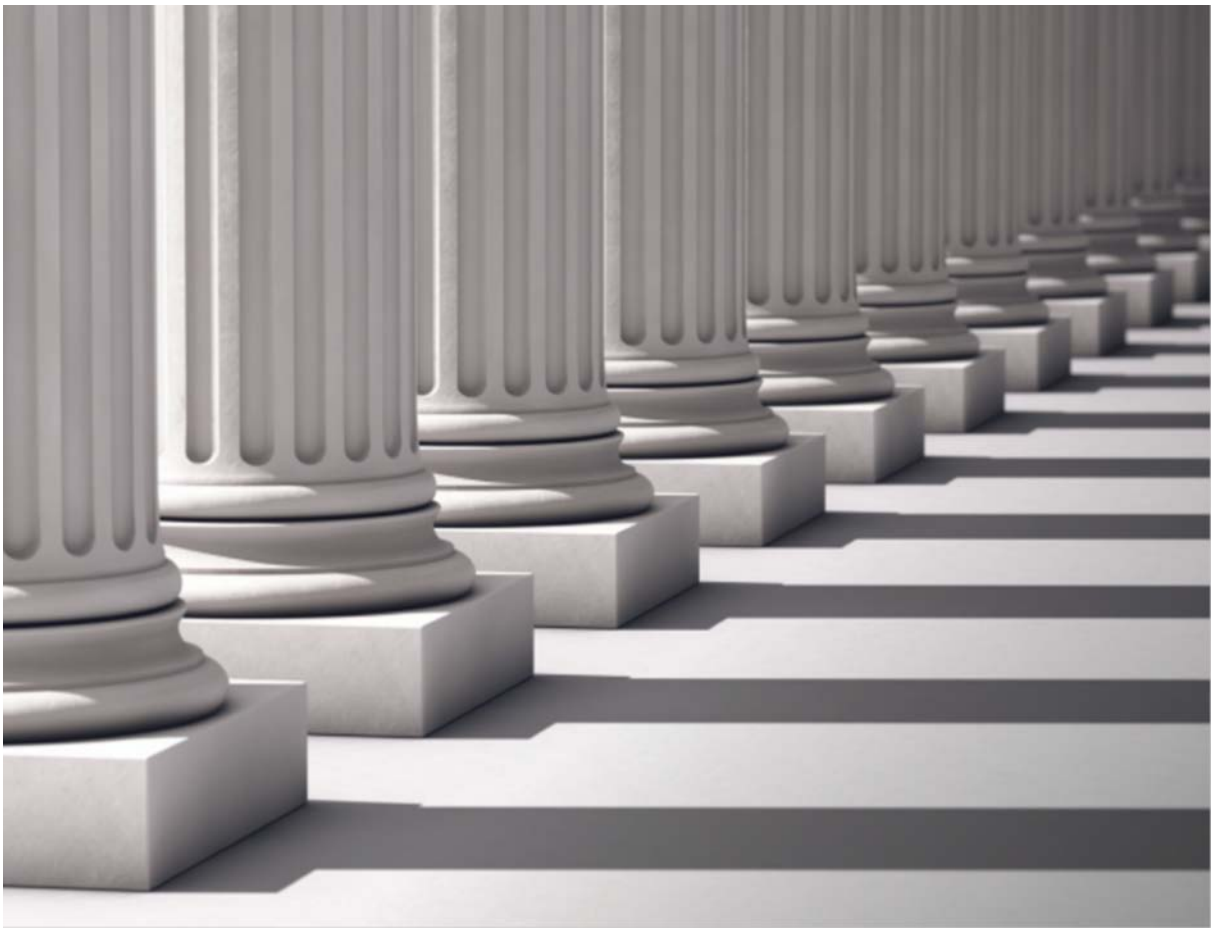

Bibliometric Analysis of Romania's Research Output, 2005-2014

Unitatea Executiva pentru Finantarea Invatamantului Superior, a Cercetarii, Dezvoltarii si Inovarii (UEFISCDI)

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1. Introduction and Methodology

Scope of Report

Unitatea Executiva pentru Finantarea Invatamantului Superior, a Cercetarii, Dezvoltarii si Inovarii (UEFISCDI) is an executive agency—governs higher education, research, development and innovation funding—under the Ministry of Education, Research, Youth and Sport (MECTS) in Romania. It works with a number of public agencies –-the Romanian National Research Council (CNCS), National Council for Financing Higher Education (CNFIS), National Council of Statistics and Prognosis for Higher Education (CNSPIS), National Development and Innovation Council (CNDI), National Council of University Libraries (CNBU), and Council of University Ethics and Management (CEMU), coordinates programmes to promote partnership and innovation, offers consultancy and assistance to develop national and international research programs, and also implements institutional development projects relating to higher education and research.

UEFISCDI would like to commission Thomson Reuters to conduct a comparative bibliometric analysis and an evaluation of Romania's research landscape over the past 10 years, covering the publication period from 2005 to 2014. Specifically, we will use research publication data and citation analysis to produce a number of bibliometric indicators for Romania and five comparator countries selected by UEFISCDI.

In addition, Research Front data (as presented in the Thomson Reuters InCites: Essential Science Indicators[SM]) will also be used to identify Romania's presence in current global Research Fronts. A Research Front consists of a group of highly cited papers that have been frequently co-cited, or cited in pairs. Small[1] showed that when researchers connect two papers in the reference list of the papers they publish time and time again, there is typically a close cognitive relationship between the co-cited papers. Groups of frequently co-cited papers, therefore, create a cluster of publications focusing on a problem, methodology, or solution.

