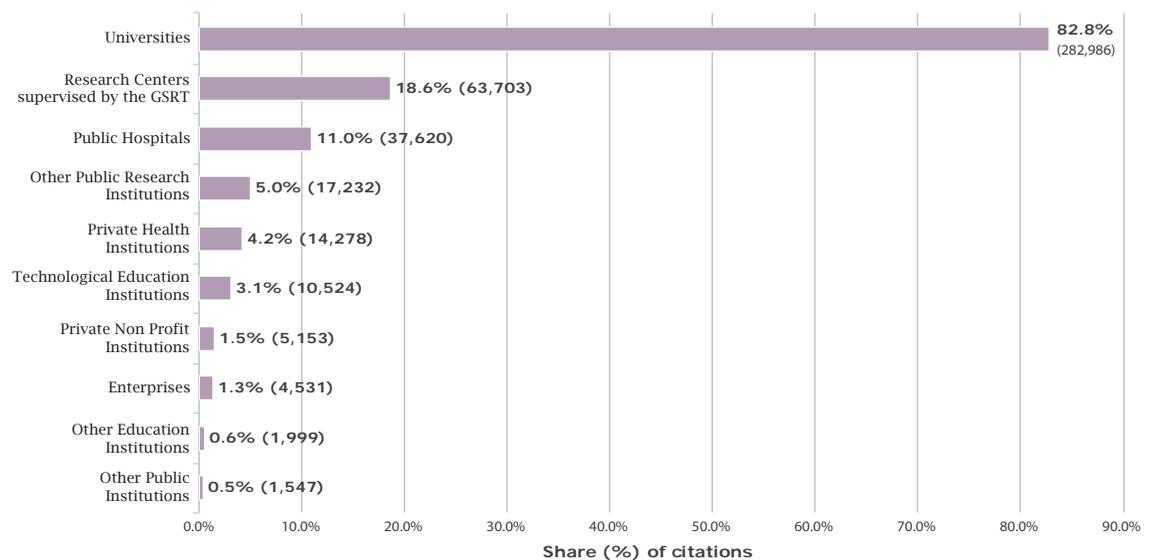
Figure 3.2.3 Number and share (%) of citations by institution category, 2010-2014

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 (2010-2014) and the relevant "field-normalised citation score" (a value greater than 1 indicates that the impact of publications is higher than the world average).

"Private Health Institutions" and "RC-GSRT" ranked first with their publications receiving the highest citation score (1.33 and 1.29, respectively). They are followed by "Private non-for Profit Institutions" (1.22), "Other Public Research Institutions" (1.17), and "Universities" (1.10).
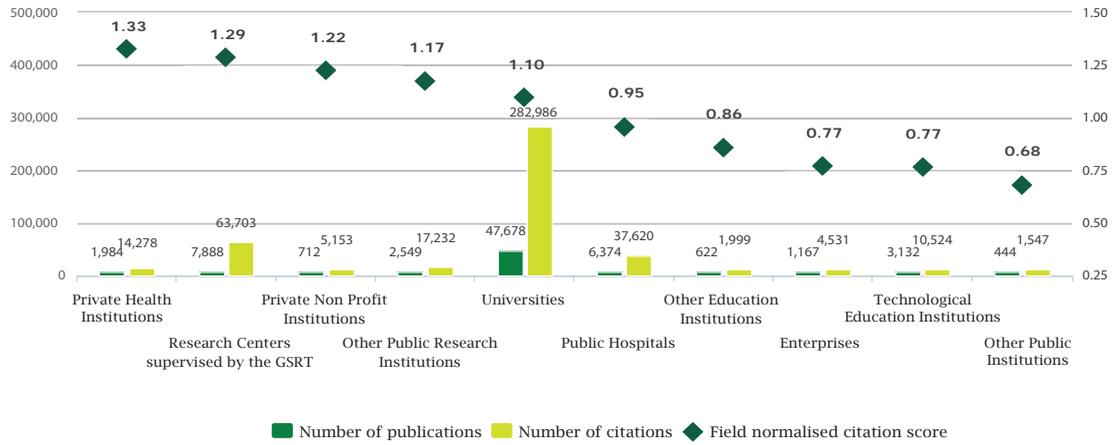
Figure 3.3.1 Publications, citations and field normalised citation score relative to the world, by institution category, 2008-2012. Data refers to the total number of publications in each category for all scientific fields

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 2010-2014, «Universities», «RC-GSRT», and «Public Hospitals» record more than 50 publications each in the 1% percentile.
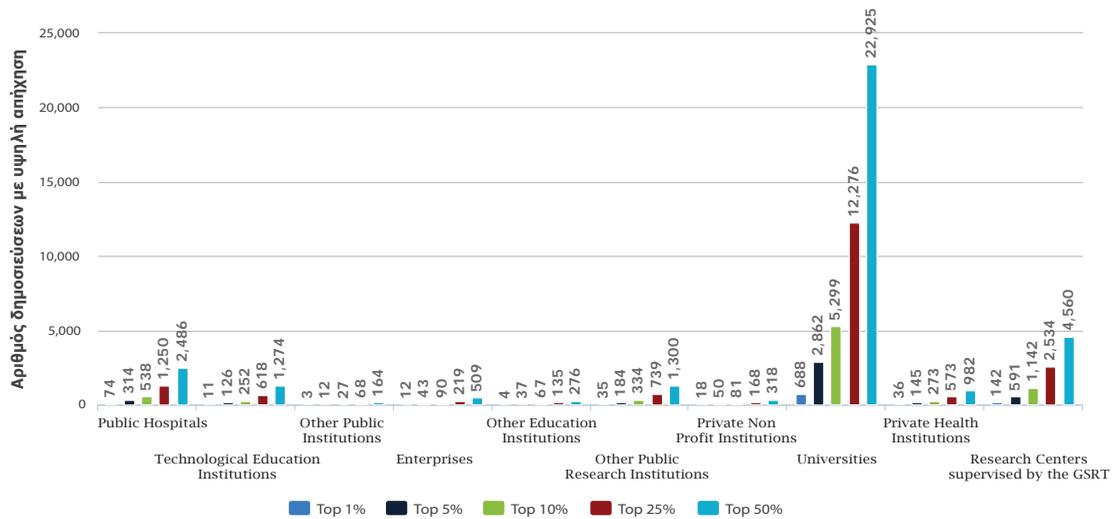
Figure 3.4.1 Number of highly cited publications, by institution category, 2010-2014

