GREEK SCIENTIFIC PUBLICATIONS 1998-2012

A Bibliometric Analysis of Greek Publications in International Scientific Journals

SCOPUS

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NATIONAL DOCUMENTATION CENTRE (EKT) | NHRF

a: 48, Vas. Constantinou Ave, GR-11635 Athens,
t: +30 210 7273900 • f: +30 210 7246824
e: ekt@ekt.gr • www.ekt.gr

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Coordination– scientific supervision:

• Dr Evi Sachini

Authors

• Dr Nena Malliou
• Dr Evi Sachini
• Dr Nikos Karampekios
• Dr Dimitris Karaiskos

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

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

PREFACE

The present study 'Greek Scientific Publications 1998-2012, a Bibliometric Analysis of Greek Publications in International Scientific Journals, Scopus' stands as the latest publication concerning the bibliometric indicators for the Greek scientific publications over the 1998-2012 period by the National Documentation Center (EKT). Analogous studies have been regularly published by EKT making use of the most internationally acclaimed databases for scientific publications, the Web of Science (Thompson Reuters) and Scopus (Elsevier).

By way of these publications, EKT provides a continuously updated picture of the Greek publications and the scientific fields in which these publications belong to the wider public as well as to policy makers. Concerning the latter group, formulating public policy options upon sound evidence stands as an appropriate road towards achieving better (and more) relevant policy outcomes. Safeguarding soundness and comparability of data, bibliometric analysis is based on data for publications in international scientific journals, and the methodological approach used is in line with the practices followed by established organizations in the area.

According to the latest data, and following a continuous increase over the last two decades, the number of Greek publications seems to have stabilized. Since 2009, only minor yearly fluctuations can be observed. Yet, compared to national R&D expenditure and research personnel, the Greek research system displays a high level of productivity in terms of its number of publications. Additionally, the impact of Greek publications is constantly increasing, indicating the significance not only of the research work performed by Greek scientists but also the international network of co-operation in which they participate in.

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

Thank you for your enthusiastic response and your comments which help us improve. We hope you enjoy reading the study.

Dr. Evi Sachini

Director EKT

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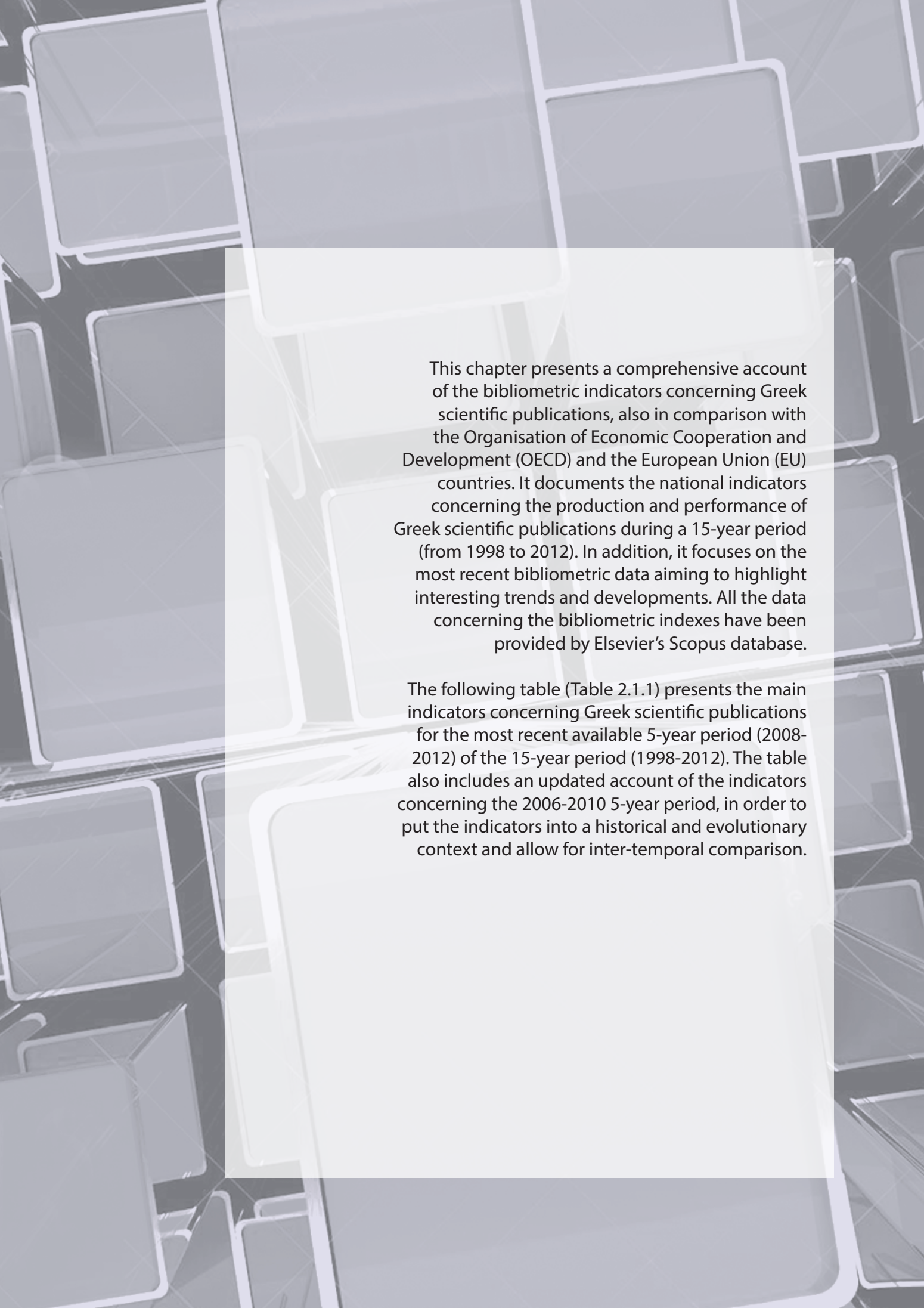
1. Introduction

This study titled «Greek Scientific Publicationsç 1998-2012, A Bibliometric Analysis of Greek Publications in International Journals» is part of a series of studies regularly published by the National Documentation Centre (EKT) aiming to analyze the Greek scientific activity in international peer-reviewed journals. By making use of Elsevier's Scopus database, one of the largest worldwide abstract and citation database of peer-reviewed literature, this study aims to document the fundamental production and performance indicators of Greek publications for the 15-year period ranging from 1998 to 2012 on a national and per-institution category level. In addition, it focuses on the latest 5-year period (2008-2012) in order to highlight recent trends and developments.

Bibliometric indicators stand as an important element of an evidence-based approach towards research activities by contributing in measuring the performance of the national scientific and research system. In effect, such indicators are valuable sources of information concerning the scientific fields in which the domestic science base is activated in. In addition, they identify new and promising fields, as well as map any (inter)national networks that have been created towards achieving common research objectives.

The available indicators in this study analyze the up-to-date relevant Greek environment, in addition to allowing for an exploration across time of the national scientific production and in relation to the European and international level. This is achieved by making use of the following indicators: scientific publications, citations of scientific publications, relative citation impact, scientific fields and publishing institutions.

Producing the indicators followed upon the most internationally-acclaimed and -trusted methodologies in the field of bibliometric analysis. In addition, customized IT applications developed in-house by EKT for refining the available bibliometric data were made use of in every step of the process (cleansing, thematic categorization, normalization, calculation, diagrammatic and table representation).



This chapter presents a comprehensive account of the bibliometric indicators concerning Greek scientific publications, also in comparison with the Organisation of Economic Cooperation and Development (OECD) and the European Union (EU) countries. It documents the national indicators concerning the production and performance of Greek scientific publications during a 15-year period (from 1998 to 2012). In addition, it focuses on the most recent bibliometric data aiming to highlight interesting trends and developments. All the data concerning the bibliometric indexes have been provided by Elsevier's Scopus database.

The following table (Table 2.1.1) presents the main indicators concerning Greek scientific publications for the most recent available 5-year period (2008-2012) of the 15-year period (1998-2012). The table also includes an updated account of the indicators concerning the 2006-2010 5-year period, in order to put the indicators into a historical and evolutionary context and allow for inter-temporal comparison.

2. Greek Scientific Publications: Overall Bibliometric Indicators

Table 2.1.1 Main Indicators of Greek scientific publications

PUBLICATIONS	2010	2012
Number of Greek publications	11,933	12,214
Share (%) of Greek publications in EU countries	2.39%	2.26%
Share (%) of Greek publications in OECD countries	0.85%	0.80%
CITATIONS	**2006-2010**	**2008-2012**
Number of citations to Greek publications	280,187	344,309
Share (%) of Greek citations in EU	2.18%	2.33%
Share (%) of Greek citations in OECD	0.91%	0.97%
CITATION IMPACT	**2006-2010**	**2008-2012**
Citation Impact (average number of citations per publication)	5.51	5.85
Relative citation impact of Greek publications compared to EU	0.91	0.98
Relative citation impact of Greek publications compared to OECD	1.04	1.14

2.1 Publications

The production of Greek scientific publications has been steadily increasing from 1998 up to end of the previous decade (Figure 2.1.1). Since then, the number of publications has been oscillating slightly above 12,000. For the year 2012, Greek publications have reached the number of 12,214.

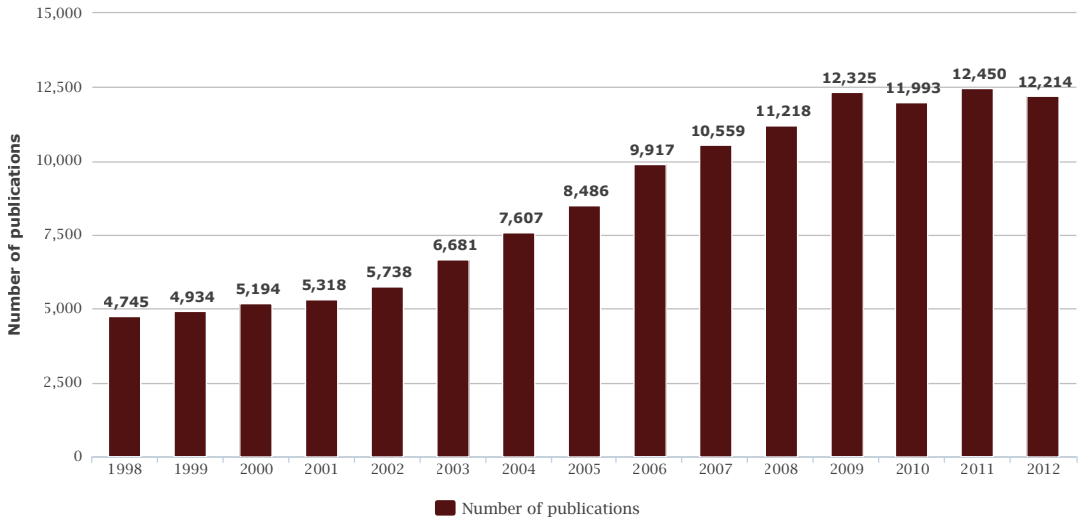


Figure 2.1.1 Development of the number of Greek scientific publications, 1998-2012

Reaching this plateau is evident if one takes into account the rate of change of the Greek publications compared to the similar rate of OECD and EU countries (Figure 2.1.2). While both OECD and EU countries have been experiencing a positive rate of change, Greece indicates an overall negative rate since 2009.

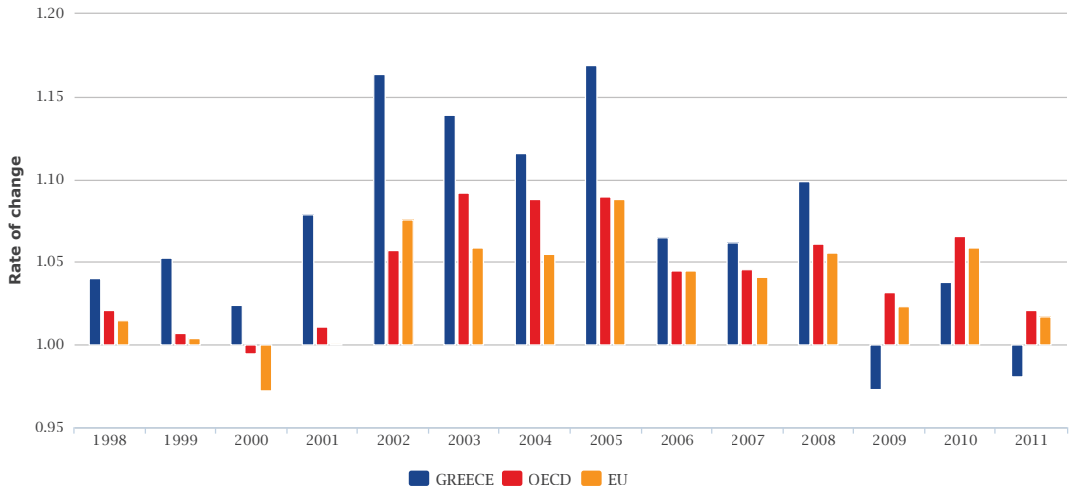


Figure 2.1.2 Change in the number of publications in Greece, EU and OECD, 1998-2012

The same declining trend is highlighted by taking into account the percentage of Greek publications for the total of OECD and EU countries (Figure 2.1.3). With a 2.51% of total EU publications in 2009, the country has declined to 2.26% in 2012. Similarly, from 0.91% of total OECD publications (2009), the country decreased to 0.81% in 2012.