Highly cited papers are defined as those that rank in the top 1% by citations received for papers of the same field and year of publication. By analyzing a subset of all papers for co-citation, the most influential part of current research can be summarized. Thus, a Research Front consists of a number of 'core' papers, which are highly cited papers frequently co-cited, and the citing papers describe the cohesive relationship among the core papers. As the citing papers represent the most recent work, they, therefore, represent the leading edge of a research front. An analysis of the titles of the core papers provides the name for each research front.

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[1] Henry Small, 'Co-citation in the scientific literature: a new measure of the relationship between two documents,' Journal of the American Society for Information Science, 24 (4): 265-269, July-August 1973.

Henry Small and Belver C. Griffith, 'Structure of scientific literatures. 1. Identifying and graphing specialties,' Science Studies, 4 (1):17-40, 1974.

Henry Small, 'Paradigms, citations, and maps of science: a personal history,' Journal of the American Society of Information Science and Technology, 54 (5): 394-399, March 2003.

Henry Small, ''Tracking and predicting growth areas in science,' Scientometrics, 68 (3): 595-610, December 2006.

The aim of this report is to provide bibliometric analysis on Romania's research output by way of 9 evaluative questions:

- What are the dynamics of publications? Namely, how much research has taken place and how does Romania's research perform relative to the world?
- Where has Romania's research been published?
- What is the dynamic in publishing fields? Specifically, in what fields is research being conducted?
- What are Romania's disciplinary strengths, weaknesses, opportunities, and threats?
- Which countries are Romania's top collaborators?
- Where has Romania's research been cited?
- What is the correlation of Romanian's publications with global research fronts?
- How do publication output and research impact of Romania compare against comparator countries during this time period?
- How do publication output and research impact of Romania compare against comparator countries when Romania's top 10 Essential Science Indicator fields are examined?

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Thomson Reuters Research Analytics is a suite of products, services and tools that provide comprehensive research analysis, evaluation and management. For over half a century we have pioneered the world of citation indexing and analysis, helping to connect scientific and scholarly thought around the world. Today, academic and research institutions, governments, not-for-profits, funding agencies, and all others with a stake in research, need reliable, objective methods for managing and measuring performance. Visit our WEBPAGE for more information.

Thomson Reuters Research Data Science & Evaluation team provides reporting and consultancy services within Research Analytics using customized analyses to bring together several indicators of research performance in such a way as to enable customers to rapidly make sense of and interpret a wide-range of data points to facilitate research strategy decision-making. We have extensive experience with databases on research inputs, activity and outputs and have developed innovative analytical approaches for benchmarking, interpreting and visualization of international, national and institutional research impact.

Bibliometrics and citation analysis

Research evaluation is increasingly making wider use of bibliometric data and analyses. Bibliometrics is the analysis of data derived from publications and their citations. Publication of research outcomes is an integral part of the research process and is a universal activity. Consequently, bibliometric data have a currency across subjects, time and location that is found in few other sources of research-relevant data. The use of bibliometric analysis, allied to informed review by experts, increases the objectivity of, and confidence in, evaluation.

Research publications accumulate citation counts when they are referred to by more recent publications. Citations to prior work are a normal part of publication and reflect the value placed on a work by later researchers. Some papers get cited frequently and many remain uncited. Highly cited work is recognised as having a greater impact and Thomson Reuters has shown that high citation rates are correlated with other qualitative evaluations of research performance, such as peer review[2]. This relationship holds across most science and technology areas and, to a limited extent, in social sciences and even in some humanities subjects.

Indicators derived from publication and citation data should always be used with caution. Some fields publish at faster rates than others and citation rates also vary. Citation counts must be carefully normalised to account for such variations by field. Because citation counts naturally grow over time, it is essential to account for growth by year. Normalisation is usually done by reference to the relevant global average for the field and for the year of publication.

Bibliometric indicators have been found to be more informative for core natural sciences, especially for basic science, than they are for applied and professional areas and for social sciences. In professional areas the range of publication modes used by leading researchers is likely to be diverse as they target a diverse, non-academic audience. In social sciences there is also a diversity of publication modes and citation rates are typically much lower than in natural sciences.

Bibliometrics work best with large data samples. As the data are disaggregated, so the relationship weakens. Average indicator values (e.g. of citation impact) for small numbers of publications can be skewed by single outlier values. At a finer scale, when analysing the specific outcome for individual departments, the statistical relationship is rarely a sufficient guide by itself. For this reason, bibliometrics are best used in support of, but not as a substitute for, expert decision processes. Well-founded analyses can enable conclusions to be reached more rapidly and with greater certainty, and are therefore an aid to management and to increased confidence among stakeholders, but they cannot substitute for review by well-informed and experienced peers.

Data Source

For this evaluation, bibliometric data will be sourced from databases underlying the Thomson Reuters Web of Science™, which gives access to conference proceedings, patents, websites, and chemical structures, compounds and reactions in addition to journals. It has a unified structure that integrates all data and search terms and therefore provides a level of comparability not found in other databases. It is widely acknowledged to be the world's leading source of citation and bibliometric data. The Thomson Reuters Web of Science™ Core Collection is part of the Web of Science, and focuses on research published in journals and conferences in science, medicine, arts, humanities and social sciences. The authoritative, multidisciplinary content covers over 12,000 of the highest impact journals worldwide, including Open Access journals and over 150,000 conference proceedings. Coverage is both current and retrospective in the sciences, social sciences, arts and humanities, in some cases back to 1900. Within the research community, these data are often still referred to by the acronym 'ISI'.