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, 2010-2014. Values above the percentile levels indicate a better performance compared to the world average. Publications from seven institution categories equal or surpass the 1% percentile level, with "Private non-for Profit Institutions" scoring the highest (2.5%).
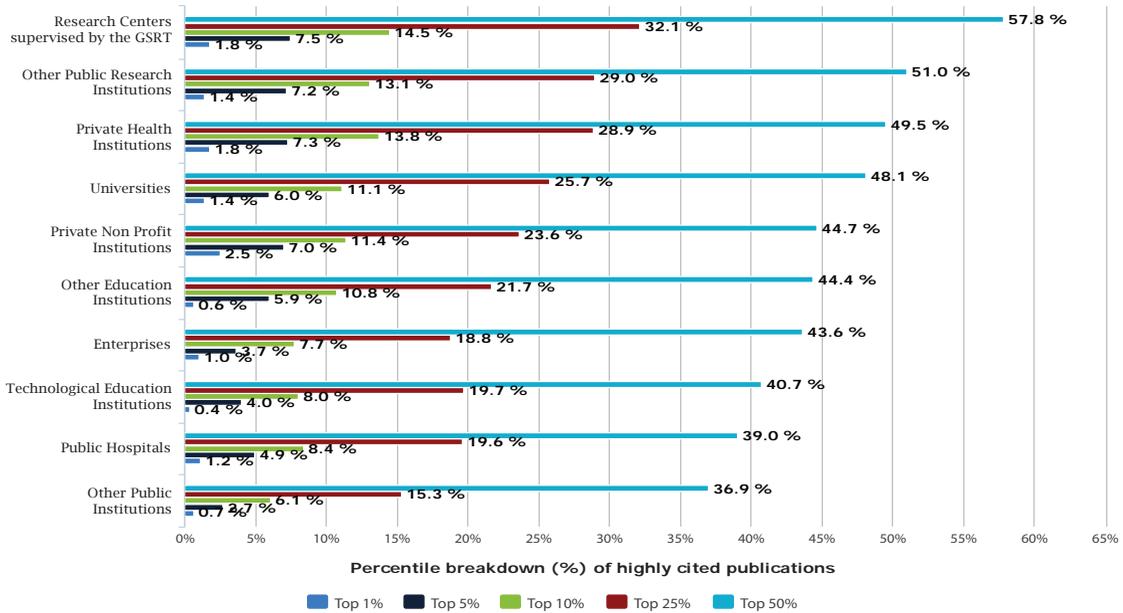
Figure 3.4.2 Percentile breakdown (%) of highly cited publications, by institution category, 2010-2014

3.5 Major fields of science

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, 2010-2014.

In "Natural Sciences", a small number of publications attributed to the "Private Health Institutions" record the highest citation score (1.71), followed by "Private Non profit Institutions" (1.66), "RC-GSRT" (1.36), "Other Public Research Institutions" and "Universities" (1.17, both) and "Public Hospitals" (1.08).

In "Engineering and Technology" the highest citation score was 1.35 and was attributed to the publications of "Other Education Institutions", followed by "Other Public Research Institutions" (1.19), «RC-GSRT» (1.12) and "Universities" (1.03).

In "Medical Sciences", publications of five institution categories had a better performance than the world average: «Private Health Institutions» (1.28), «RC-GSRT» (1.25), "Private Non profit Institutions" (1.19), «Other Public Research Institutions» (1.18) and "Universities" (1.08).

In "Agricultural Sciences" the highest citation score was attributed to the publications of "RC-GSRT" (1.32).

In "Social Sciences", publications by four institution categories attained a performance better than the world average: "Private Non profit Institutions" (1.95), «Other Public Research Institutions» (1.76), "RC-GRST" (1.35) and "Other Education Institutions" (1.04).