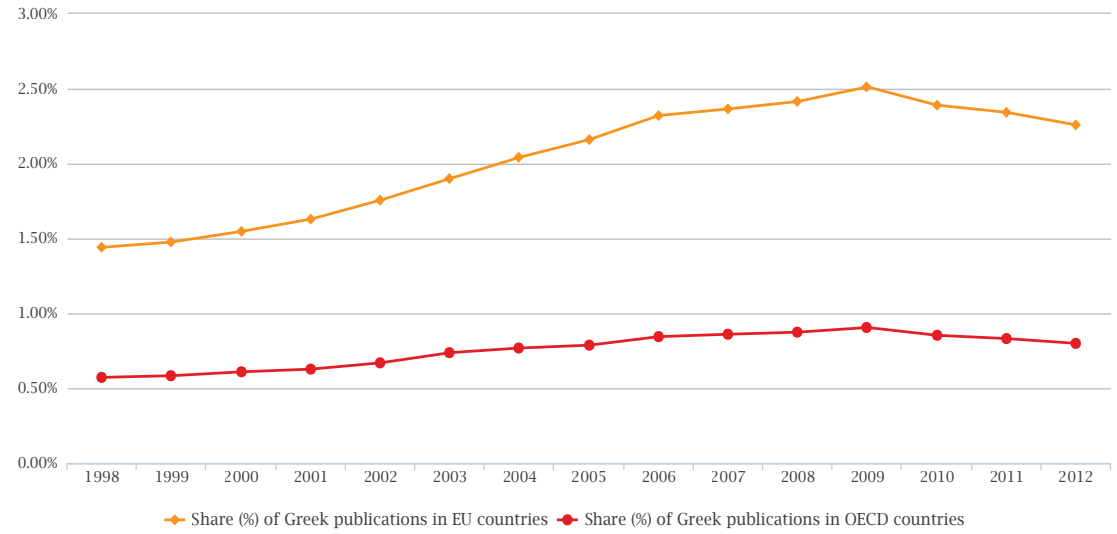


Figure 2.1.3 Share (%) of Greek publications in EU and OECD, 1998-2012

If population density is taken into account (Figure 2.1.4), the national research system indicates a higher productivity capability in comparison to EU countries (1,098 as opposed to 1,080).

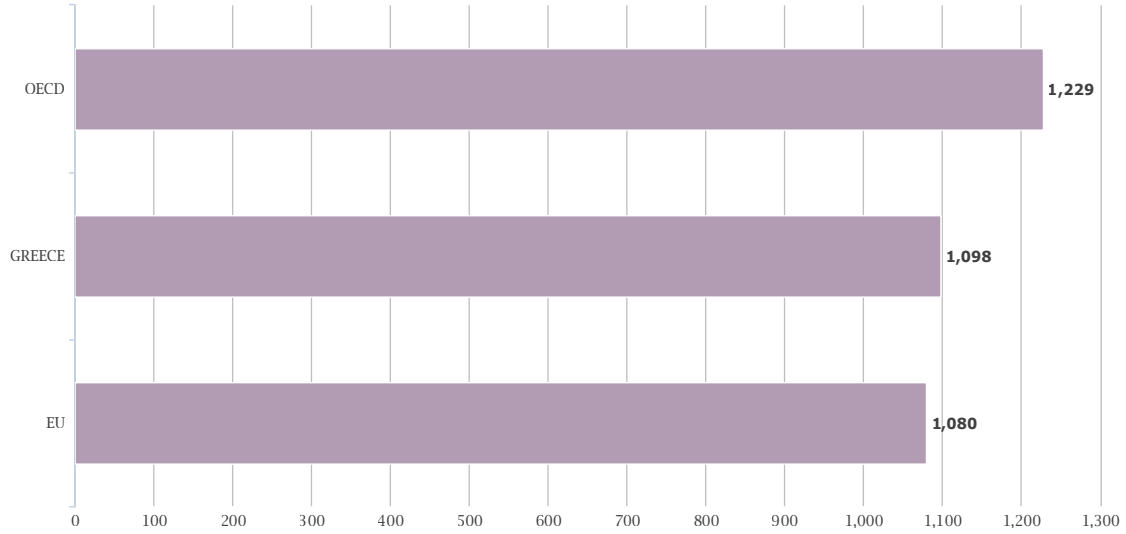


Figure 2.1.4 Number of publications in OECD countries per million of population, 2012

2.2 Citations

Concerning the originality and influence of Greek scientific publications, they have been experiencing a steady growth given that the number of citations of Greek publications has been on the rise since 1998, reaching 344,309 citations for the most recent period (2008-2012) (Figure 2.2.1).

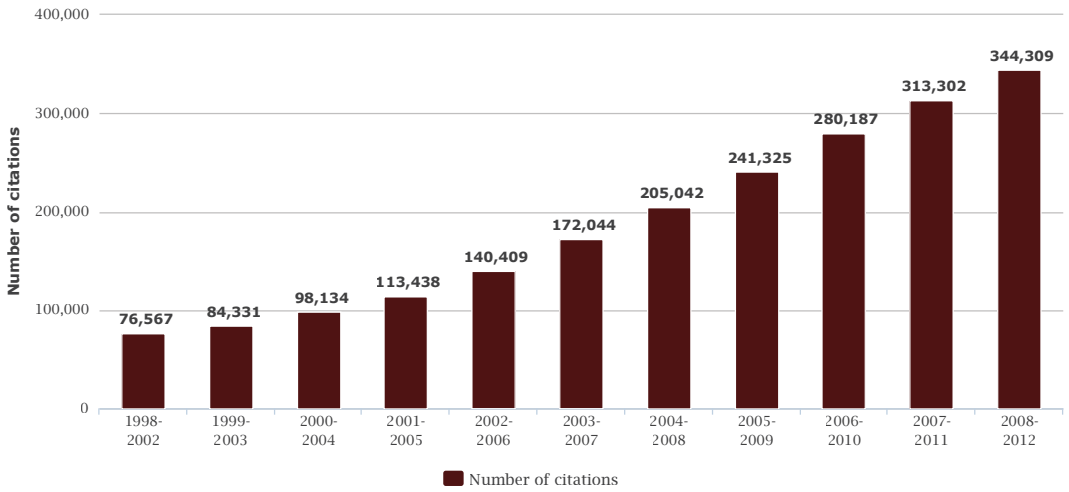


Figure 2.2.1 Development of the number of citations to Greek publications, 1998-2012

This is also made evident by examining the rate of change of the number of citations for Greece vis-a-vis OECD and EU countries (Figure 2.2.2). The country has been systematically outperforming both group of countries (1.10 as opposed to 1.06 for both OECD and EU countries for the latest 5-year period, 2007-2011). It should be noted, however, that the national rate of change has been in decline since the 2001-2005 period having climaxed to 1.24.

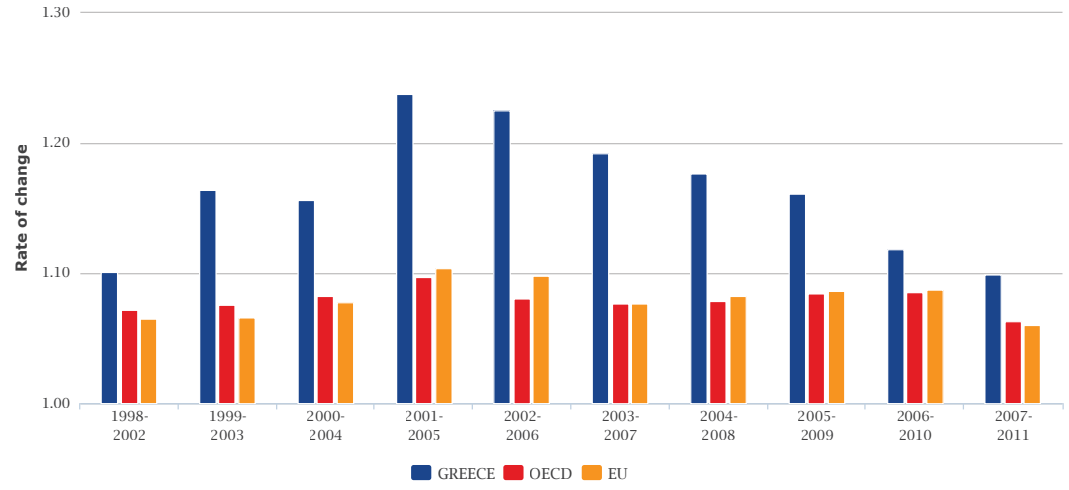


Figure 2.2.2 Change in the number of citations for Greece, EU and OECD, 1998-2012

The same upward trend is highlighted by taking into account the percentage of Greek citations for the total of OECD and EU countries (Figure 2.2.3). Having reached 2.33% and 0.97%, respectively, for the most recent period (2008-2012), the increase of citations takes place despite the abovementioned finding of the decrease in the absolute numbers of Greek publications. This, taken together with the expanding share of Greek publications being cited (from 61.6% in 2004-2008 to 67.6% in 2008-2012) (Figure 2.2.4), reflects the increasing quality and originality of Greek scientific authors.

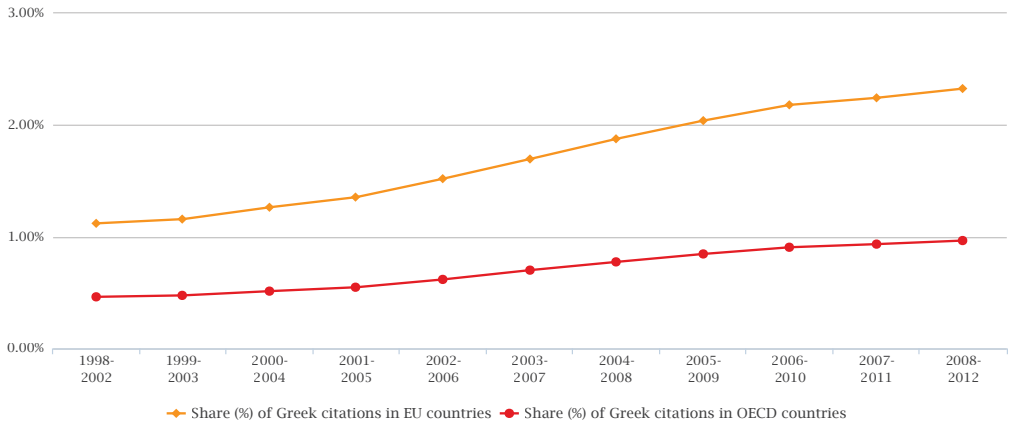


Figure 2.2.3 Share (%) of Greek citations in EU and OECD, 1998-2012

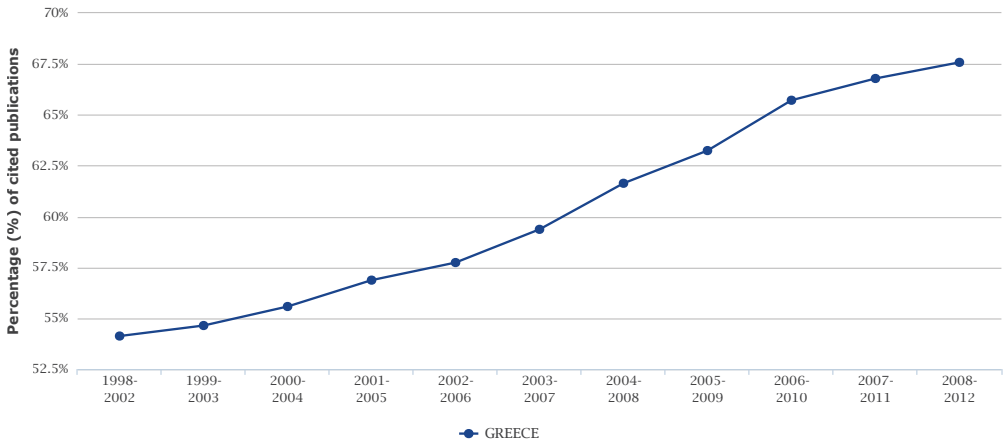


Figure 2.2.4 Percentage (%) of cited publications in Greece, EU and OECD, 1998-2012

2.3 Citation Impact

Similarly, analysis of the Greek publications' citation impact indicator reflects the inter-temporal upward trend (Figure 2.3.1). Having already surpassed the OECD countries' citation impact (5.72 as opposed to 5.04, respectively, for the 2008-2012 period), the country is just below reaching the EU average (5.85).

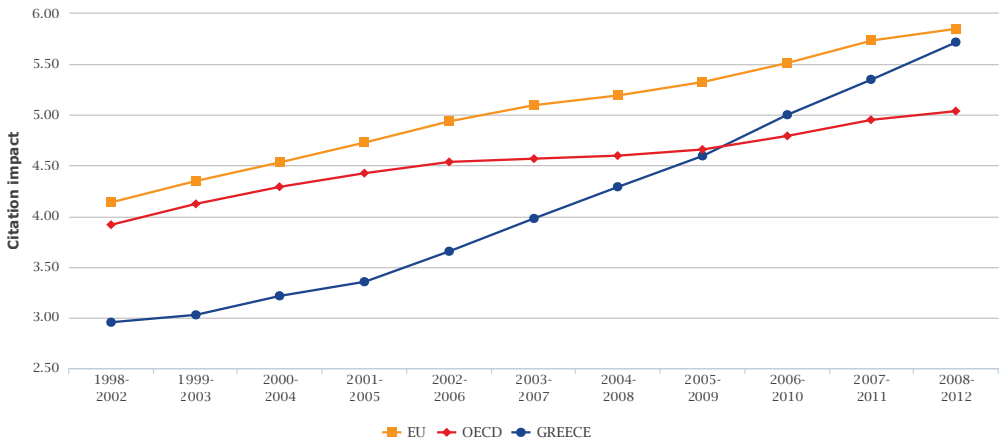


Figure 2.3.1 Citation impact of publications from Greece, EU and OECD, 1998-2012

Further analysis of the citation impact' rate of change corroborates the finding; not only the Greek rate of change is consistently higher than that of both OECD and EU countries, but also fluctuates only minimally across previous time periods (Figure 2.3.2).

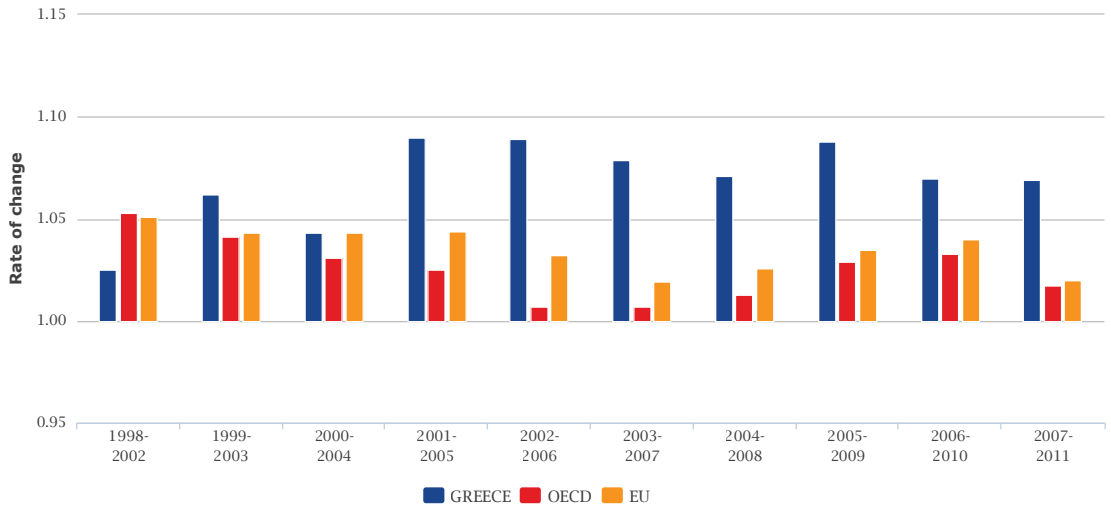


Figure 2.3.2 Change in the citation impact of publications from Greece, EU and OECD, 1998-2012

In addition, considering the Greek scientific publications' relative citation impact in comparison to that of OECD and EU countries (value 1 indicating parity), Greek impact has exceeded that of OECD (1.14), and follows EU by a factor of only .02 (0.98) (Figure 2.3.3).