[2] *Evidence* Ltd. (2002) Maintaining Research Excellence and Volume: A report by *Evidence* Ltd to the Higher Education Funding Councils for England, Scotland and Wales and to Universities UK. (*Adams J, et al.)* 48pp.

Thomson Reuters has extensive experience with databases on research inputs, activity and outputs and has developed innovative analytical approaches for benchmarking and interpreting international, national and institutional research impact.

Methodology

Papers/publications: Thomson Reuters abstracts publications including editorials, meeting abstracts and book reviews as well as research journal articles. The terms 'paper' and 'publication' are often used interchangeably to refer to printed and electronic outputs of many types. In this document the term '**paper**' has been used exclusively to refer to substantive journal articles and reviews, and excludes proceeding papers, editorials, meeting abstracts or other types of publication. **Papers** are the subset of publications for which citation data are most informative and which are used in calculations of citation impact.

Citations: The citation count is the number of times that a citation has been recorded for a given publication since it was published. Not all citations are necessarily recorded since not all publications are indexed. The material indexed by Thomson Reuters, however, is estimated to attract about 95% of global citations.

Field-normalised citation impact (nci_F): 'Citations per paper' is an index of academic or research impact (as compared with economic or social impact). As citation rates vary between research fields and with time, consequently, analyses must take both field and year into account. In addition, the type of publication will influence the citation count. For this reason, only citation counts of papers (as defined above) are used in calculations of citation impact. The standard normalisation factor is the world average citations per paper for the year and journal category in which the paper was published. This normalisation is also referred to as 'rebasing' the citation count.

Web of Science journal categories or Thomson Reuters InCites: Essential Science Indicators℠ fields: Standard bibliometric methodology uses journal category or Essential Science Indicators fields as a proxy for research fields. Essential Science Indicators fields aggregate data at a higher level than the journal categories – there are only 22 Essential Science Indicators research fields compared to 254 journal categories. Journals are assigned to one or more categories, and every article within that journal is subsequently assigned to that category. Papers from prestigious, 'multidisciplinary' and general medical journals such as *Nature*, *Science*, *The Lancet*, *The BMJ*, *The New England Journal of Medicine and the Proceedings of the National Academy of Sciences* (PNAS) are assigned to specific categories based on the journal categories of the references cited in the article. The selection procedures for the journals included in the citation databases are documented here http://scientific.thomsonreuters.com/mjl/.[3]

[3] *Essential Science Indicators* are defined by a unique grouping of journals with no journal being assigned to more than one field. These fields are focussed on the science, technology, engineering and medicine subjects and arts & humanities subjects are excluded. Customised analyses, however, can be designed to include these as an additional category.

2. Bibliometric Analysis of Romania's Research Output

This section of the Report profiles the publication output of Romania. It includes citation impact, collaboration, and analysis of total productivity by publication type and journal category, and also a disciplinary analysis of strengths, weaknesses, opportunities, and threats. In addition, it includes a citation distribution by country. Together, these analyses provide a rich picture of Romania's research output and performance.

2.1 How much research has taken place?

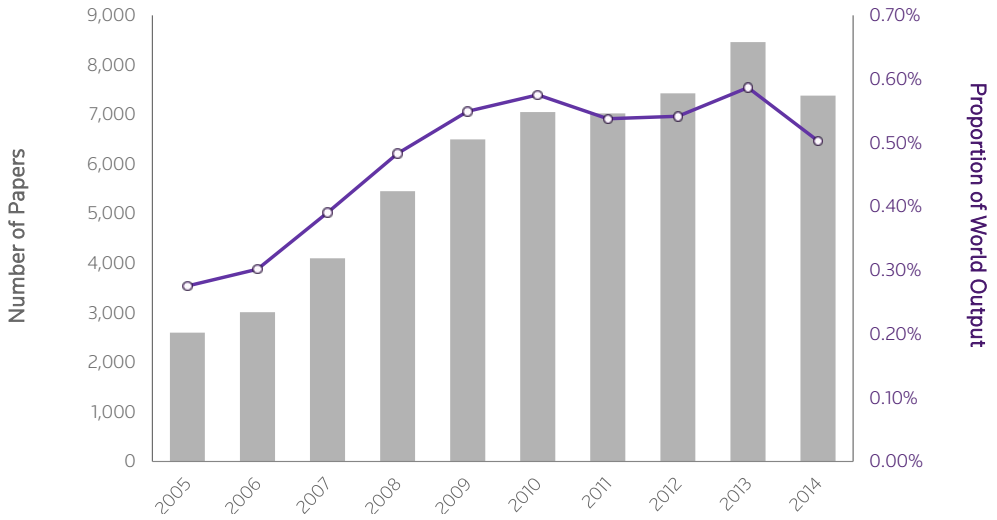


Figure 2.1.1 Romania's paper output and share of world output, 2005 and 2014

Romania's output of papers has increased, for the most part, between 2005 and 2014. Overall, there has been a 184 % increase in the number of papers published for Romania.