Finally, in the field of "Humanities", only "RC-GRST" recorded a citation score above world average (1.66), while "Universities" equal the world average (1.00).
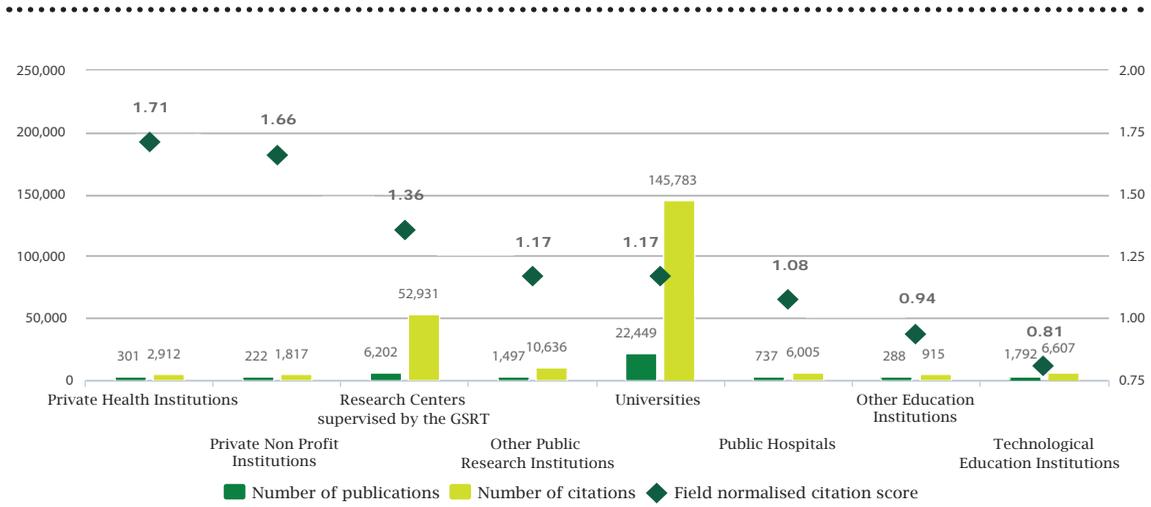
Figure 3.5.1 Publications, citations and field normalised citation score in the major field of «Natural Sciences» relative to the world, by institution category, 2010-2014
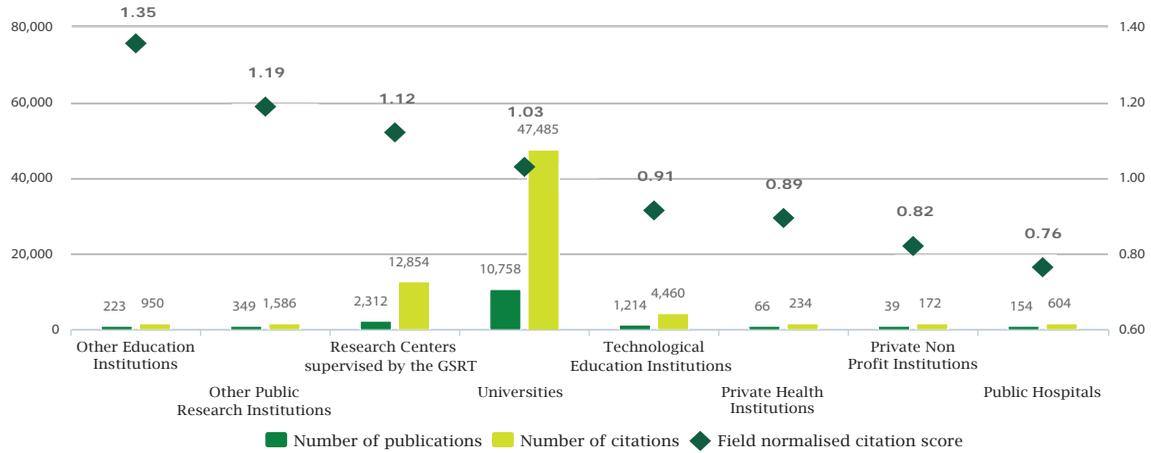
Figure 3.5.1 Publications, citations and field normalised citation score in the major field of «Engineering & Technology» relative to the world, by institution category, 2010-2014 «Engineering & Technology» relative to the world, by institution category, 2010-2014
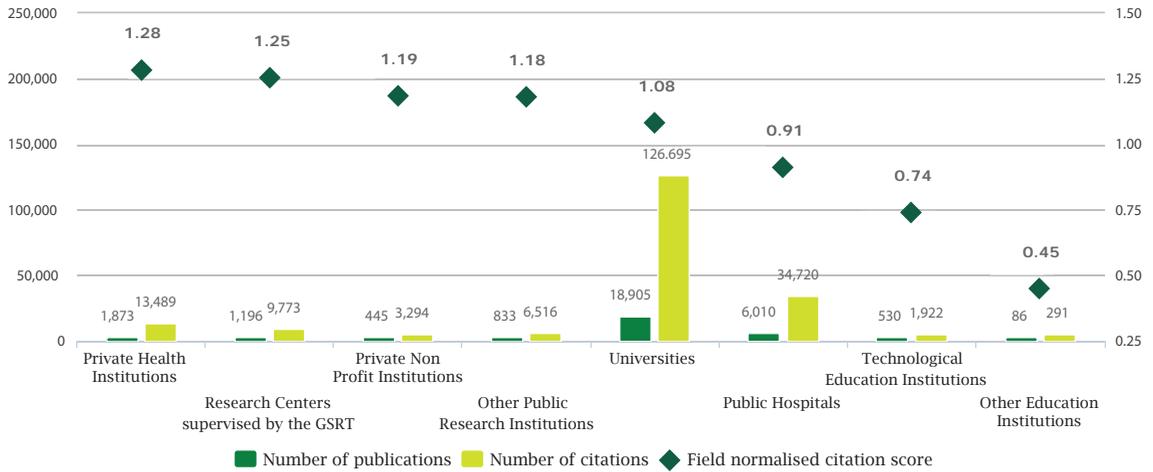