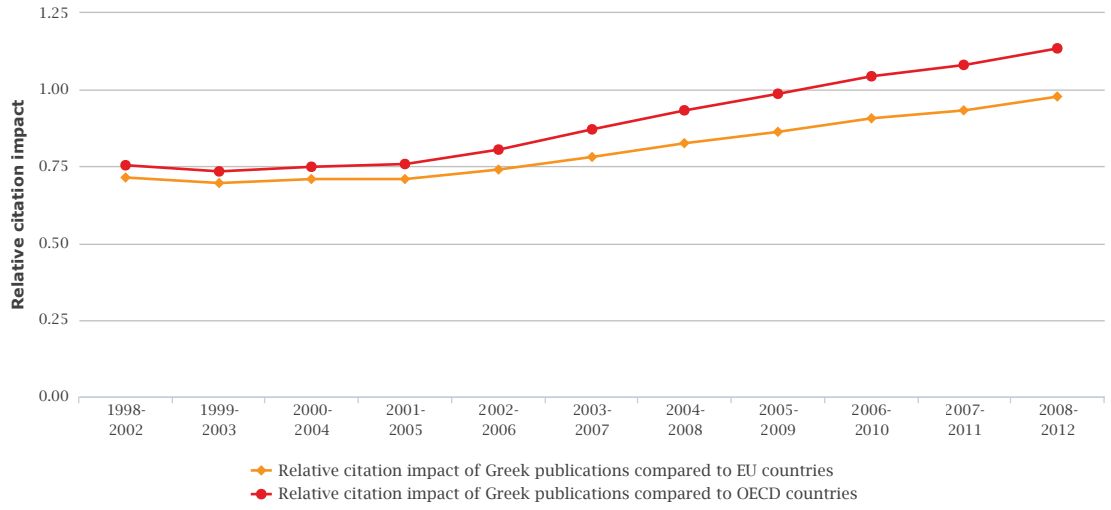


Figure 2.3.3 Relative citation impact of publications from Greece compared to EU and OECD, 1998-2012

2.4 Scientific Fields of Excellence

Examining the distribution of Greek scientific publications across scientific fields (Figure 2.4.1), the majority, in terms of numbers, are attributed to the field of "Natural Sciences" (54.3% of total), followed by the fields of "Medical & Health Sciences" (42.7%), "Engineering and Technology"(22.2%), "Social Sciences" (10.9%),

"Agricultural Sciences" (4.9%) and "Humanities" (2.4%) for the most recent year (2012). Examining the distribution of the shares across time, a slight increase in the fields of "Social Sciences" and "Humanities" at the expense of the "Engineering and Technology" and "Natural Sciences" fields can be observed.

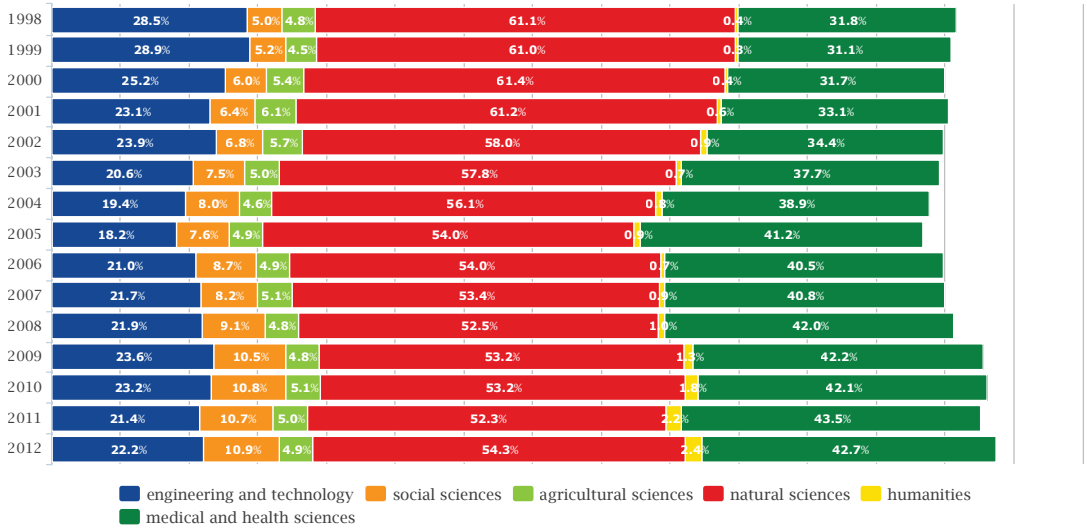
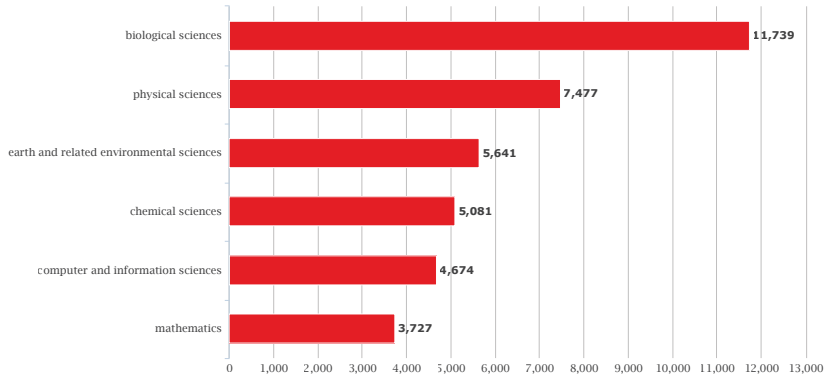


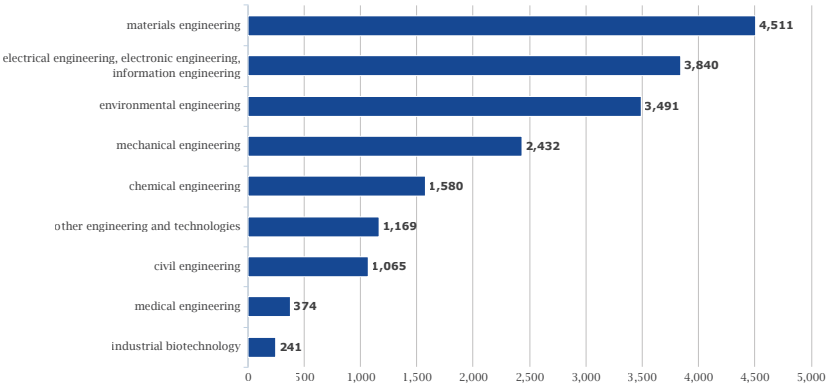
Figure 2.4.1 Distribution (%) of Greek publications across major fields of science, 1998-2012

Figure 2.4.2 tracks the number of Greek publications in the subcategories of the six major fields of science. Data refer to the most recent 5-year period, 2008-2012.

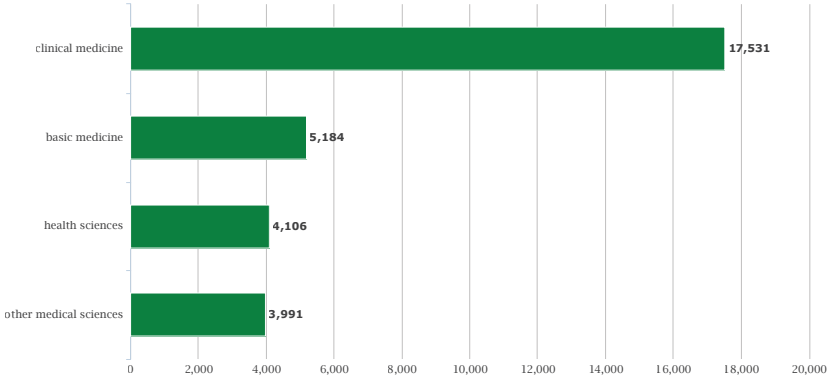
Natural Sciences



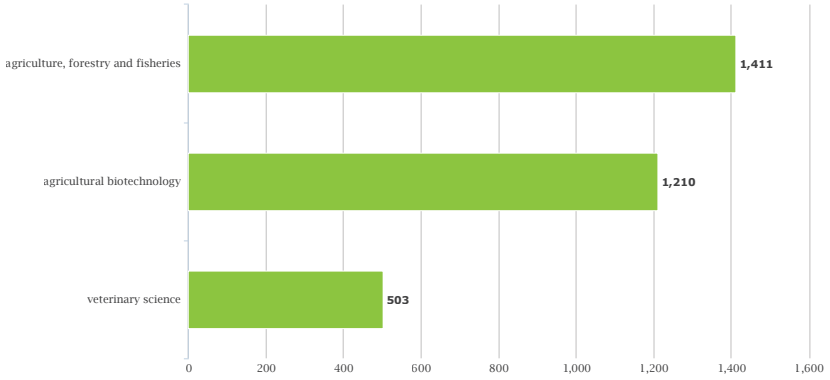
Engineering & Technology



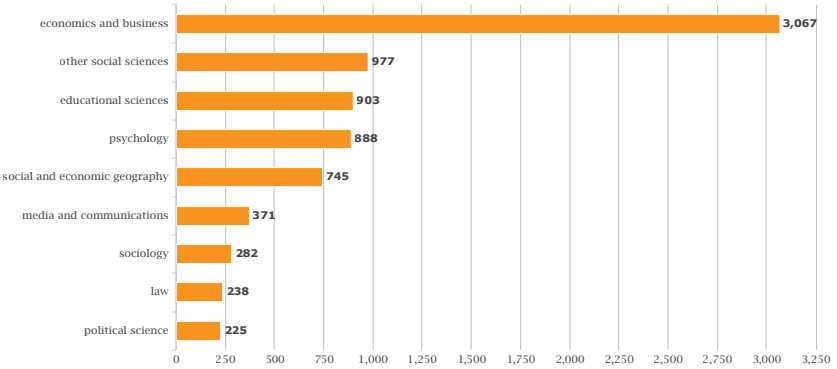
Medical & Health Sciences



Agricultural Sciences



Social Sciences



Humanities

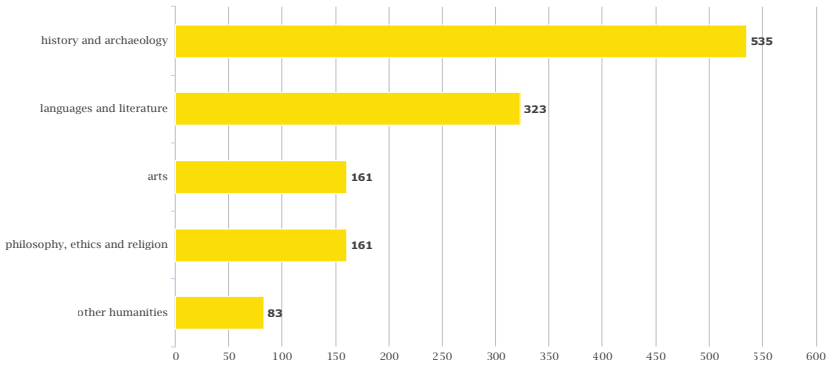


Figure 2.4.2 Number of publicatons in the 6 major fields of science, 2008-2012

Figure 2.4.3 shows the "field-normalised citation score" of Greek publications for the 5-year period 2008-2012 in the six major scientific fields. 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 done at the level of each article/publication according to the Scopus scientific subject fields. In the case of a publication 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.

Amongst the six scientific fields, the field "Humanities" despite the low publication (and citation) numbers manages to attain the highest citation score (1.37). It is followed by the fields of "Engineering and Technology" (1.26), "Natural Sciences" (1.19), "Medical & Health Sciences" (1.14), "Agricultural Sciences" (1.09), and "Social Sciences" (0.96).

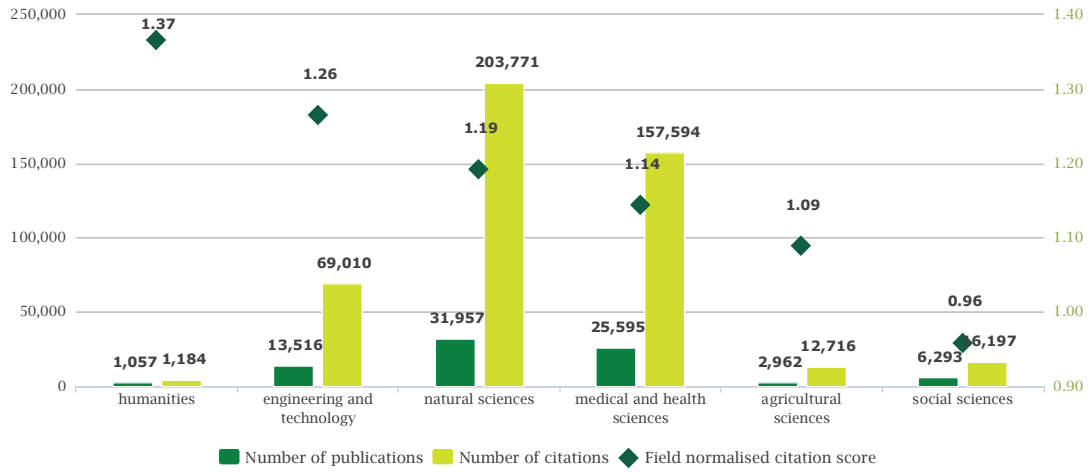


Figure 2.4.3 Publications, citations and field normalised citation score of Greek publications relative to the world, 2008-2012

Focusing on specific thematic areas of the six scientific fields (Table 2.4.1), the areas with a citation score above value 1, thus indicating areas of research excellence, are the following: 74 areas in "Natural Sciences, 39 areas in the field "Engineering & Technology", 46 in "Medical & Health Sciences", 6 in "Agricultural Sciences", 16 in "Social Sciences" and 8 in "Humanities".