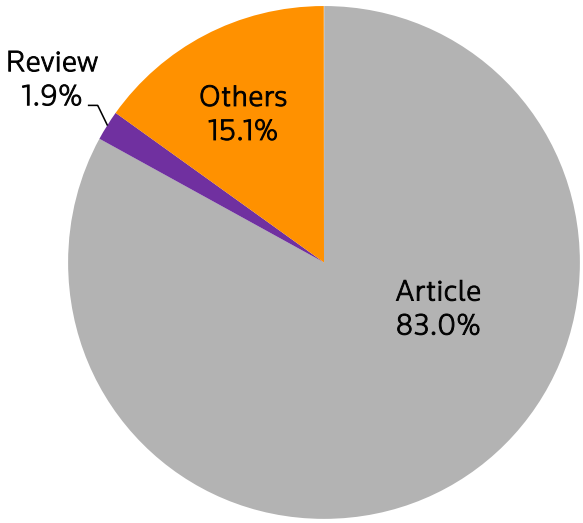


Figure 2.1.2 Romania's publication output by document type, 2005- 2014

Citation and citation-based indicators of research performance have been most studied and best characterised for substantive research articles and reviews. The pie chart shows that these two publication types account for about 85% of Romania's total research that was published in scholarly journals, and are therefore representative of Romania's output as a whole.

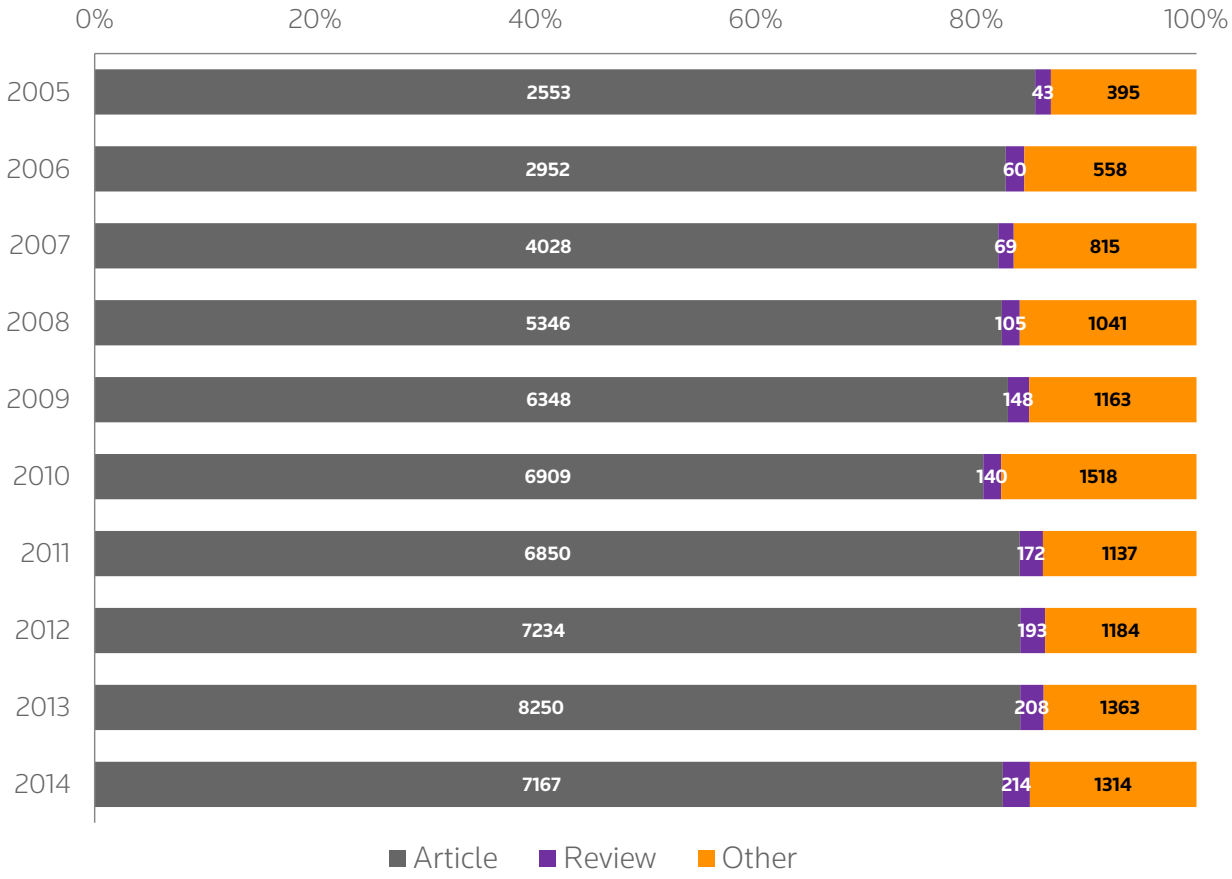
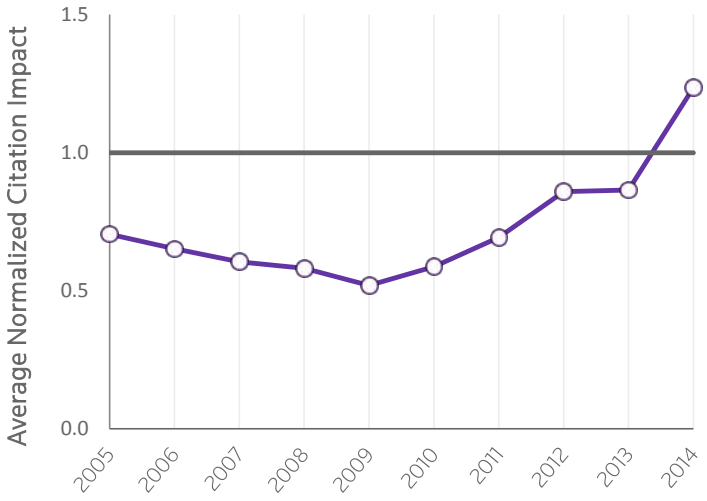