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Figure 3.5.1 Publications, citations and field normalised citation score in the major field of «Medical & Health Sciences» relative to the world, by institution category, 2010-2014
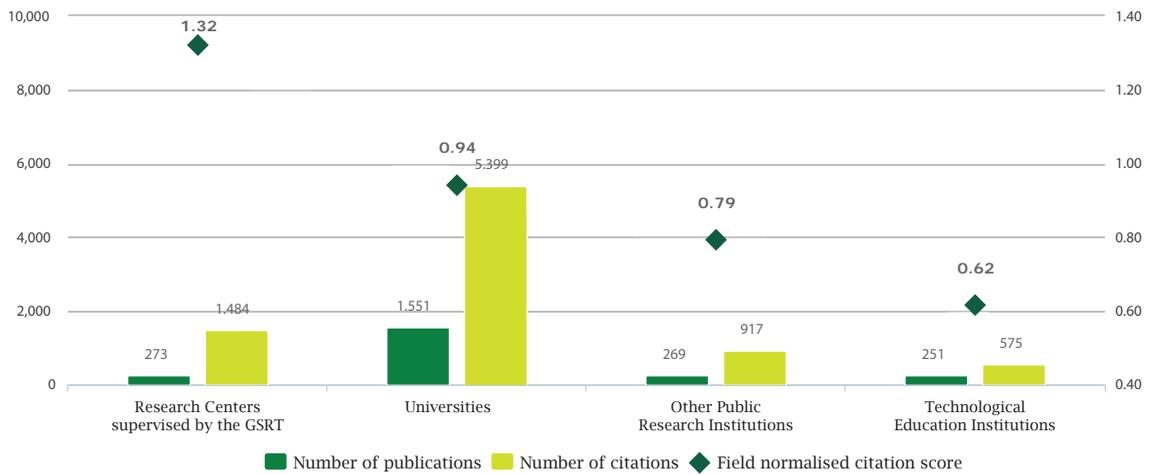
Figure 3.5.1 Publications, citations and field normalised citation score in the major field of «Agricultural Sciences» relative to the world, by institution category, 2010-2014
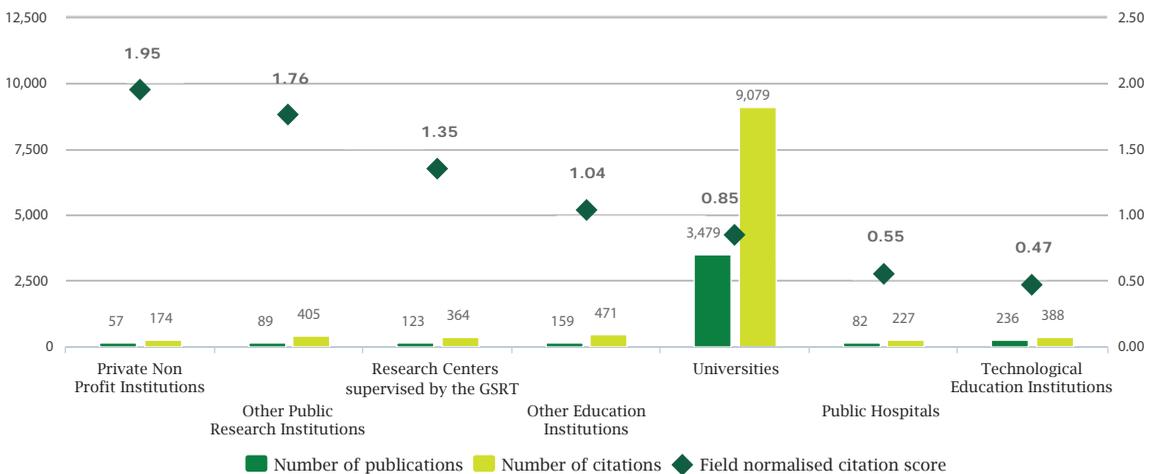
Figure 3.5.1 Publications, citations and field normalised citation score in the major field of «Social Sciences» relative to the world, by institution category, 2010-2014
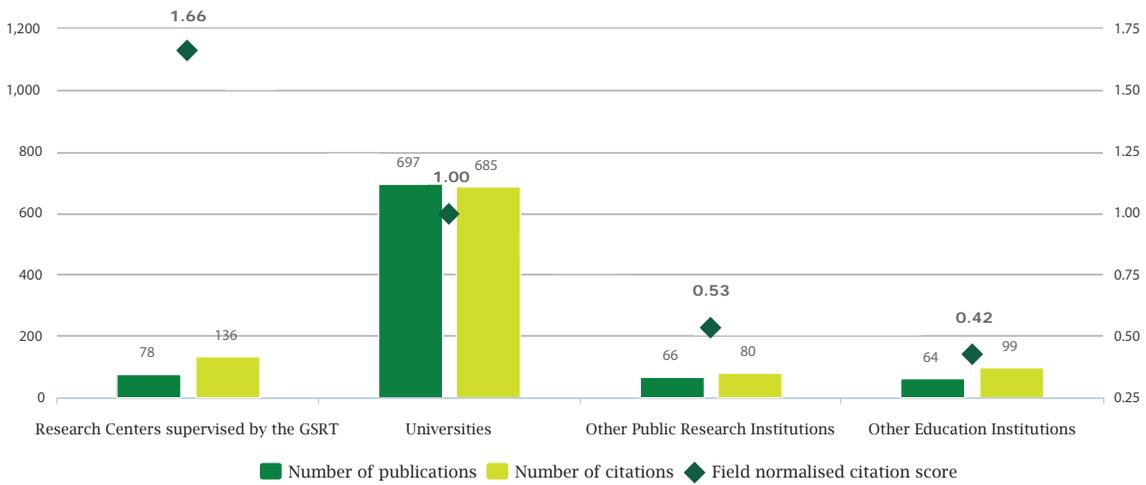
42