Table 2.4.1 Scientific subfields of Greek publications with field normalised citation score ≥1, 2008-2012

Natural Sciences		
Specific scientific field (Scopus)	**Field normalised citation score**	**Number of publications**
nuclear and high energy physics	2.73	1,167
physics and astronomy (all)	2.00	1,446
mathematical physics	1.82	334
genetics	1.65	1,076
immunology and microbiology (all)	1.63	105
environmental science (miscellaneous)	1.59	63
instrumentation	1.55	421
global and planetary change	1.54	108
catalysis	1.54	325
surfaces and interfaces	1.44	280
stratigraphy	1.42	50
physics and astronomy (miscellaneous)	1.41	395

Natural Sciences

Specific scientific field (Scopus)	Field normalised citation score	Number of publications
immunology	1.41	952
atmospheric science	1.39	532
oceanography	1.37	329
biochemistry, genetics and molecular biology (all)	1.37	823
human-computer interaction	1.36	173
computer vision and pattern recognition	1.34	218
chemistry (all)	1.34	1,592
acoustics and ultrasonics	1.34	125
chemistry (miscellaneous)	1.33	71
atomic and molecular physics, and optics	1.32	983
health, toxicology and mutagenesis	1.29	462
cell biology	1.27	861
earth and planetary sciences (miscellaneous)	1.21	271
ecology, evolution, behavior and systematics	1.21	805
computer graphics and computer-aided design	1.21	163
ecology	1.21	416
computer science (all)	1.21	478
logic	1.20	38
aquatic science	1.20	639
parasitology	1.20	138
computers in earth sciences	1.18	97
geology	1.18	270
organic chemistry	1.18	1,125
insect science	1.17	295
biotechnology	1.17	727
computer science applications	1.16	1,886
software	1.16	1,184
molecular biology	1.16	1,344
molecular medicine	1.16	763
earth-surface processes	1.16	221
physiology	1.16	602
ecological modeling	1.15	129
environmental science (all)	1.15	849
radiation	1.15	208
aging	1.15	92
inorganic chemistry	1.15	599
geophysics	1.14	479
computer science (miscellaneous)	1.13	70
condensed matter physics	1.12	2,342
electrochemistry	1.12	274
space and planetary science	1.12	781

Natural Sciences

Specific scientific field (Scopus)	Field normalised citation score	Number of publications
applied mathematics	1.12	1,585
astronomy and astrophysics	1.11	693
endocrinology	1.11	876
computer networks and communications	1.11	952
applied microbiology and biotechnology	1.10	306
artificial intelligence	1.09	717
virology	1.09	238
physical and theoretical chemistry	1.08	1,214
biochemistry	1.07	1.951
developmental biology	1.07	202
microbiology	1.07	472
cancer research	1.05	1,555
computational theory and mathematics	1.05	433
fluid flow and transfer processes	1.04	104
analysis	1.04	402
spectroscopy	1.04	352
environmental chemistry	1.03	789
analytical chemistry	1.03	769
clinical biochemistry	1.03	763
paleontology	1.02	75
statistical and nonlinear physics	1.02	310

Engineering and Technology

Specific scientific field (Scopus)	Field normalised citation score	Number of publications
chemical engineering (miscellaneous)	2.31	21
energy (all)	2.16	359
engineering (miscellaneous)	2.01	149
fuel technology	1.92	338
energy engineering and power technology	1.87	515
process chemistry and technology	1.62	243
renewable energy, sustainability and the environment	1.59	621
building and construction	1.58	407
automotive engineering	1.55	156
ceramics and composites	1.53	314
civil and structural engineering	1.53	958
signal processing	1.50	367
polymers and plastics	1.42	522
media technology	1.38	109
architecture	1.37	42
industrial and manufacturing engineering	1.34	683

Engineering and Technology

Specific scientific field (Scopus)	Field normalised citation score	Number of publications
geotechnical engineering and engineering geology	1.33	441
bioengineering	1.32	477
aerospace engineering	1.32	211
environmental engineering	1.27	689
nuclear energy and engineering	1.25	197
control and systems engineering	1.24	605
materials chemistry	1.21	1,172
electrical and electronic engineering	1.21	2,737
biomaterials	1.20	241
computational mechanics	1.20	176
electronic, optical and magnetic materials	1.20	1.227
hardware and architecture	1.20	564
materials science (miscellaneous)	1.19	36
materials science (all)	1.19	1,596
mechanical engineering	1.13	1,521
chemical engineering (all)	1.10	888
biomedical engineering	1.08	374
metals and alloys	1.07	232
mechanics of materials	1.05	1,036
water science and technology	1.04	652
surfaces, coatings and films	1.03	757
engineering (all)	1.02	671
safety, risk, reliability and quality	1.02	352

Medical & Health Sciences

Specific scientific field (Scopus)	Field normalised citation score	Number of publications
epidemiology	1.92	357
rehabilitation	1.71	146
rheumatology	1.70	348
advanced and specialized nursing	1.70	89
anesthesiology and pain medicine	1.61	193
orthodontics	1.61	69
critical care and intensive care medicine	1.59	313
health policy	1.56	153
infectious diseases	1.53	1,032
internal medicine	1.41	542
developmental neuroscience	1.40	44
reproductive medicine	1.40	424
dermatology	1.39	386
urology	1.38	471
public health, environmental and occupational health	1.37	971

Medical & Health Sciences

Specific scientific field (Scopus)	Field normalised citation score	Number of publications
nutrition and dietetics	1.37	477
microbiology (medical)	1.36	658
genetics (clinical)	1.35	351
hepatology	1.34	286
immunology and allergy	1.34	722
medicine (miscellaneous)	1.31	518
health professions (all)	1.27	49
medicine (all)	1.26	3,497
dentistry (all)	1.25	346
geriatrics and gerontology	1.24	180
toxicology	1.24	287
chemical health and safety	1.20	44
cardiology and cardiovascular medicine	1.20	2,581
radiological and ultrasound technology	1.19	244
biochemistry (medical)	1.19	287
neurology (clinical)	1.18	947
ophthalmology	1.18	496
otorhinolaryngology	1.17	519
endocrinology, diabetes and metabolism	1.17	1,162
physiology (medical)	1.17	363
transplantation	1.15	135
pharmaceutical science	1.13	403
oral surgery	1.09	162
emergency medicine	1.08	218
psychiatry and mental health	1.08	622
neuroscience (all)	1.08	312
hematology	1.06	930
cellular and molecular neuroscience	1.06	229
obstetrics and gynecology	1.06	1,085
pharmacology	1.03	1,581
pharmacology (medical)	1.01	1,064

Agricultural Sciences

Specific scientific field (Scopus)	Field normalised citation score	Number of publications
food science	1.19	1,210
forestry	1.07	223
soil science	1.07	341
food animals	1.06	97
agronomy and crop science	1.06	859
veterinary (all)	1.01	372

Social Sciences

Specific scientific field (Scopus)	Field normalised citation score	Number of publications
anthropology	1.87	72
decision sciences (all)	1.67	58
urban studies	1.53	48
communication	1.40	95
transportation	1.38	215
safety research	1.35	62
marketing	1.33	192
management science and operations research	1.33	443
law	1.18	238
library and information sciences	1.14	279
information systems and management	1.11	307
business, management and accounting (miscellaneous)	1.09	69
economics, econometrics and finance (miscellaneous)	1.07	71
human factors and ergonomics	1.06	61
health (social science)	1.01	134
strategy and management	1.00	467

Humanities

Specific scientific field (Scopus)	Field normalised citation score	Number of publications
archeology	2.61	210
arts and humanities (miscellaneous)	1.80	83
History	1.62	408
visual arts and performing arts	1.34	81
archeology (arts and humanities)	1.22	134
philosophy	1.09	68
arts and humanities (all)	1.08	53
classics	1.02	111

In addition, by correlating the citation score with the Activity Index (low-to-high volume publication production) a bi-dimensional location of strong versus weak-performing thematic areas is possible (Figure 2.4.4). In the "High activity- High Impact" area, a total of 97 specific scientific fields are displayed: 39 in "Natural Sciences", 14 in "Engineering & Technology", 28 in "Medical & Health Sciences", 4 in Agricultural Sciences, 10 in "Social Sciences" and 2 in "Humanities".

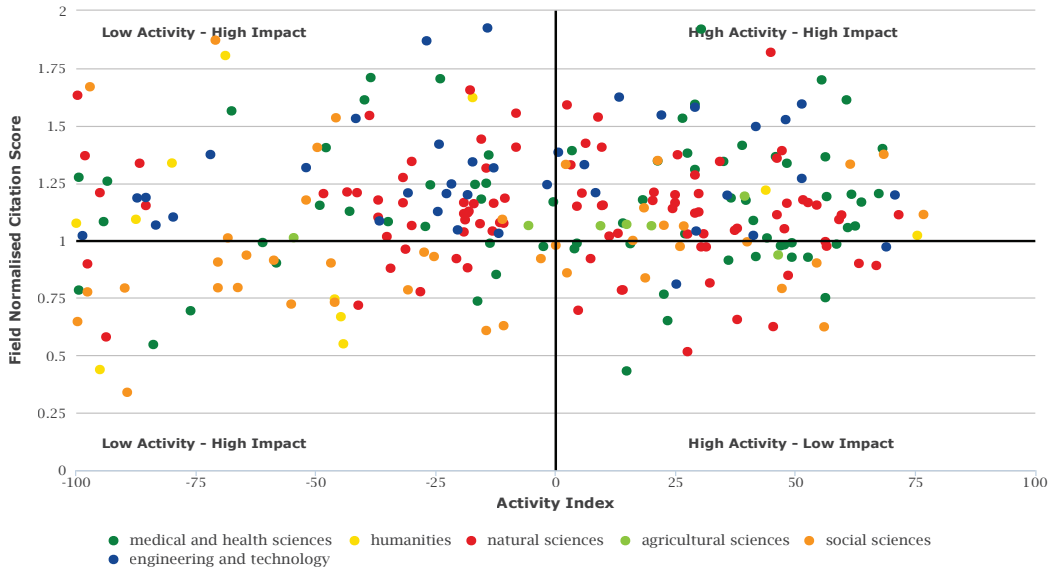


Figure 2.4.4 Plot of Activity Index and field-normalised citation score of Greek publications per specialised thematic areas, 2008-2012

2.5 Collaboration

Concerning the production of scientific publications as a result of scientific collaboration, a continuous drop in the ratio of the publications being produced by a sole Greek institution is documented (Figure 2.5.1). Having climaxed in 2002, 55.2%, it has dropped to 33.9% in 2012. Also, the ratio of publications being produced by exclusively Greek institutions remains inter-temporally unaltered, slightly above 20%.

Conversely, and in complete accordance with international findings pointing to increased international collaboration as a means to sustain a competent national research system, the share of publications being produced as a result of international collaboration is increasing across time. From 33.8% in 2005, it reached 44.5% in 2012.

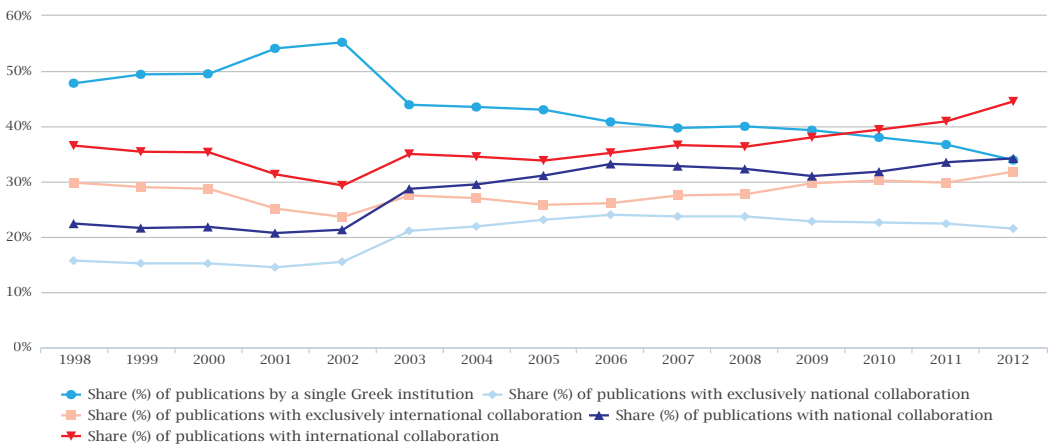


Figure 2.5.1 National and international collaboration in Greek publications, 1998-2012

The highest number of collaboration takes place with the United States of America, United Kingdom, Germany, France and Italy (Figure 2.5.2).

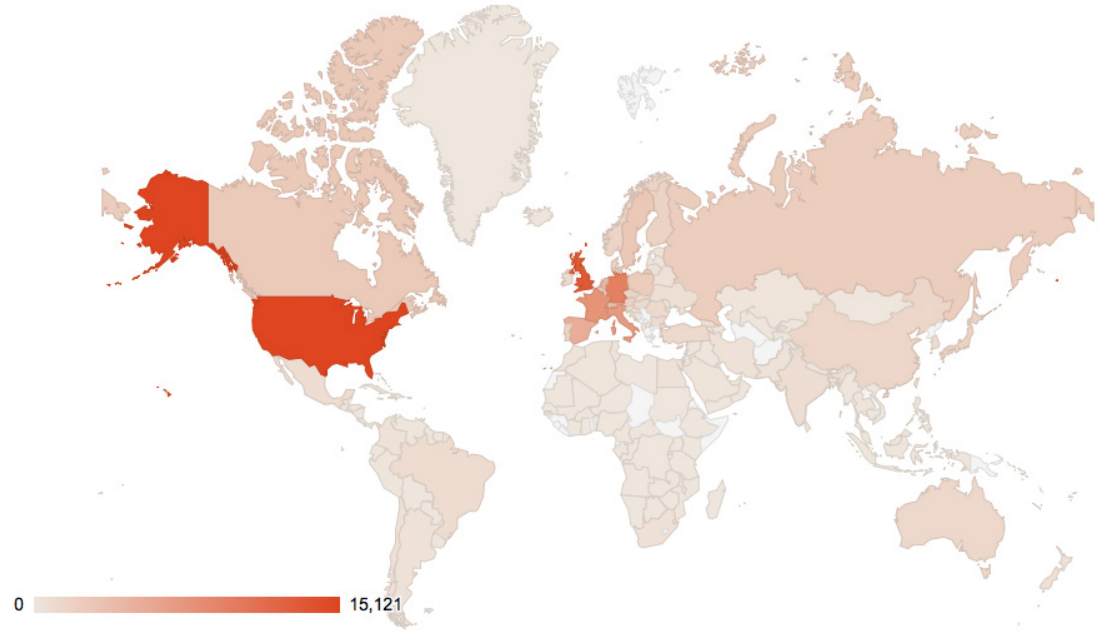


Figure 2.5.2 Countries collaborating in Greek publications, 2008-2012

Figure 2.5.3 illustrates the annual growth in the number of Greek publications with national,* international* and no collaboration* for the period 1998-2012.