Figure 2.1.3 Romania's publication output by document type and year, 2005- 2014

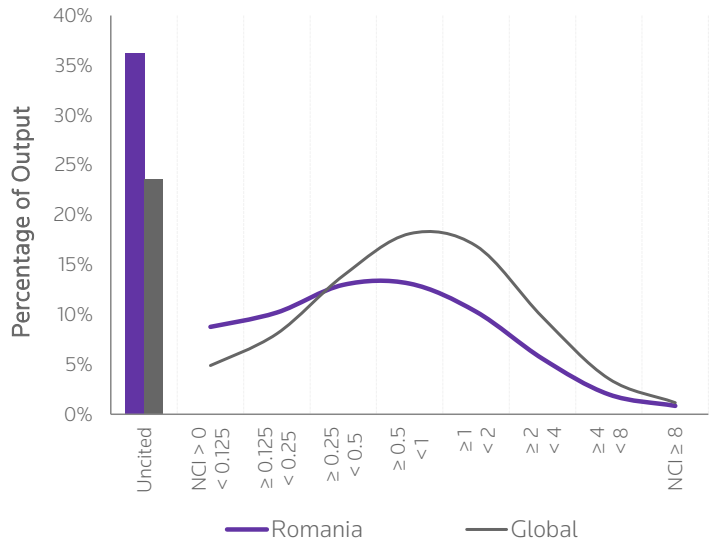
Romania experienced the biggest percentage increase, 36%, in research papers (Article & Review) from 2006 (N = 3012) to 2007 (N = 4097), and the biggest decrease, -13 %, from 2013 (N = 8458) to 2014 (N = 7381).

2.2 How does Romania's research perform relative to the world?



Romania's normalised citation impact, while remained below world average citation impact (NCI = 1.0) between 2005 and 2013, has managed to climb above that threshold in 2014.

Figures 2.2.1 Average field-normalised citation impact by year, 2005- 2014



The Impact Profiles shows that Romania has a higher proportion of uncited papers and papers in the groups below world average citation impact, relative to global total research. As suggested by the representation peak, a majority of Romania's papers were cited between half-to-one times of the world average.

Looking at the most highly-cited papers, 3 % of Romania's papers have received at least four-times the world average number of citations.

Figures 2.2.2 Impact Profile® normalized against world citation activity for Romania, 2005- 2014

An Impact Profile® shows the distribution of research papers by the level of citations they have received. This provides much more information about the basis and structure of research performance than conventionally reported averages in citation indices.

2.3 Publication output by institution

Table 2.3 Top 30 Romanian institutions with the highest publication volume, 2005 - 2014

Institution	City	Paper Count
Polytechnic University of Bucharest	Bucharest	7,115
University of Bucharest	Bucharest	6,605
Babes Bolyai University from Cluj	Cluj-Napoca	6,440
Romanian Academy of Sciences	Bucharest	5,195
Alexandru Ioan Cuza University	Iasi	3,943
GH Asachi Technical University	Iasi	3,119
Horia Hulubei National Institute of Physics & Nuclear Engineering	Magurele	2,990
Iuliu Hatieganu University of Medicine & Pharmacy	Cluj-Napoca	2,593
Carol Davila University of Medicine & Pharmacy	Bucharest	2,451
Grigore T Popa University of Medicine & Pharmacy	Iasi	2,310
Petru Poni Institute of Macromolecular Chemistry	Iasi	2,198
Polytechnic University of Timisoara	Timisoara	1,814
National Institute for Laser, Plasma & Radiation Physics – Romania	Magurele	1,809
National Institute of Materials Physics – Romania	Magurele	1,781
West University of Timisoara	Timisoara	1,735
Bucharest Academy of Economic Studies	Bucharest	1,570
Technical University of Cluj Napoca	Cluj-Napoca	1,435
University of Craiova	Craiova	1,285
Transylvania University of Brasov	Brasov	1,276
Dunarea De Jos University Galati	Galati	1,011
University of Oradea	Oradea	897
Ovidius University	Constanta	857
Institute Space Science Magurele	Magurele	615
University of Agricultural Sciences & Veterinary Medicine Cluj Napoca	Cluj Napoca	600
University Medical & Pharmacy Craiova	Craiova	589
University Medical & Pharmacy Victor Babes Timisoara	Timisoara	560
Lucian Blaga University of Sibiu	Sibiu	481
National Institute Research & Development Isotop & Molecular Technology Cluj Napoca	Cluj Napoca	437
National Institute of Research & Development for Technical Physics – Romania	Iasi	340
Institute of Atomic Physics – Romania	Magurele	329