Figure 3.5.1 Publications, citations and field normalised citation score in the major field of «Humanities» relative to the world, by institution category, 2010-2014

3.6 Scientific collaboration

During the period 2000-2014, all institution categories increased their levels of international and national collaboration, while from 2012 the trend slowed down or even reversed. For example, publications which were result of national collaboration rose from 1,378 in 2000 to 4,054 in 2014 for «Universities», from 463 to 1,019 for "RC-GSRT" and from 374 to 976 for "Public Hospitals" (Figure 3.6.1).
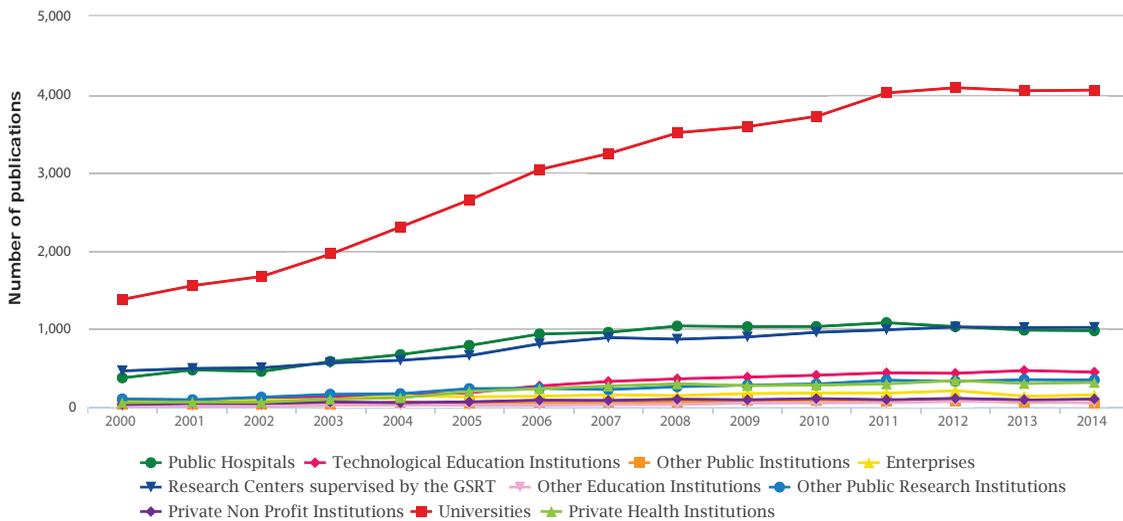
Figure 3.6.1 Number of publications with national collaboration, by institution category, 2000-2014

Most of the publications that were the result of collaboration include "Universities" as one of the collaborating organizations. Strong networking can be observed between "Universities" and "Public Hospitals, and between "Universities" and "RC-GSRT" (Figure 3.6.2).

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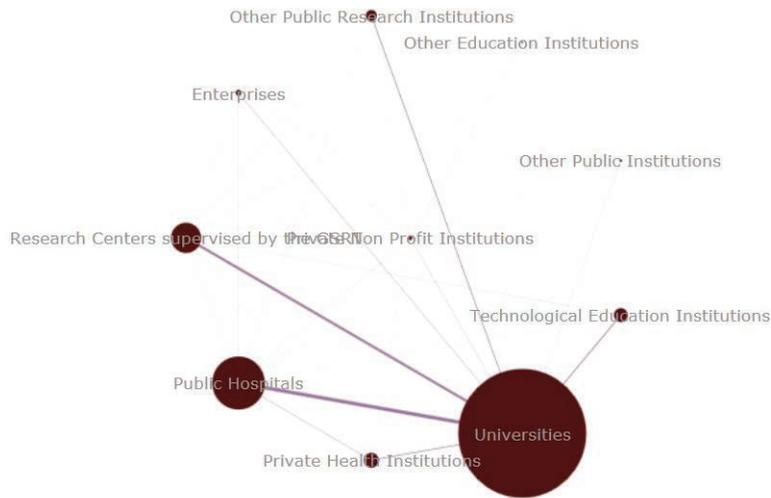
Figure 3.6.2 Mapping of collaborations between categories of Greek institutions, 2010-2014

The number of Greek publications produced with international collaboration also increased. More specifically, the number rose from 1,454 in 2000 to 4,942 in 2014 for «Universities», from 498 to 980 for «RC-GSRT» and from 93 to 472 for «Public Hospitals» (Figure 3.6.3).
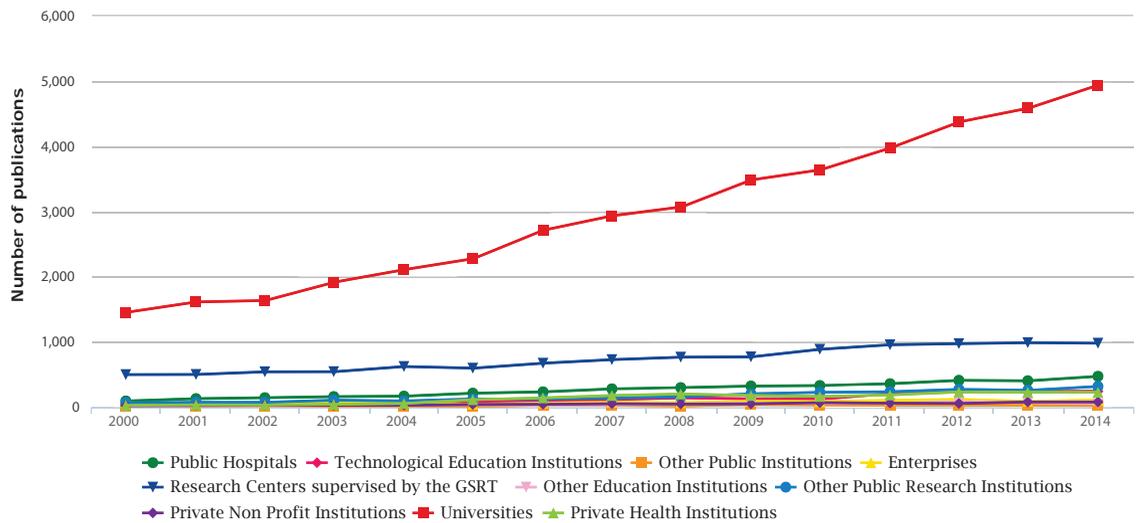
Figure 3.6.3 Number of publications with international collaboration, by institution category, 2000-2014

The level and the type of collaboration –national or international– varied significantly within institution categories (Figure 3.6.4). «Universities» had the highest share of publications without collaboration, which was equal to 28.9% during the 5-year period 2010-2014. «RC-GSRT» had the highest share of publications with international collaborations (60.6%). Finally, «Other Public Institutions» had the highest share of publications with national collaborations (80.4%).