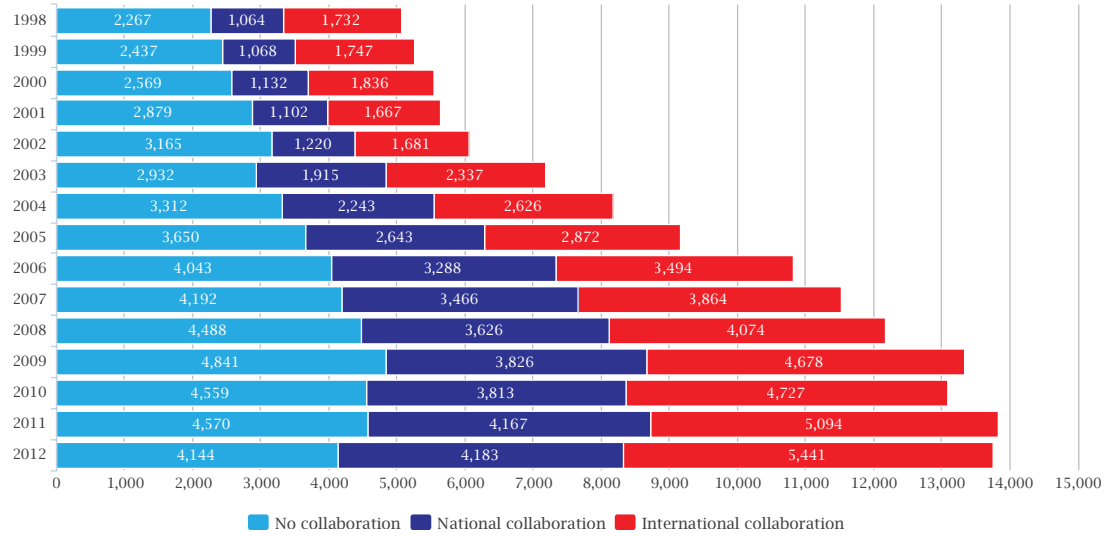


Figure 2.5.3 Distribution of Greek publications by type of collaboration, 1998-2012

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

Significantly, the type of scientific collaboration is positively correlated with the relative citation impact score of the produced publications (Figure 2.5.4). Publications produced by international collaboration feature a higher relative citation impact score than those (publications) produced by solely Greek collaboration, and even higher than those (publications) produced without any collaboration. This stands for all scientific fields.

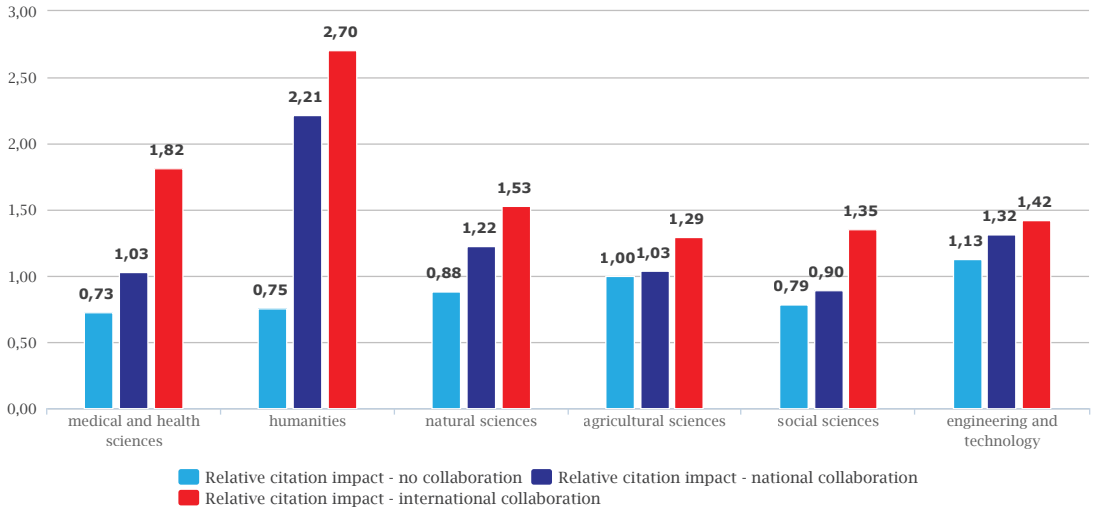


Figure 2.5.4 Field-normalised citation score of Greek publications for the six major fields of science per type of collaboration, 2008-2012

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

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

3. Greek Scientific Publications by Institution Categories

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

COLOUR	INSTITUTION CATEGORY	2006-2010		2008-2012	
		NUMBER OF PUBLICATIONS	NUMBER OF CITATIONS	NUMBER OF PUBLICATIONS	NUMBER OF CITATIONS
	Universities	44.310	222.113	47.510	271.529
	Public Hospitals (PH)	7.482	34.162	7.772	39.110
	Research Centers supervised by the General Secretariat for Research and Technology (RC-GSRT)	6.694	44.164	7.219	54.817
	Technological Educational Institutes (TEI)	2.883	8.196	3.499	10.869
	Other Public Research Institutions	2.075	9.579	2.352	13.961
	Private Health Institutions	1.390	11.298	1.457	10.931
	Enterprises	1.031	4.068	1.222	5.714
	Other Higher Educational Institutions	631	2.052	772	3.158
	Private Non Profit Institutions	538	2.762	599	3.319
	Other Public Institutions	406	1.574	403	1.725

3.1 Publications

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

For the year 2012, Universities published 9,886 publications continuing their steady increase since 1998. PHs ranked second with 1,543 publications, indicating a continuation of a slight drop since their climax in 2009 (1,604). RC-GSRTs are third with 1,512 publications, following a ten-year period of sustained increase. Both OPRIs and TEIs continue their increase –steep in the case of TEIs- in the number of publications. Lastly, Enterprises, despite their increase on an annually basis, the absolute numbers involved (206 in 2011, 382 in 2012) stand as especially low indicative of the low degree of interconnection with the domestic science base.

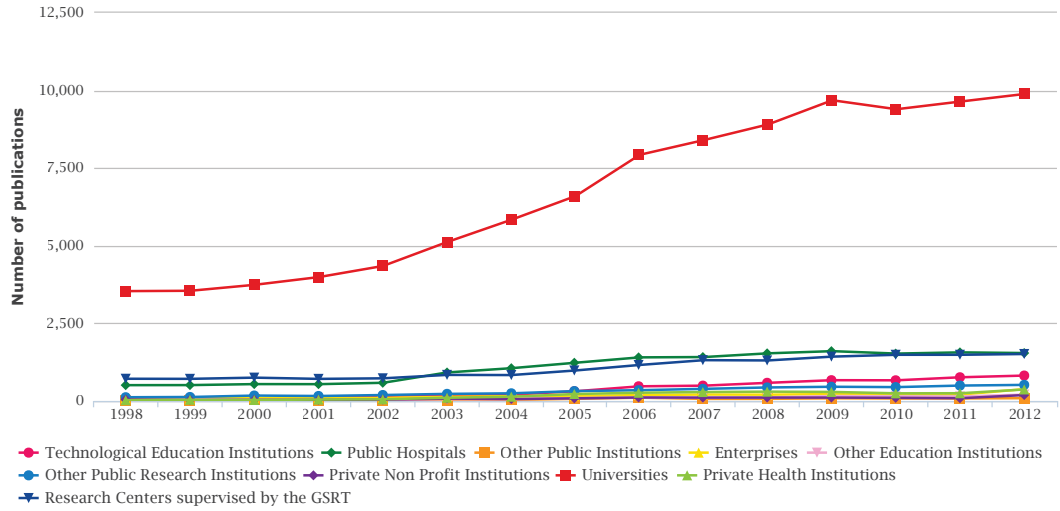


Figure 3.1.1 Development of the number of publications, by institution category, 1998-2012

Viewed in comparison with base year (1998: 100), while all institutional categories are recording an increase, it is the Private Health Institutions that have been boosting along having reached an index of 1,427 for 2012 (Figure 3.1.2). They are followed by the TEIs and Other Higher Educational Institutions also steadily increasing (986 and 733 respectively for the latest year).

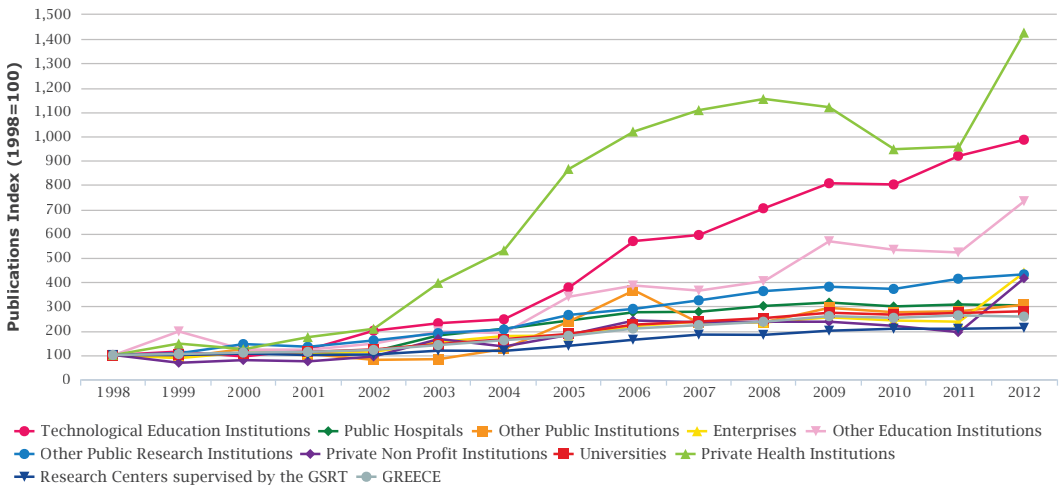


Figure 3.1.2 Publications Index (1998=100), by institution category, 1998-2012

With a share of 78.9%, Universities are the prime contributors in the total Greek scientific publications (Figure 3.1.3).* PHs are ranked second (12.9%), closely followed by RC-GSRTs (12.0%). These three institution categories account for more than two thirds of the overall national capacity.

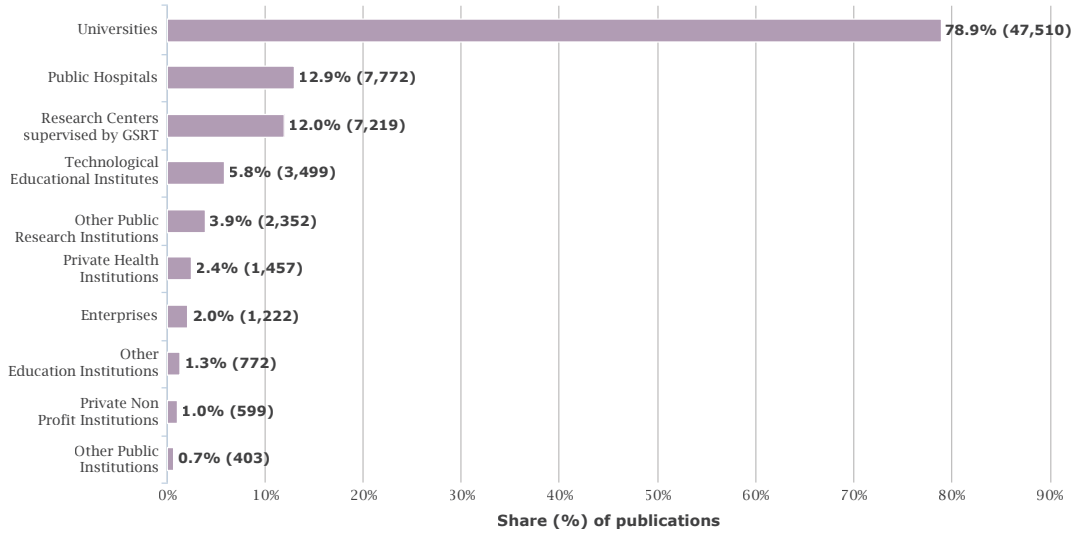


Figure 3.1.3 Number and share (%) of publications, by institution category, 2008-2012

3.2 Citations

In line with the steady rise of the number of publications, viewed across time, the number of citations has also been steadily increasing across all institution categories (Figure 3.2.1). Whereas the citations of RC-GSRTs and PHIs have been experiencing an increase (from 17,073 and 9,734 for the period 1998-2002, to 54,817 and 39,110 for 2008-2012, respectively), it is the Universities that have increased more than five-fold (52,290 to 271,529) in the same time span.

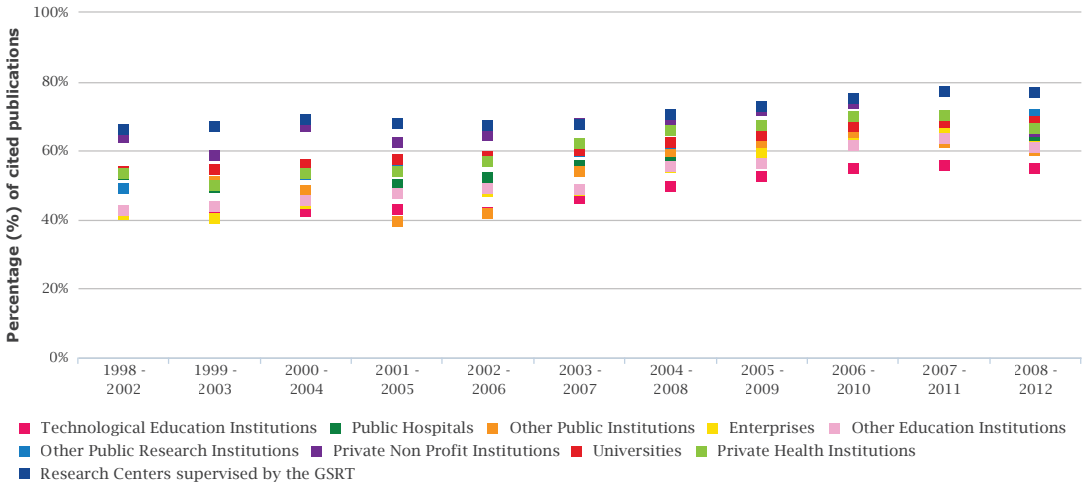


Figure 3.2.1 Percentage (%) of cited publications, by institution category, 1998-2012

* As demonstrated in the Methodology, each institution category received a whole count of the publication (whole counting) for publications produced as a result of collaboration between institutions in different institution categories. The (%) share of publications by institution category was calculated as a proportion of the total number of Greek publications (Figure 3.1.3) and indicates the degree of "participation" of each category to Greece's total publication output. Hence, in the case of Universities, a share of 78.9% means that Universities participated in 78.9% of the total number of Greek publications.