2.4 In what fields is research being conducted?

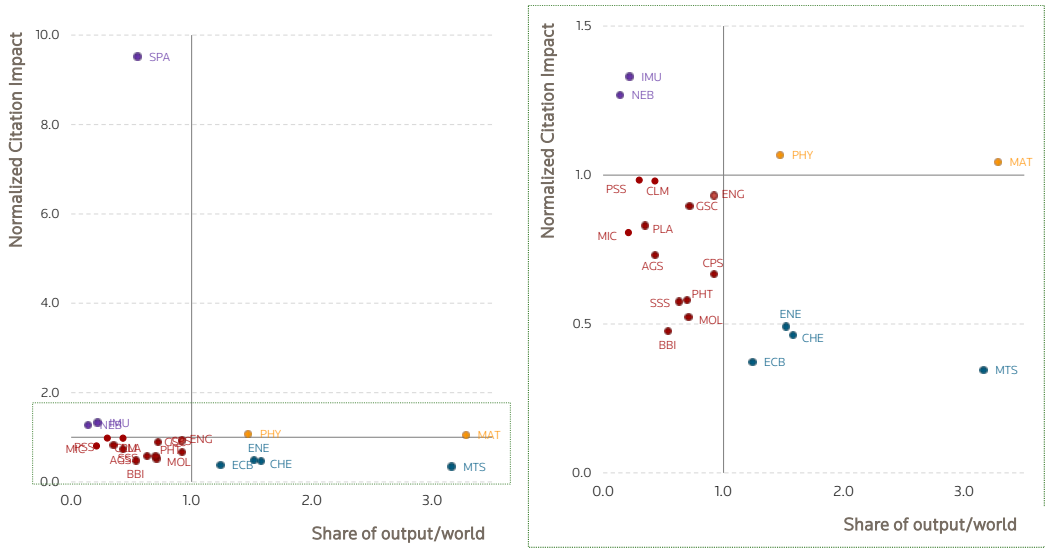


Figure 2.4 Analysis of Strengths, Weaknesses, Opportunities, and Threats by Journal Subject Category, 2005-2014, relative to world output and performance. The right panel features the enlarged area containing embedded data shown on the left.

S: Physics and Mathematics were two fields in the strength area with the highest relative output share and normalized citation impact, respectively.

W: Microbiology had the lowest relative output share (0.21), and Biology & Biochemistry the lowest relative citation impact (NCI = 0.48).

O: Space Science ranked highest in normalized citation impact (NCI=9.52), but had only modest contribution (0.6 times) when compared to total global output share.

T: It stands out that Materials Science, among the top ranked productive disciplines (Romania's share was 3.16 times more than total global output), had only moderate citation impact (NCI = 0.35).

Fields in the top right quadrant of the Figure represent research strengths. These are areas of high citation impact and with a relatively large share of institutional research output

Fields in the bottom left quadrant of the Figure represent areas of weakness. These subjects are poorly cited relative to similar research. However, these subjects do not form a significant part of the institutional research portfolio.

Fields in the top left quadrant of the Figure represent opportunities. These are areas of high citation impact relative to the world but with a lower share of the institutional research portfolio.

Fields in the bottom right quadrant of the Figure represent areas of threat. These subjects are poorly cited relative to similar research but form significant parts of the institutional research portfolio.

Table 2.4 Top 22 Essential Science Indicator fields in which Romania had the highest publication volume and their respective normalised citation impacts, 2005 - 2014

Essential Science Indicator (ESI) Category Code	ESI Category Name	Number of papers	Average Normalised Citation Impact
CHE	CHEMISTRY	10,746	0.463
MTS	MATERIALS SCIENCE	9,298	0.345
PHY	PHYSICS	7,734	1.066
MAT	MATHEMATICS	5,583	1.044
CLM	CLINICAL MEDICINE	4,716	0.980
ENG	ENGINEERING	4,230	0.931
ENE	ENVIRONMENT/ECOLOGY	2,573	0.492
SSS	SOCIAL SCIENCE, GENERAL	2,136	0.575
BBI	BIOLOGY & BIOCHEMISTRY	1,639	0.476
CPS	COMPUTER SCIENCE	1,395	0.668
MOL	MOLECULAR BIOLOGY & GENETICS	1,310	0.523
GSC	GEOSCIENCES	1,220	0.895
ECB	ECONOMICS & BUSINESS	1,210	0.373
PHT	PHARMACOLOGY & TOXICOLOGY	1,094	0.582
PLA	PLANT & ANIMAL SCIENCE	1,071	0.830
AGS	AGRICULTURAL SCIENCES	690	0.731
PSS	PSYCHIATRY & TOXICOLOGY	453	0.983
SPA	SPACE SCIENCE	368	9.521
NEB	NEUROSCIENCE & BEHAVIOR	288	1.268
IMU	IMMUNOLOGY	223	1.331
MIC	MICROBIOLOGY	180	0.807

2.5 Which areas has Romania's research been published?

Table 2.5 Top 5 Journal Subject Category by publication volume for each ESI field, 2005 - 2014

ESI field	Journal Subject Category	Number of papers	Average Normalised Citation Impact
AGRICULTURAL SCIENCES	Food Science & Technology	432	0.848
	Agronomy	172	0.473
	Chemistry, Applied	88	1.641
	Nutrition & Dietetics	82	1.545
	Agriculture, Multidisciplinary	39	0.878
BIOLOGY & BIOCHEMISTRY	Biotechnology & Applied Microbiology	810	0.192
	Biochemistry & Molecular Biology	390	0.72
	Biology	189	0.708
	Biophysics	157	0.677
	Endocrinology & Metabolism	82	0.489
CHEMISTRY	Chemistry, Multidisciplinary	5,672	0.218
	Engineering, Chemical	3,313	0.303
	Chemistry, Physical	1,459	0.654
	Chemistry, Analytical	1,156	0.696
	Polymer Science	961	0.631
CLINICAL MEDICINE	Surgery	933	0.447
	Gastroenterology & Hepatology	458	1.086
	Medicine, Research & Experimental	393	0.28
	Oncology	381	2.474
	Endocrinology & Metabolism	377	0.44
COMPUTER SCIENCE	Computer Science, Theory & Methods	526	0.631
	Computer Science, Information Systems	440	0.543
	Automation & Control Systems	308	0.262
	Computer Science, Artificial Intelligence	242	0.697
	Computer Science, Software Engineering	193	0.938
ECONOMICS & BUSINESS	Economics	1,150	0.365
	Mathematics, Interdisciplinary Applications	309	0.24
	Business	107	0.314
	Management	44	0.926
	Social Sciences, Mathematical Methods	16	0.754
ENGINEERING	Engineering, Electrical & Electronic	1,299	0.731
	Mechanics	808	1.35
	Engineering, Mechanical	597	1.337