Institution category	No collaboration	National collaboration	International collaboration
Research Centers supervised by the GSRT	10.6%	63.4%	60.6%
Private Health Institutions	7.5%	77.3%	52.3%
Other Public Research Institutions	9.1%	65.3%	51.3%
Other Education Institutions	17.7%	49.4%	50.3%
Private Non Profit Institutions	9.8%	71.3%	47.6%
Universities	28.9%	41.8%	45.1%
Enterprises	9.5%	73.6%	42.9%
Technological Education Institutions	16.0%	69.9%	33.2%
Other Public Institutions	8.3%	80.4%	31.5%
Public Hospitals	9.2%	80.0%	31.0%

■ Share (%) of publications with international collaboration ■ Share (%) of publications with national collaboration
■ Share (%) of publications with no collaboration

Figure 3.6.4 Share (%) of publications with national, international and no collaboration, by institution category, 2010-2014

APPENDICES

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.

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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 6major fields and 42 sub-fields of science of the Frascati Manual is provided in Appendix III.

Institution Categories

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

• The total number of Greek publications
• Specific categories of institutions
• Individual institutions.

SECTOR	CATEGORY	ABBREVIATION	DESCRIPTION
Higher Education	Universities	Universities	Universities and Technical Universities, University Research Institutes (U.R.I.) and University Hospitals
	Technological Education Institutes	TEI	Technological Education Institutes
	Other Education Institutions	Other Education Institutions	Other Education 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).
Research	Research centers supervised by the General Secretariat of Research and Technology	GSRT Research Centers	Research centers supervised by the General Secretariat of Research and Technology
	Other Public Research Institutions	Other Public Research Institutions	Other Public Research Institutions supervised by various Ministries
Health	Public Health Institutions	Public Health Institutions	Public Health Institutions of the national health system, hospitals, Institutions supervised by the Ministry of Health and Social Solidarity and Hospitals supervised by the Ministry of Defence
	Private Health Institutions	Private Health Institutions	Private Institutions active in the health sector such as private hospitals, diagnostic centers, research centers etc.
Other Public Institutions		Other Public Institutions	Ministries, Museums, Higher Military Education Institutions, Other Public Institutions and Public Enterprises
Other Private Institutions		Other Public Institutions	Other Private Institutions such as Private Educational Institutions, Museums, Banks, non-profit organisations, non-governmental organisations and private enterprises

Annex IV provides the list of institutions examined in this study.

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.

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Types of publications

Throughout the 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. Also, the NSI database is based on these types of publications to provide summary descriptors for publications per country. Therefore, in this study we based on data related with articles, research notes and reviews and we excluded editorials, letters, correction notes and abstracts.

It is also important to note that in the field of natural sciences, the publication type "letter" corresponds to short articles with novel scientific results and usually high numbers of expected citations. When calculating bibliometric indicators, such "letters" are usually classified as publications or as research notes.. However, In the WoS databases the type "letter" refers to types of publications such as letters to the journals' editors, letters including corrections or comments about past articles etc.

Year of publication

The distribution of publications across years is an important parameter in bibliometric analysis. Publications are commonly categorized according to the official date of their release in printed form. InCites database provides information for both the date of a publication's official release as well as the date of its registration in the Web of Science system. However, in the case of the NSI database, publications across years are distributed according to the year of registration in WoS.

For reasons of data consistency, indicators were calculated according to information derived from both databases. it was therefore decided to treat the year of a publications' registration in the WoS as the year of its publication. It should be noted that the publication date differs from the registration date in the WoS in about 18% of registrations on the Incites database.

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 (2000-2014).

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 interna-

tional 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 filed 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.

Finally, another important issue in the calculation of citation impact was the skewed distribution of citations. In many cases, within a given number of publications, a few publications were disproportionately highly cited while a large proportion had only few or no citations at all. This distribution would differ significantly per case (e.g. for scientific fields or institutions). The issue of skewed distribution of citations is not adequately addressed by the common bibliometric indicators. An interesting approach is the logarithm-based citation z-score, which takes both the citation rate variability of different fields into account as well as the skewed distribution of citations over publications. However, this indicator is rather complicated and was not used in this study since it was not possible to calculate it from Incites and NSI databases.

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In this study, we present highly cited publications using indicators for the number **(P Top X%) and percentile (Top X%)** of publications that were ranked worldwide in the 1%, 5%, 10%, 25% and 50% most cited publications by publication year and scientific field. These indicators were used complementary to the field normalised citation score (citation score).

Rate of Change

Results regarding the bibliometric indicators throughout the period 1996-2010 were displayed either on an annual basis or within rolling 5-year periods.

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

$$\Delta t_2 - t_1 = 1 + \frac{n2 - n1}{n1}$$

where Δt_2-t_1 is the rate of change n1, n2 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 n1, n2 remain the same for the years (or period of years) t_1 and t_2.

Least 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 (ορ 50) publications for the period 2000-2014, 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.