Examining the percentage of publications receiving citations per institution category (Figure 3.2.2), it is the RC-GSRTs that have been fairing first across time, achieving 76.9% of their publications being cited in the most recent time period (2008-2012). These are followed by Universities (68.5%), Private Health Institutions (66.4%), and Private non-for Profit Institutions (65.6%).

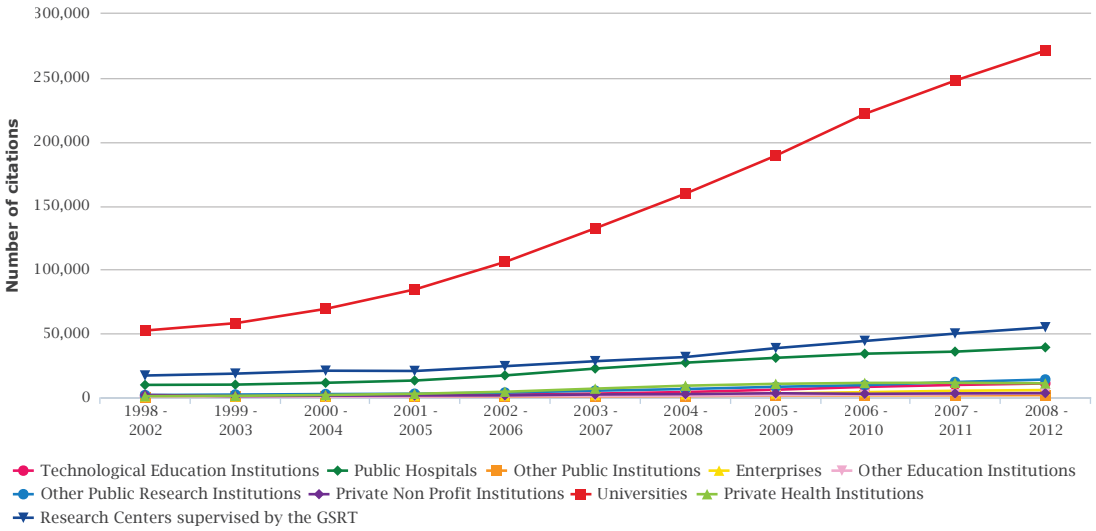


Figure 3.2.2 Number of citations, by institution category, 1998-2012

Given though the size of the Universities, the publications receiving citations of the Universities account for 78.9% on the national level. RC-GSRTs rank second (15.9%), followed by PHs (11.4%) (Figure 3.2.3).

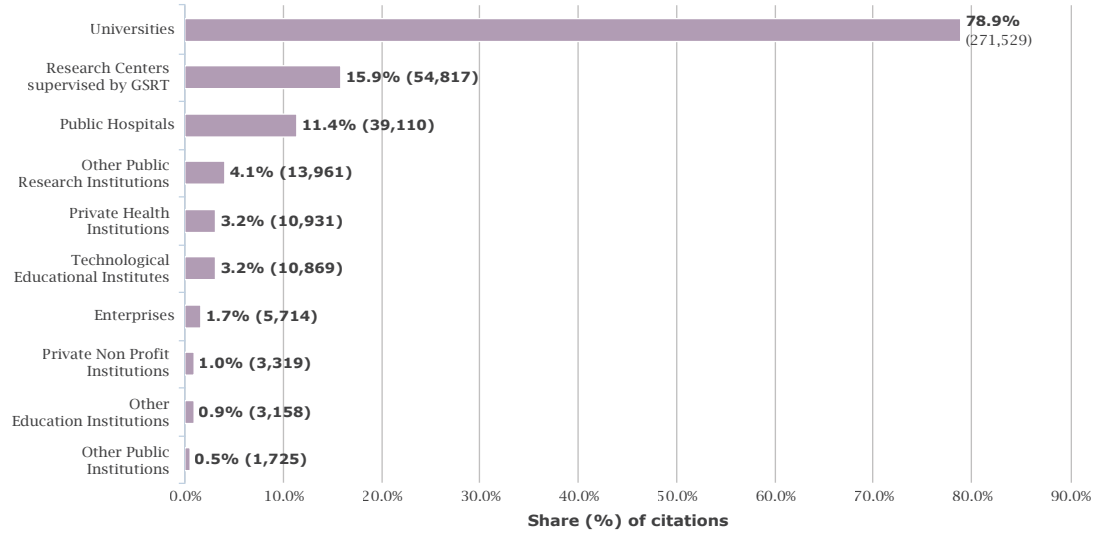


Figure 3.2.3 Number and share (%) of citations by institution category, 2008-2012

3.3 Citation Impact

Figure 3.3.1 presents the number of publications, the number of citations, and the field normalised citation score per institution category for the most recent period (2008-2012). The field-normalised citation score or "citation score" is the relative number of citations to publications of a specific category compared to the world average of citations to publications of the same time period and scientific subject field. The normalisation is done at the level of publication according to the Scopus scientific subject fields. In case that a publication was attributed to more than one subject field, a mean value of the fields was calculated. The citation score was

calculated using software developed by EKT. A value greater than 1, indicated that the impact of publications was higher than the world average.

RC-GSRTs rank first, with their publications receiving the highest citation score (1.53). Private Health Institutions, Other Higher Educational Institutions and OPRIs follow closely behind (1.30, 1.29 and 1.23, respectively), indicating the high quality of a number of institutions forming part in these categories. Universities rank fourth (1.20), Private non-for Profit Institutions fifth (1.14), and Enterprises sixth (1.10) despite their very low absolute numbers both in terms of publications.

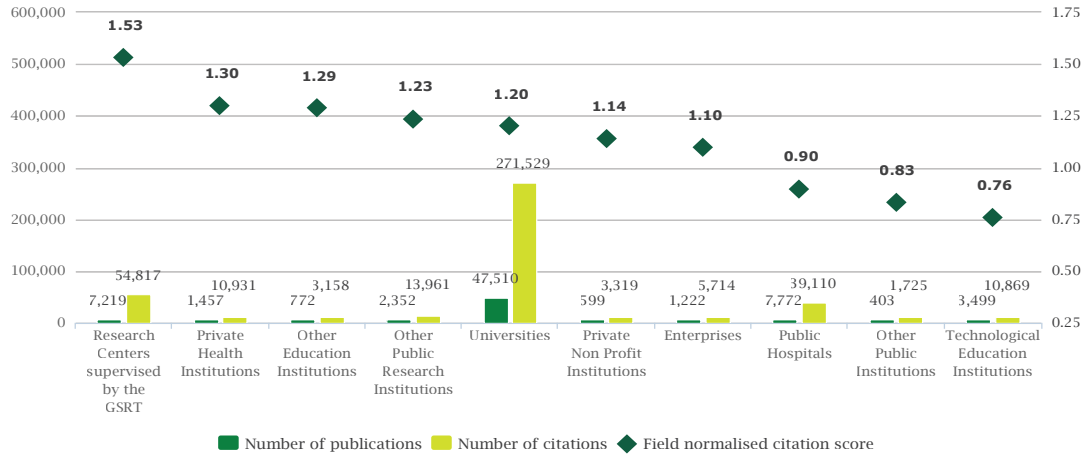


Figure 3.3.1 Publications, citations and field normalised citation score relative to the world, by institution category, 2008-2012. Data refers to the total number of publications in each category for all scientific fields

3.4 Scientific Fields of Excellence

Examining the distribution of publications, citations and field normalised citation score per institution category* across the main six scientific fields for the most recent period (2008-2012), a number of observations can be made (Figure 3.4.1).

In the field of "Natural Sciences", RC-GSRTs receive the highest citation score (1.39). The categories receiving an above world-average are the following: Private non-for Profit Institutions (1.21), OPRIs (1.20), Universities (1.19), Other Educational Institutions (1.11), PHs (1.05), and Private Health Institutions (1.03).

In the field of "Engineering and Technology", RC-GSRTs fair first with a relative citation score of 1.42, followed by Universities (1.28), OPRIs (1.20), TEIs (1.14), and Other Educational Institutions (1.11).

In the field of "Medical & Health Sciences", Other Educational Institutions rank first with a very high above world-average score (2.04), followed by RC-GSRTs (1.55), OPRIs (1.42), Private Health Institutions (1.37), Universities (1.16), and Private non-for Profit Institutions (1.04).

In the field of "Agricultural Sciences", RC-GSRTs come first with a citation score of 1.41, followed by PHs (1.15) and Universities (1.14).

In the field of "Social Sciences" only RC-GSRTs (1.31), and Other Educational Institutions (1.16) receive a citation score above world-average.

In the field of "Humanities", despite the very low absolute publication and citation numbers, Greek institutions appear to be particularly strong. RC-GSRTs receive an index almost three times of world average (2.93), whereas, OPRIs and Other Educational Institutions also fair very strong (2.74 and 2.00, respectively). Universities, again, are above world average (1.23).

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

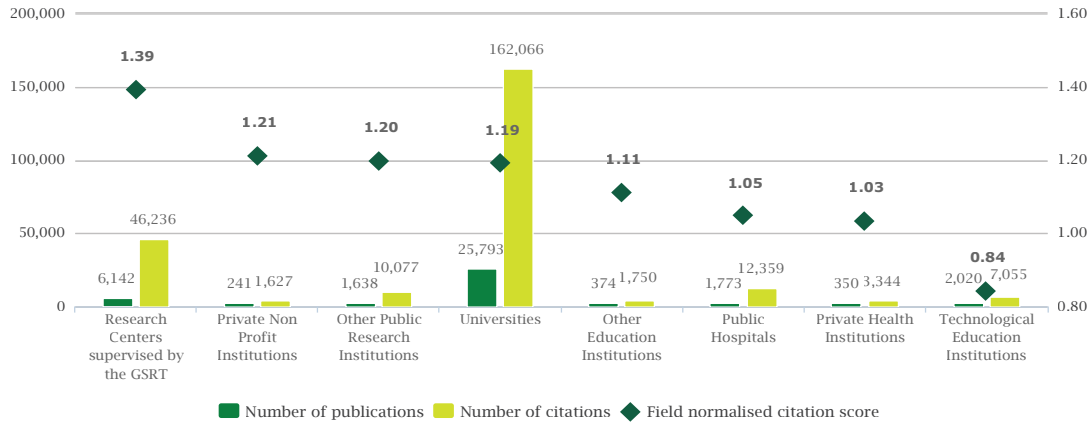


Figure 3.4.1 Publications, citations and field normalised citation score in the major field of "Natural Sciences" relative to the world, by institution category, 2008-2012

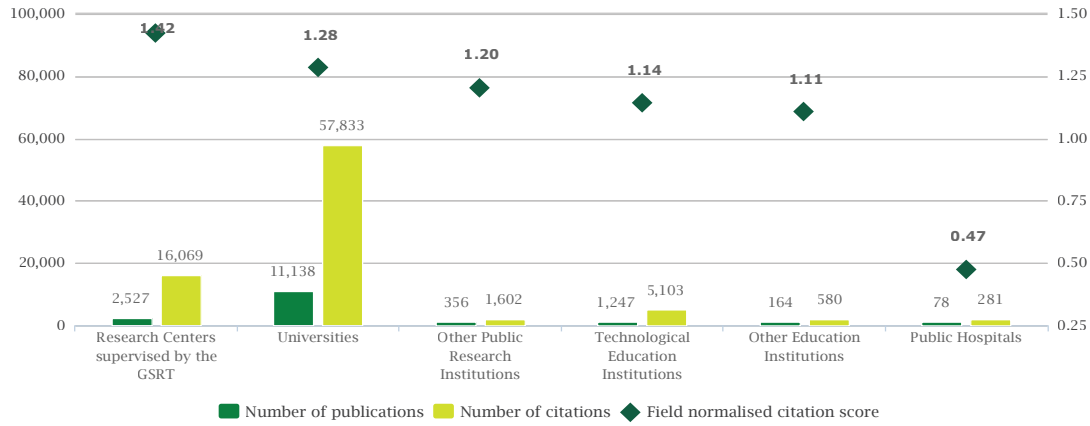


Figure 3.4.1 Publications, citations and field normalised citation score in the major field of "Engineering & Technology" relative to the world, by institution category, 2008-2012

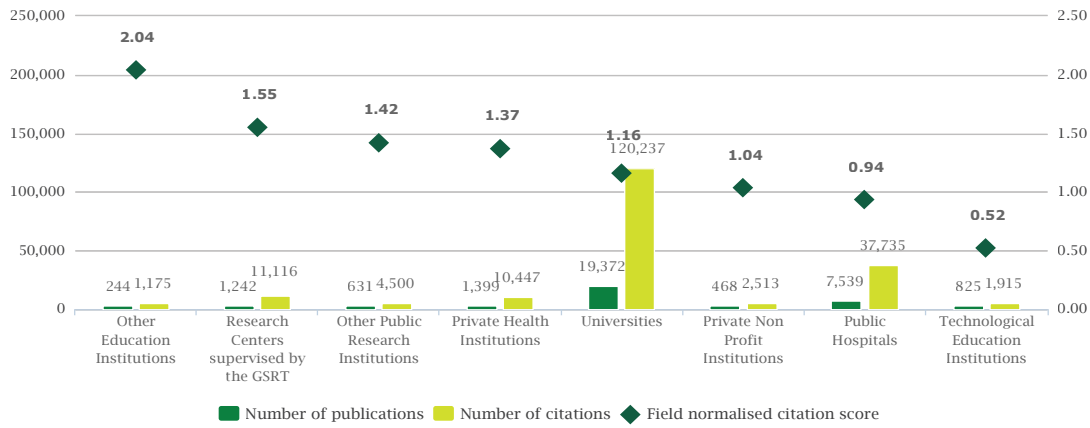


Figure 3.4.1 Publications, citations and field normalised citation score in the major field of "Medical & Health Sciences" relative to the world, by institution category, 2008-2012