ESI field	Journal Subject Category	Number of papers	Average Normalised Citation Impact
ENGINEERING (continued)	Automation & Control Systems	479	0.734
	Thermodynamics	475	1.576
ENVIRONMENT /ECOLOGY	Environmental Sciences	2,394	0.428
	Ecology	157	1.755
	Water Resources	106	1.191
	Engineering, Environmental	85	1.179
	Biodiversity Conservation	62	1.786
GEOSCIENCES	Geosciences, Multidisciplinary	432	1.204
	Geochemistry & Geophysics	248	0.854
	Environmental Sciences	210	0.402
	Meteorology & Atmospheric Sciences	194	0.898
	Geography, Physical	168	1.644
IMMUNOLOGY	Immunology	131	1.605
	Infectious Diseases	113	0.947
	Allergy	40	3.419
	Public, Environmental & Occupational Health	20	0.967
	Microbiology	18	1.611
MATERIALS SCIENCE	Materials Science, Multidisciplinary	5,371	0.358
	Metallurgy & Metallurgical Engineering	2,892	0.168
	Physics, Applied	2,628	0.375
	Optics	2,328	0.214
	Nanoscience & Nanotechnology	746	0.458
MATHEMATICS	Mathematics	3,858	1.094
	Mathematics, Applied	3,150	1.19
	Physics, Multidisciplinary	359	0.22
	Multidisciplinary Sciences	111	0.046
	Statistics & Probability	108	0.526
MICROBIOLOGY	Microbiology	104	0.76
	Parasitology	55	809
	Virology	32	1.292
	Biotechnology & Applied Microbiology	18	0.573
	Immunology	9	0.159
MOLECULAR BIOLOGY & GENETICS	Developmental Biology	923	0.164
	Cell Biology	226	1.142
	Medicine, Research & Experimental	115	1.383

ESI field	Journal Subject Category	Number of papers	Average Normalised Citation Impact
MOLECULAR BIOLOGY & GENETICS (continued)	Genetics & Heredity	113	2.154
	Biochemistry & Molecular Biology	74	0.836
NEUROSCIENCE & BEHAVIOUR	Neurosciences	207	1.256
	Clinical Neurology	149	1.23
	Psychiatry	27	1.83
	Behavioral Sciences	15	0.699
	Pharmacology & Pharmacy	14	1.274
PHARMACOLOGY & TOXICOLOGY	Pharmacology & Pharmacy	993	0.553
	Chemistry, Medicinal	115	0.669
	Toxicology	59	0.99
	Chemistry, Analytical	39	1.175
	Chemistry, Multidisciplinary	25	0.707
PHYSICS	Physics, Multidisciplinary	2,404	0.802
	Physics, Particles & Fields	1,377	2.129
	Physics, Nuclear	1,204	2.447
	Physics, Applied	1,141	0.544
	Physics, Condensed Matter	1,044	0.484
PLANT & ANIMAL SCIENCES	Plant Sciences	326	0.747
	Zoology	297	0.729
	Veterinary Sciences	132	0.879
	Forestry	96	0.916
	Entomology	71	0.89
PSYCHIATRY /PSYCHOLOGY	Psychology, Clinical	191	0.621
	Psychiatry	136	1.716
	Psychology, Multidisciplinary	55	0.896
	Psychology, Social	36	0.966
	Psychology, Experimental	28	0.828
SOCIAL SCIENCES, GENERAL	History	542	0.23
	Area Studies	540	0.197
	History & Philosophy Of Science	330	0.592
	Religion	321	0.591
	Sociology	253	0.827

ESI field	Journal Subject Category	Number of papers	Average Normalised Citation Impact
SPACE SCIENCE	Astronomy & Astrophysics	368	9.521
	Physics, Particles & Fields	52	1.39
	Geosciences, Multidisciplinary	18	0.629
	Meteorology & Atmospheric Sciences	14	0.742
	Mathematics, Interdisciplinary Applications	5	0.995
NO CATEGORY	Religion	273	1.517
	Philosophy	137	0.132
	Public Administration	62	0.153
	Literature	42	0.377
	History	39	0.205

2.6 Which countries are Romania's top collaborators?

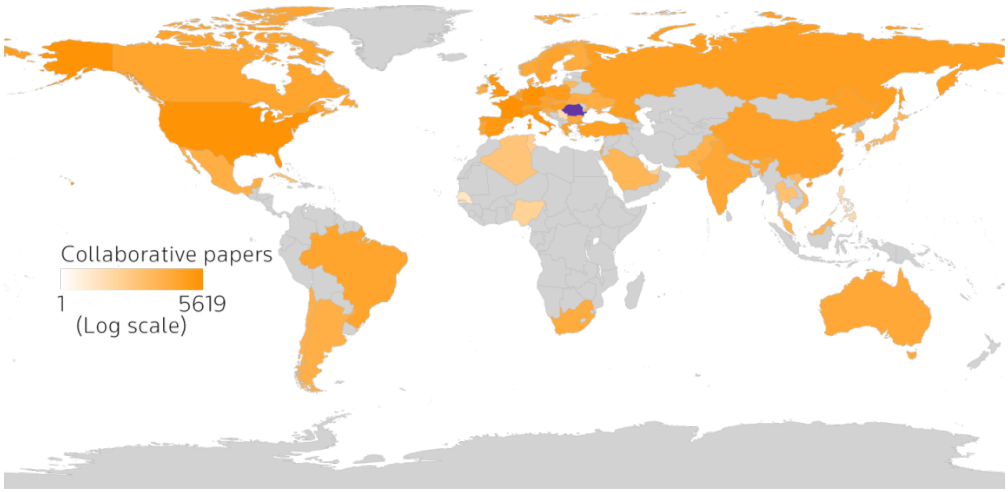


Figure 2.6 International collaboration by country, 2005-2014. The countries which collaborate most frequently with Romania are shaded in orange, but with varying intensity—those appear darker connotes stronger collaborative ties than those in lighter hue. Countries with no collaboration were shaded in grey.