Interpretation of results

The study's aim was to provide reliable bibliometric data, an important source of information for the Greek research landscape. Along with the indicators used, there exists a wide range of indicators for the measurement of research activity -such as the number of patents, licenses, research projects, social impact etc-. Within this range, bibliometric indicators are among the most significant metrics.

However, 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 had to make the following choices and decisions:

• To reflect information regarding current research activity, figures present information and indicators corresponding to the last 5-year period 2010-2014 so as to control abnormal annual variations.

• We provide a trend analysis, when applicable, throughout the period 2000-2014.

- To ensure the reliability of results, indicators were calculated only for institutions with a publication output above the threshold (75 publications for the period 2000-2014).

- 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 study involved a robust infrastructure and appropriate software tools, which will support future bibliometric studies, part of the series. By ensuring consistency in procedures, methodology and software used, we make possible the accurate mapping of research activity for each given period and we may enable comparisons across data.

At last, we should mention that the average number of publications per researcher or per full time equivalent is an indicator widely used in comparative evaluation of research activity of institutions. This indicator allows comparisons in terms of "productivity" and gives more reliable results regarding each institution's performance. Since there was a lack of data about the country's base of researchers, the study presents indicators regarding the volume of publications per institution or institution category which cannot be used as a measure for the evaluation of institutional performance/productivity.

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: • country total. • institution category. • scientific field. • institution.	An indication of the volume of research output for: • Greece. • each institution category. • each scientific field. • each institution.
Share of publications (%)	It is calculated as a percentage of: • Greek publications in relation to EU and OECD publications. • publications per institution category in relation to the total number of Greek publications. • publications falling under one scientific field in relation to the total number of Greek publications. • publications issued by an institution in relation to the total number of publications in the same category of institutions.	An indication for the participation of: • Greece within all EU and OECD publications. • each institution category within all Greek publications. • each scientific field within all scientific fields. • each institution within the category it belongs to.
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: • country total. • institution category. • institution.	An indication for the levels of visibility / recognition of scientific publications produced by: • Greece. • each institution category. • 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: • country total. • institution category. • scientific field. • institution.	An indication of the influence and visibility of scientific publications produced by: • Greece. • each institution category. • each scientific field. • 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: • Greece in relation to the number of citations that EU and OECD's publications received. • citations in one institution category in relation to the total number of citations for Greek publications. • citations found in each scientific field in relation to the total number of citations for Greek publications. • citations in each institution in relation to the total number of citations for the category of institutions.	An indication for the influence and visibility of: • Greece within the EU and OECD. • each institution category within Greece. • each scientific field within all scientific fields. • each institution within the category it belongs to.
Citation impact	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. 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.	An indication for the impact of publications.
Relative citation impact	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. 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. 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.	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.

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INDICATOR	DESCRIPTION	INTEPRETATION
Field normalised citation score **(abv: citation score)**	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. 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. 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. In the study citation scores were calculated after normalisation for:	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:
	• the sum of Greek publications.	• Greece.
	• Greek publications by scientific field.	• Greece within the 6 major scientific fields.
	• the sum of publications for an institution category.	• each institution category.
	• the publications for an institution category by scientific field.	• each institution categorywithin the 6 major scientific fields.
	• the sum of publications for an institution.	• each institution.
	• publications of an institution by scientific field.	• each institution within the 6 major scientific fields.
Number of top publications (P Top X%)	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. 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:	An indication of the volume of high impact publications produced by:
	• for country total.	• Greece.
	• per institution category.	• each institution category.
	• per institution.	• each institution.
Percentile breakdown of top publications (Top X%)	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%. 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:	Comparison to the world average for percentile breakdown of top publications is made for:
	• for country total.	• Greece.
	• per institution category.	• each institution category.
	• per institution.	• 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

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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
		• zoology
	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

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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
		• metallurgy & mining
	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
		• toxicology
	Clinical Medicine	• 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

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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
		• 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

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APPENDIX IV: INSTITUTIONS

Institutions examined

SECTOR	CATEGORY	ABBREVIATION	DESCRIPTION
Higher Education	Universities	Universities	Universities and Technical Universities, Universities' Research Centers and University hospitals
	Technological Education Institutes	TEI	Technological Education Institutes
	Other Education Institutions	Other Education Institutions	Other Education 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 schools, etc.)
Research	Research Centers supervised by the General Secretariat of Research and Technology	GSRT Research Centers	Research Centers supervised by the General Secretariat of Research and Technology
	Other Public Research Institutions	Other Public Research Institutions	Other Public Research Institutions supervised by different Ministries.
Health	Public Health Institutions	Public Health Institutions	Public Health Institutions of the national health system, hospitals, Institutions supervised by the Ministry of Health and Social Solidarity and Hospitals supervised by the Ministry of Defence.
	Private Health Institutions	Private Health Institutions	Private Institutions active in the health sector such as private hospitals, diagnostic centers, research centers etc.
Other Public Institutions	Other Public Institutions		Ministries, Museums, Higher Military Education Institutions, Other Public Institutions and Public Enterprises
Other Private Institutions	Other Private Institutions		Other Private Institutions such as Private Educational Institutions, Museums, Banks, non-profit organisations, non-governmental organisations and private enterprises