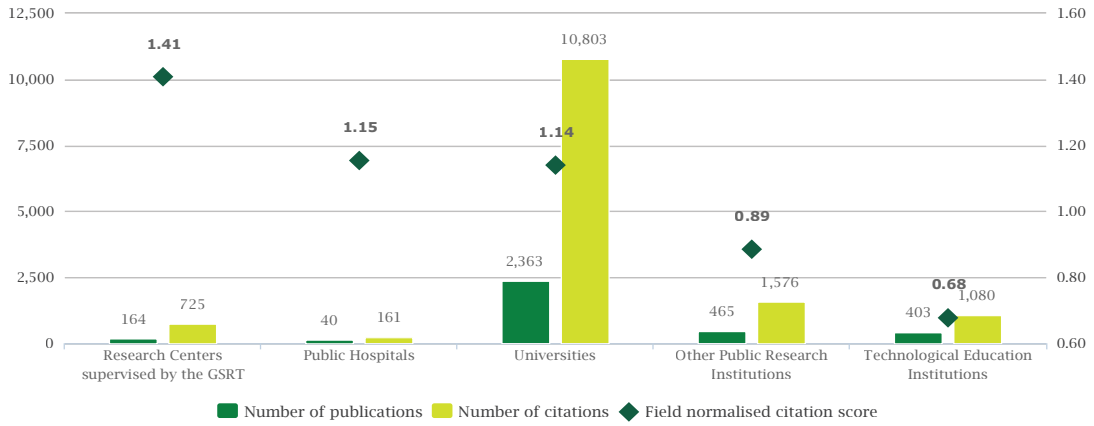


Figure 3.4.1 Publications, citations and field normalised citation score in the major field of "Agricultural Sciences" relative to the world, by institution category, 2008-2012

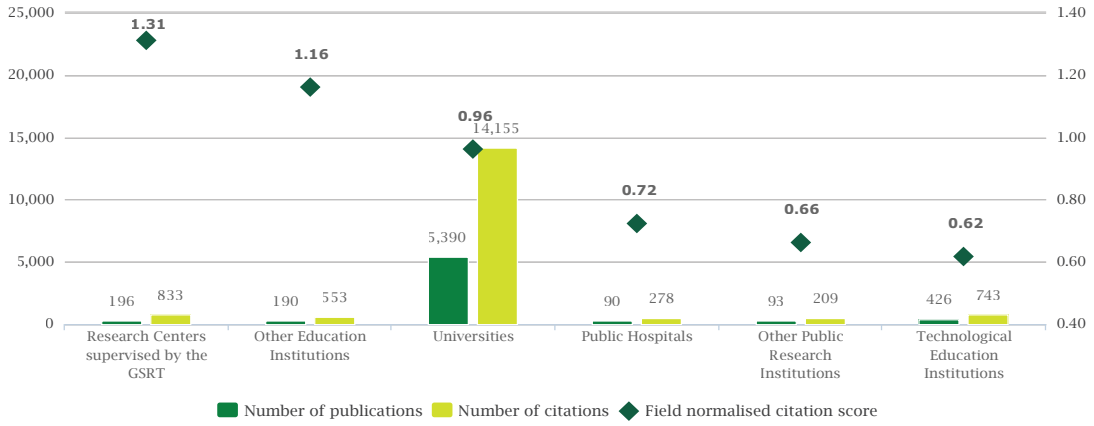


Figure 3.4.1 Publications, citations and field normalised citation score in the major field of "Social Sciences" relative to the world, by institution category, 2008-2012

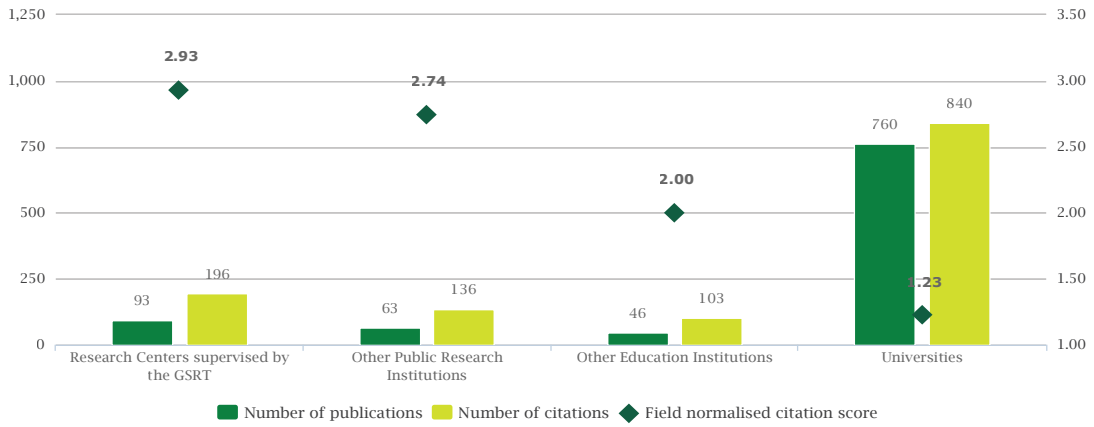


Figure 3.4.1 Publications, citations and field normalised citation score in the major field of "Humanities" relative to the world, by institution category, 2008-2012

3.5 Collaboration

Concerning the production of scientific publications as a result of scientific collaboration,* all institution categories appear to increase the cross-institutional collaboration across time at a national level (Figure 3.5.1). For example, Universities have increased the number of publications being produced with collaboration with (at least) one Greek partner from any institutional category from 1,091 (2002) to 3,839 (2012). And while the rate of increase for every other institutional category is not so steep, a continuous increase of cross-institutional collaboration is also evident.

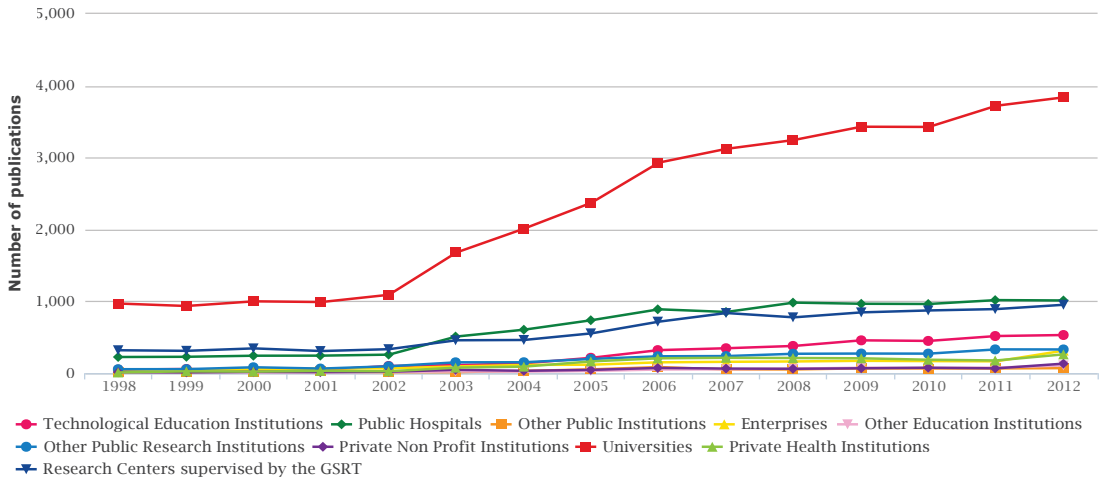


Figure 3.5.1 Number of publications with national collaboration, by institution category, 1998-2012

It is to be noted that this increase in publications as a result of collaboration, is not limited within the Greek institutional categories (Figure 3.5.2). Again, Universities rank first with their increase in numbers of international collaborations across time, starting from 1,237 in 1998 to 4,215 in 2012. All other institution categories follow suit, though, on a more linear trend.

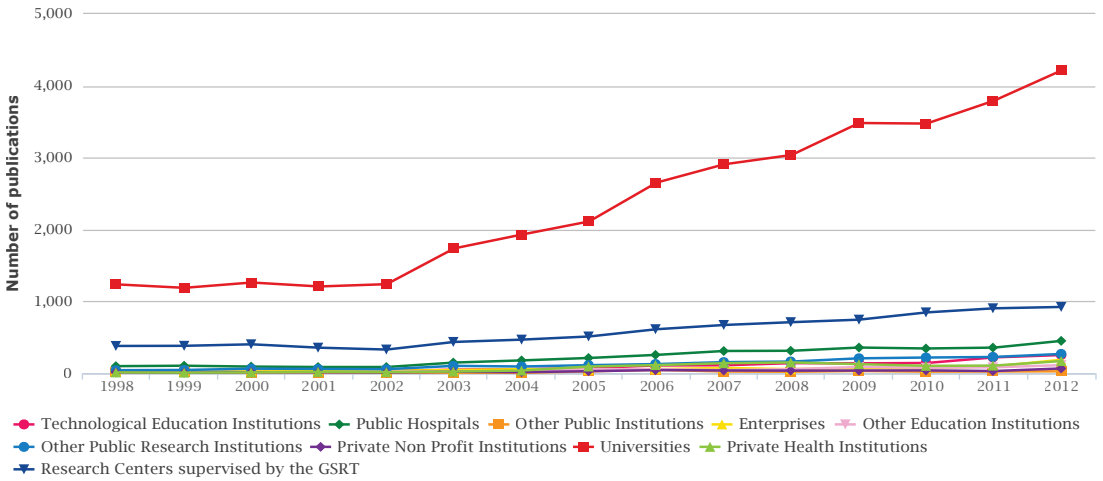


Figure 3.5.2 Number of publications with international collaboration, by institution category, 1998-2012

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

Analyzing the portion of publications taking place as a result of no, exclusively Greek or international collaboration (Figure 3.5.3), RC-GSRTs appear to be the most outward looking having 57.2% of their publications being produced in collaboration with a foreign partner. Universities rank first among all institution categories concerning the publications produced without any partner (36.3%). Interestingly, Intra-Greek partnerships appear to be the rule for most institution categories.

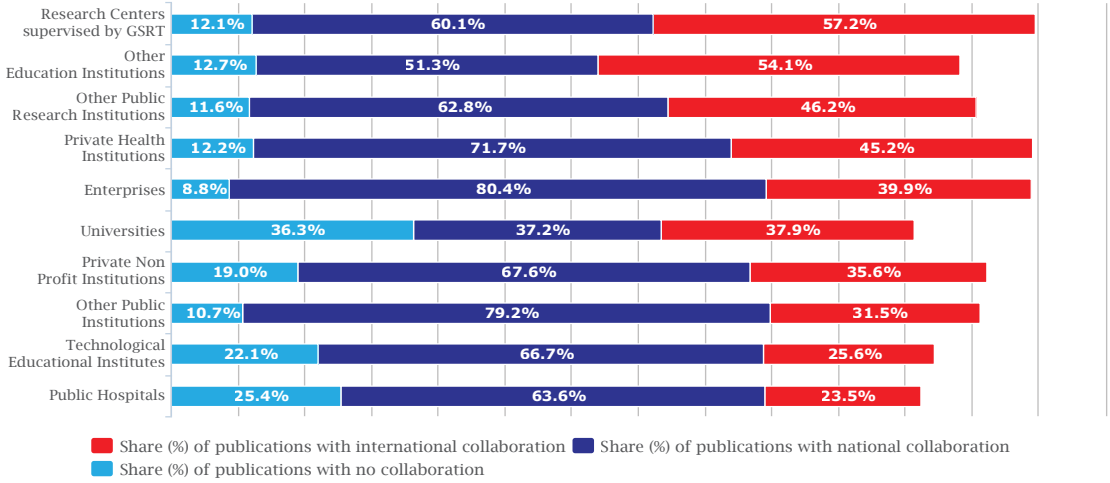


Figure 3.5.3 Share (%) of publications with national, international and no collaboration, by institution category, 2008-2012

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 based on data from the Scopus Database. The presentation of indicators from the two internationally established databases (Web of Science: for the previous studies of EKT, and Scopus: for the present study), 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

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 Scopus international database.

More specifically, the Scopus database contains detailed data and information on scientific publications and citations and supports the Elsevier web tool of the same name, available at **http://www.scopus.com/**. Elsevier developed, specifically for the purposes of this study, a diverse data set of Scopus - Greece, enriched with data, thus making possible the calculation of the indicators which are hosted in the study.

Fields of Science

The Scopus database allows for categorization of publications in 313 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 Scopus 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 are active.

To this end, the 313 subject fields of the Scopus 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.

Types of publications

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

Time frame for analysis of citations

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

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

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

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

Counting of publications

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

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

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

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

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

Citation Impact Indicators

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

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

is calculated as the ratio of the corresponding citation impacts. When the value of the relative citation impact is greater than 1, the publications of the analysed unit have a greater impact than those within the reference frame.

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

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

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

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

The field normalised citation score or citation score is the key indicator used in this study to estimate the impact of the publications of the analytical units examined (e.g. institution category, institution, subject 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.

Growth rates

Rate of Change

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

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

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

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.

Indexes calculated using a base year

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

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

where vt1|t=100 is the index value in year t1 using t as the base year, vt1 is the index value in year t1 and vt=100 is the index value in base year t.

Threshold number of publications

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

Data Processing

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

Specifically, the software enables:

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

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

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

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

Interpretation of results

To avoid fragmented and invalid comparisons, a combined interpretation of bibliometric indicators is required on the part of the reader. Hence, when interpreting indicators such as the rate of change, the relative citation

impact or citation score, the percentage of cited publications or the percentile breakdown of highly cited publications, one has to also consider the number of publications as well as their systematic production over time.