1. Universities

UNIVERSITIES	ABBREVIATION
1. Athens School of Fine Arts	ASFA
2. Aristotle University of Thessaloniki	AUTH
3. Agricultural University of Athens	AUA
4. Demokritos University of Thrace	DUTH
5. International Hellenic University	IHU
6. National & Kapodistrian University of Athens	UOA
7. Hellenic Open University	HOU
8. National Technical University of Athens	NTUA
9. Ionian University	IONIO
10. Athens University of Economics and Business	AUEB
11. University of the Aegean	AEGEAN
12. University of Western Macedonia	UOWM
13. University of Thessaly	UTH
14. University of Ioannina	UOI
15. University of Crete	UOC
16. University of Macedonia of Economic and Social Sciences	UOM
17. University of Patras	UPATRAS
18. University of Piraeus	UNIPI
19. University of Peloponnese	UOP
20. Panteion University of Social and Political Sciencesv	PANTEION
21. Technical University of Crete	TUC
22. Harokopio University of Athens	HUA

University publications also include the publications produced by affiliated Research Institutes as well as the publications by the University Hospitals:

UNIVERSITY HOSPITALS
1. Eginition Hospital
2. Aretaieio Hospital
3. University General Hospital "ATTIKON"
4. University General Hospital of Thessaloniki AHEPA
5. University Hospital of Alexandroupolis / Academic General Hospital of Alexandroupolis
6. Univeristy General Hospital of Heraklion / Venizelio-Panakio Hospital of Heraklion
7. General University Hospital of Larissa
8. University Hospital of Ioannina / Hadjukosta General Hospital of Ioannina
9. General University Hospital of Patras / "Agios Andreas" General Hospital Patras

2. Technological Educational Institutions - TEI

TECHNOLOGICAL EDUCATIONAL INSTITUTIONS
1. School of Pedagogical and Technological Education - ASPETE
2. TEI (Technological Educational Institution) of Athens
3. TEI (Technological Educational Institute) of West Macedonia
4. TEI (Technological Educational Institute) of Epirus
5. A.T.E.I. (Alexandreio Technological Educational Institute) of Thessaloniki
6. TEI (Technological Educational Institute) of Ionian Islands
7. TEI (Technological Educational Institute) of Eastern Macedonia and Thrace
8. TEI (Technological Educational Institute) of Peloponnese
9. TEI (Technological Educational Institute) of Crete
10. TEI (Technological Educational Institute) of Central Greece
11. TEI (Technological Educational Institute) of Thessaly
12. TEI (Technological Educational Institute) of Western Greece
13. TEI (Technological Educational Institute) of Piraeus
14. TEI (Technological Educational Institute) of Central Macedonia

3. Research Centers supervised by the General Secretariat of Research and Technology (GSRT)

GSRT RESEARCH CENTERS	ABBREVIATION
1. Athena - Research and Innovation Center in Information, Communication and Knowledge Technologies	ATHENA
2. National Observatory of Athens	NOA
3. National Hellenic Research Foundation	NHRF
4. The Center for Research and Technology Hellas	CERTH
5. National Center of Scientific Research DEMOKRITOS	NCSR DEMOKRITOS
6. Hellenic Center for Marine Research	HCMR
7. National Center for Social Research	EKKE
8. Greek Atomic Energy Commission	GAEC
9. Hellenic Pasteur Institute	HPI
10. Biomedical Sciences Research Center "Alexander Fleming"	B.S.R.C. Fleming
11. Foundation for Research and Technology - Hellas	FORTH

4. Other Public Research Institutions

OTHER PUBLIC RESEARCH INSTITUTIONS	ABBREVIATION
1. Academy of Athens	Academy of Athens
2. Hellenic Agricultural Organization Demeter	DEMETER
3. Computer Technology Institute and Press "Diophantus"	DIOPHANTUS
4. National Centre for Viable and Sustainable Growth	EKBAA
5. Organisation for Anti-seismic Planning and Protection	OASP
6. Center for Renewable Energy Sources and Saving	CRES
7. Center of Planning and Economic Research	KEPE
8. Benaki Phytopathological Institute	BPI
9. Mediterranean Agronomic Institute of Chania	MAICH
10. Entities of the Ministry of Culture	YPPO
11. Entities of the Ministry of Health	YPYG

5. Public Health Institutions

PUBLIC HEALTH INSTITUTIONS	ABBREVIATION
1. "Agios Savvas" Regional Hospital for Cancer Treatment	AGIOS SAVVAS
2. "Aghia Sophia" Children's Hospital	AGHIA SOPHIA
3. G. Gennimatas General Hospital of Athens	G. GENNIMATAS
4. G. Papanikolaou General Hospital of Thessaloniki	G. PAPANIKOLAOU
5. Evaggelismos Hospital Athens	EVAGGELISMOS
6. THEAGENIO Cancer Hospital of Thessaloniki	THEAGENIO
7. "Ippokratio" Regional General Hospital of Athens	IPPOKRATEIO ATHENS
8. IPPOKRATEIO General Hospital of Thessaloniki	IPPOKRATEIO THESSALONIKI
9. KORGIALENIO-BENAKIO Hospital of Athens	KORGIALENIO
10. General Hospital of Athens LAIKO	LAIKO
11. General Hospital of Athens ALEXANDRA	ALEXANDRA
12. Hospitals supervised by Ministry of National Defence	MOD HOSPITALS
13. G. PAPAGEORGIOU General Hospital	G. PAPAGEORGIOU
14. SOTIRIA General Hospital of Athens	SOTIRIA

6. Private Health Institutions

PRIVATE HEALTH INSTITUTIONS	ABBREVIATION
1. Alfa Institute of Biomedical Sciences	AIBS
2. METROPOLITAN hospital	METROPOLITAN
3. St. Luke's Hospital	St. Luke
4. Henry Dunant hospital	Henry Dunant
5. EUROCLINIC Group	EUROCLINIC GROUP
6. IASO Hospital	IASO
7. Athens Medical Group	ATHENS MEDICAL GROUP
8. HYGEIA Group	Hygeia

APPENDIX V: REFERENCES

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