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

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

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

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

APPENDIX II: INDICATORS

Table of Bibliometric Indicators used

INDICATOR	DESCRIPTION	INTEPRETATION
Number of publications	The number of scientific publications is calculated on the basis of:	An indication of the volume of research output for:
	• country total.	• Greece.
	• institution category.	• each institution category.
	• scientific field.	• each scientific field.
	• institution.	• each institution.
Share of publications (%)	It is calculated as a percentage of:	An indication for the participation of:
	• Greek publications in relation to EU and OECD publications.	• Greece within all EU and OECD publications.
	• publications per institution category in relation to the total number of Greek publications.	• each institution category within all Greek publications.
	• publications falling under one scientific field in relation to the total number of Greek publications.	• each scientific field within all scientific fields.
	• publications issued by an institution in relation to the total number of publications in the same category of institutions.	• 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:	An indication for the levels of visibility / recognition of scientific publications produced by:
	• country total.	• Greece.
	• institution category.	• each institution category.
	• institution.	• each institution.
Number of citations	The number of citations within a specific time period to articles published by the analysed unit during the same time period. It is calculated using overlapping 5-year periods on the following levels:	An indication of the influence and visibility of scientific publications produced by:
	• country total.	• Greece.
	• institution category.	• each institution category.
	• scientific field.	• each scientific field.
	• institution.	• each institution.

INDICATOR	DESCRIPTION	INTEPRETATION
Share of citations (%)	It is calculated using overlapping 5-year periods as the percentage of citations received by the publications of:	An indication for the influence and visibility of:
	• Greece in relation to the number of citations that EU and OECD's publications received.	• Greece within the EU and OECD.
	• citations in one institution category in relation to the total number of citations for Greek publications.	• each institution category within Greece.
	• citations found in each scientific field in relation to the total number of citations for Greek publications.	• each scientific field within all scientific fields.
	• citations in each institution in relation to the total number of citations for the category of institutions.	• 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.

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.

APPENDIX III: FIELDS OF SCIENCE

Classification of the Subject fields of the Scopus 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 - SCOPUS DATABASE
Natural Sciences	Mathematics	• Algebra and Number Theory
		• Analysis
		• Applied Mathematics
		• Computational Mathematics
		• Control and Optimization
		• Discrete Mathematics and Combinatorics
		• Geometry and Topology
		• Logic
		• Mathematics (all)
		• Mathematical Physics
		• Mathematics (miscellaneous)
		• Modeling and Simulation
		• Numerical Analysis
		• Statistics and Probability
	Computer and Information Sciences	• Computer Science (miscellaneous)
		• Computer Science (all)
		• Artificial Intelligence
		• Computational Theory and Mathematics
		• Computer Graphics and Computer-Aided Design
		• Computer Networks and Communications
		• Computer Science Applications
		• Computer Vision and Pattern Recognition
		• Human-Computer Interaction
		• Information Systems
		• Software
		• Theoretical Computer Science
	Physical Sciences	• Acoustics and Ultrasonics
		• Astronomy and Astrophysics
		• Atomic and Molecular Physics, and Optics
		• Condensed Matter Physics
		• Fluid Flow and Transfer Processes
		• Instrumentation
		• Nuclear and High Energy Physics

MAJOR FIELDS OF SCIENCE & TECHNOLOGY FRASCATI MANUAL	SCIENTIFIC SUBFIELDS FRASCATI MANUAL	SUBJECT FIELDS - SCOPUS DATABASE
Natural Sciences	Physical Sciences	• Physics and Astronomy (miscellaneous)
		• Physics and Astronomy (all)
		• Radiation
		• Spectroscopy
		• Statistical and Nonlinear Physics
		• Surfaces and Interfaces
	Chemical Sciences	• Analytical Chemistry
		• Catalysis
		• Chemistry (miscellaneous)
		• Chemistry (all)
		• Colloid and Surface Chemistry
		• Electrochemistry
		• Filtration and Separation
		• Inorganic Chemistry
		• Organic Chemistry
		• Physical and Theoretical Chemistry
	Earth and related Environmental Sciences	• Atmospheric Science
		• Computers in Earth Sciences
		• Earth and Planetary Sciences (miscellaneous)
		• Earth-Surface Processes
		• Ecological Modeling
		• Ecology
		• Economic Geology
		• Environmental Chemistry
		• Environmental Science (all)
		• Environmental Science (miscellaneous)
		• Geochemistry and Petrology
		• Geology
		• Geophysics
		• Global and Planetary Change
		• Health, Toxicology and Mutagenesis
		• Management, Monitoring, Policy and Law
		• Nature and Landscape Conservation
		• Oceanography
		• Paleontology
		• Pollution
		• Space and Planetary Science
		• Stratigraphy

MAJOR FIELDS OF SCIENCE & TECHNOLOGY FRASCATI MANUAL	SCIENTIFIC SUBFIELDS FRASCATI MANUAL	SUBJECT FIELDS - SCOPUS DATABASE
Natural Sciences	**Biological Sciences**	• Aging
		• Animal Science and Zoology
		• Applied Microbiology and Biotechnology
		• Aquatic Science
		• Biochemistry
		• Biochemistry, Genetics and Molecular Biology (all)
		• Biochemistry, Genetics and Molecular Biology (miscellaneous)
		• Biophysics
		• Biotechnology
		• Cancer Research
		• Cell Biology
		• Clinical Biochemistry
		• Developmental Biology
		• Ecology, Evolution, Behavior and Systematics
		• Endocrinology
		• Genetics
		• Immunology
		• Immunology and Microbiology (all)
		• Immunology and Microbiology (miscellaneous)
		• Insect Science
		• Microbiology
		• Molecular Biology
		• Molecular Medicine
		• Parasitology
		• Physiology
		• Plant Science
		• Structural Biology
		• Virology
Engineering & Technology	**Civil Engineering**	• Architecture
		• Building and Construction
		• Civil and Structural Engineering
		• Computational Mechanics

MAJOR FIELDS OF SCIENCE & TECHNOLOGY FRASCATI MANUAL	SCIENTIFIC SUBFIELDS FRASCATI MANUAL	SUBJECT FIELDS - SCOPUS DATABASE
Engineering & Technology	Electrical Engineering, Electronic Engineering, Information Engineering	• Control and Systems Engineering
		• Electrical and Electronic Engineering
		• Hardware and Architecture
		• Media Technology
		• Signal Processing
	Mechanical Engineering	• Aerospace Engineering
		• Automotive Engineering
		• Industrial and Manufacturing Engineering
		• Mechanical Engineering
		• Nuclear Energy and Engineering
	Materials Engineering	• Ceramics and Composites
		• Electronic, Optical and Magnetic Materials
		• Materials Chemistry
		• Materials Science (all)
		• Materials Science (miscellaneous)
		• Mechanics of Materials
		• Metals and Alloys
		• Polymers and Plastics
		• Surfaces, Coatings and Films
	Environmental Engineering	• Energy (all)
		• Energy (miscellaneous)
		• Energy Engineering and Power Technology
		• Environmental Engineering
		• Fuel Technology
		• Geotechnical Engineering and Engineering Geology
		• Ocean Engineering
		• Renewable Energy, Sustainability and the Environment
		• Waste Management and Disposal
		• Water Science and Technology
	Industrial Biotechnology	• Biomaterials
	Other Engineering and Technologies	• Engineering (all)
		• Engineering (miscellaneous)
		• Safety, Risk, Reliability and Quality
	Medical engineering	• Biomedical Engineering

MAJOR FIELDS OF SCIENCE & TECHNOLOGY FRASCATI MANUAL	SCIENTIFIC SUBFIELDS FRASCATI MANUAL	SUBJECT FIELDS - SCOPUS DATABASE
Engineering & Technology	**Chemical Engineering**	• Bioengineering
		• Chemical Engineering (all)
		• Chemical Engineering (miscellaneous)
		• Process Chemistry and Technology
Medical & Health Sciences	**Basic Medicine**	• Anatomy
		• Behavioral Neuroscience
		• Biochemistry (medical)
		• Biological Psychiatry
		• Cellular and Molecular Neuroscience
		• Cognitive Neuroscience
		• Developmental Neuroscience
		• Drug Discovery
		• Embryology
		• Endocrine and Autonomic Systems
		• Histology
		• Neurology
		• Neuroscience (all)
		• Neuroscience (miscellaneous)
		• Pathology and Forensic Medicine
		• Pharmaceutical Science
		• Pharmacology
		• Pharmacology (medical)
		• Pharmacology, Toxicology and Pharmaceutics (all)
		• Pharmacology, Toxicology and Pharmaceutics (miscellaneous)
		• Physiology (medical)
		• Sensory Systems
		• Toxicology
	Clinical Medicine	• Anesthesiology and Pain Medicine
		• Cardiology and Cardiovascular Medicine
		• Complementary and Alternative Medicine
		• Critical Care and Intensive Care Medicine
		• Dental Assisting
		• Dental Hygiene

MAJOR FIELDS OF SCIENCE & TECHNOLOGY FRASCATI MANUAL	SCIENTIFIC SUBFIELDS FRASCATI MANUAL	SUBJECT FIELDS - SCOPUS DATABASE
Medical & Health Sciences	**Clinical Medicine**	• Dentistry (all)
		• Dentistry (miscellaneous)
		• Dermatology
		• Emergency Medicine
		• Endocrinology, Diabetes and Metabolism
		• Gastroenterology
		• Genetics (clinical)
		• Geriatrics and Gerontology
		• Hematology
		• Hepatology
		• Immunology and Allergy
		• Internal Medicine
		• Microbiology (medical)
		• Nephrology
		• Neurology (clinical)
		• Obstetrics and Gynecology
		• Oncology
		• Ophthalmology
		• Oral Surgery
		• Orthodontics
		• Orthopedics and Sports Medicine
		• Otorhinolaryngology
		• Pediatrics, Perinatology and Child Health
		• Periodontics
		• Psychiatry and Mental Health
		• Pulmonary and Respiratory Medicine
		• Radiology, Nuclear Medicine and Imaging
		• Rehabilitation
		• Reproductive Medicine
		• Rheumatology
		• Surgery
		• Transplantation
		• Urology

MAJOR FIELDS OF SCIENCE & TECHNOLOGY FRASCATI MANUAL	SCIENTIFIC SUBFIELDS FRASCATI MANUAL	SUBJECT FIELDS - SCOPUS DATABASE
Medical & Health Sciences	**Clinical Medicine**	• Advanced and Specialized Nursing
		• Assessment and Diagnosis
		• Care Planning
		• Chemical Health and Safety
		• Chiropractics
		• Community and Home Care
		• Complementary and Manual Therapy
		• Critical Care Nursing
		• Emergency Medical Services
		• Emergency Nursing
		• Epidemiology
		• Family Practice
		• Fundamentals and Skills
		• Gerontology
		• Health Informatics
		• Health Information Management
		• Health Policy
		• Health Professions (all)
		• Health Professions (miscellaneous)
		• Infectious Diseases
		• Issues, Ethics and Legal Aspects
		• Leadership and Management
		• LPN and LVN
		• Maternity and Midwifery
		• Medical and Surgical Nursing
		• Medical Assisting and Transcription
		• Medical Laboratory Technology
		• Medical Terminology
		• Nurse Assisting
		• Nursing (all)
		• Nursing (miscellaneous)
		• Nutrition and Dietetics
		• Occupational Therapy

MAJOR FIELDS OF SCIENCE & TECHNOLOGY FRASCATI MANUAL	SCIENTIFIC SUBFIELDS FRASCATI MANUAL	SUBJECT FIELDS - SCOPUS DATABASE
Medical & Health Sciences	Clinical Medicine	• Oncology (nursing)
		• Optometry
		• Pathophysiology
		• Pediatrics
		• Pharmacology (nursing)
		• Pharmacy
		• Physical Therapy, Sports Therapy and Rehabilitation
		• Podiatry
		• Psychiatric Mental Health
		• Public Health, Environmental and Occupational Health
		• Radiological and Ultrasound Technology
		• Research and Theory
		• Respiratory Care
		• Review and Exam Preparation
		• Speech and Hearing
	Other Medical Sciences	• Medicine (all)
		• Medicine (miscellaneous)
Agricultural Sciences	Agriculture, Forestry, and Fisheries	• Agronomy and Crop Science
		• Forestry
		• Horticulture
		• Soil Science
	Veterinary Science	• Equine
		• Food Animals
		• Small Animals
		• Veterinary (all)
		• Veterinary (miscellaneous)
	Agricultural biotechnology	• Food Science
Social Sciences	Psychology	• Applied Psychology
		• Clinical Psychology
		• Developmental and Educational Psychology
		• Experimental and Cognitive Psychology
		• Neuropsychology and Physiological Psychology

MAJOR FIELDS OF SCIENCE & TECHNOLOGY FRASCATI MANUAL	SCIENTIFIC SUBFIELDS FRASCATI MANUAL	SUBJECT FIELDS - SCOPUS DATABASE
Social Sciences	Psychology	• psychology, multidisciplinary
		• psychology, psychoanalysis
		• psychology, social
	Economics and Business	• Accounting
		• Business and International Management
		• Business, Management and Accounting (all)
		• Business, Management and Accounting (miscellaneous)
		• Decision Sciences (all)
		• Decision Sciences (miscellaneous)
		• Economics and Econometrics
		• Economics, Econometrics and Finance (all)
		• Economics, Econometrics and Finance (miscellaneous)
		• Finance
		• Industrial Relations
		• Information Systems and Management
		• Management Information Systems
		• Management of Technology and Innovation
		• Management Science and Operations Research
		• Marketing
		• Organizational Behavior and Human Resource Management
		• Statistics, Probability and Uncertainty
		• Strategy and Management
		• Tourism, Leisure and Hospitality Management
	Educational Sciences	• education
	Sociology	• Anthropology
		• Cultural Studies
		• Demography
		• Gender Studies
	Law	• law
	Political Sciences	• Political Science and International Relations
		• Public Administration

MAJOR FIELDS OF SCIENCE & TECHNOLOGY FRASCATI MANUAL	SCIENTIFIC SUBFIELDS FRASCATI MANUAL	SUBJECT FIELDS - SCOPUS DATABASE
Social Sciences	Social and Economic Geography	• Geography, Planning and Development
		• Transportation
		• Urban Studies
	Media and Communications	• Communication
		• Library and Information Sciences
	Other Social Sciences	• Development
		• Health (social science)
		• Human Factors and Ergonomics
		• Life-span and Life-course Studies
		• Safety Research
		• Social Sciences (all)
		• Social Sciences (miscellaneous)
		• Sociology and Political Science
Humanities	History and Archaeology	• Archeology
		• Archeology (arts and humanities)
		• Conservation
		• History
	Languages and Literature	• Classics
		• Language and Linguistics
		• Linguistics and Language
		• Literature and Literary Theory
	Philosophy, Ethics and Religion	• History and Philosophy of Science
		• Philosophy
		• Religious Studies
	Arts	• Arts and Humanities (all)
		• Museology
		• Music
		• Visual Arts and Performing Arts

APPENDIX IV: INSTITUTION CATEGORIES

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

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

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

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

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

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