Romania has collaborated extensively with western European countries and USA, but less with countries in the Asia Pacific region.

Table 2.6 The output of Romania's collaborative research, by the 20 countries with which it co-authored most papers between 2005 and 2014

Top Collaborating Country	Number of collaborative papers
France	5,619
Germany	5,038
USA	4,573
Italy	3,972
England	2,892
Spain	2,801
Poland	2,195
Hungary	2,081
Netherlands	1,892
Switzerland	1,836
Russia	1,820
Turkey	1,694
Belgium	1,509

Top Collaborating Country	Number of collaborative papers
Greece	1,501
China Mainland	1,493
Austria	1,461
Czech Republic	1,335
Japan	1,329
Sweden	1,317
Canada	1196

2.7 Where has Romania's research been cited?

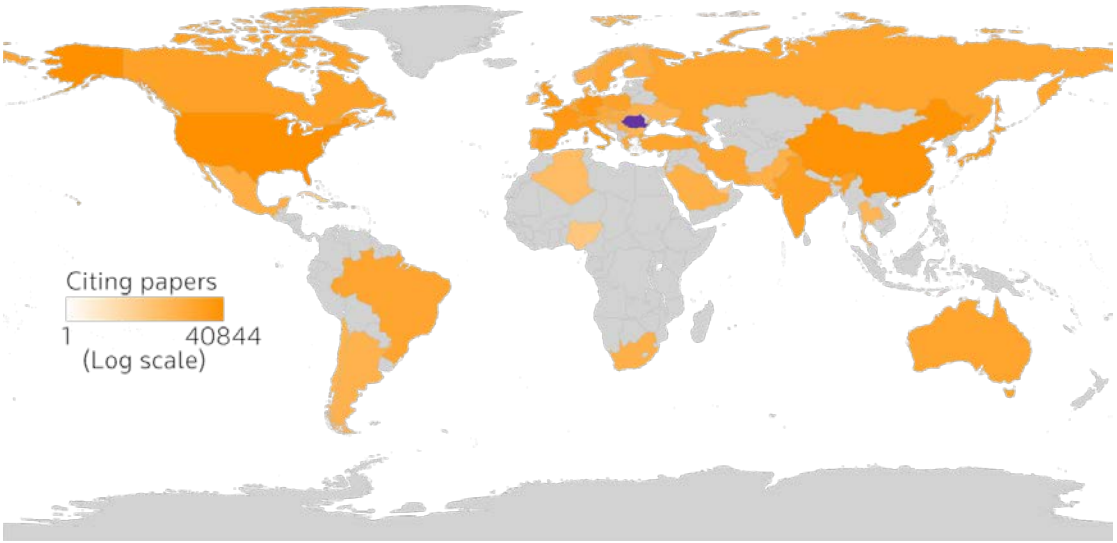


Figure 2.7 Citation to Romania's research papers by country, 2005 – 2014. Darker shades of orange indicate countries which have cited Romania research most frequently, while lighter shades of orange indicate lower levels of citation. Countries shaded in grey did not cite Romania's research.

While most of Romania's research was cited by Western European countries and USA, it appears that China also cited Romania's research quite extensively.

Table 2.7 Top 20 countries citing Romania's research, 2005 - 2014

Top Citing Country	Number of citing papers
United States	40,844
China	29,711
Germany	20,617
France	17,532
Italy	16,127
England	14,663
Spain	12,725
India	10,094
Japan	9,193
Canada	7,787
Poland	6,924
Netherlands	6,575
Switzerland	6,463

Top Citing Country	Number of citing papers
Australia	5,864
South Korea	5,834
Turkey	5,825
Russia	5,632
Brazil	5,437
Belgium	5,142
Iran	5,039

2.8 What is the correlation of Romanian's publications with global research fronts?

Table 2.8 Top 10 Essential Science Indicator Research Fronts data to which Romania has contributed at least one core paper, 2005-2014 [Please see Annex 1 for the complete set]

Research Front Description	ESI Field Description	Number of papers produced by Romania
PLANCK 2013 RESULTS;PLANCK DATA;PLANCK ALL-SKY COMPTON PARAMETER MAP;PLANCK CATALOGUE;	SPACE SCIENCE	30
COUPLED COMMON FIXED POINT RESULTS;COUPLED FIXED POINT THEOREMS;COMMON FIXED POINT RESULTS;COMMON FIXED POINT THEOREMS;	MATHEMATICS	12
CONTINUED FRACTION APPROXIMATION;GAMMA FUNCTION;NEW QUICKER SEQUENCE CONVERGENT;NEW ASYMPTOTIC EXPANSION;	MATHEMATICS	7
LOCAL FRACTIONAL VARIATIONAL ITERATION METHOD;LOCAL FRACTIONAL VARIATION ITERATION METHOD;FRACTAL HEAT CONDUCTION PROBLEM SOLVED;	MATHEMATICS	6
02 TEV PROTON-LEAD COLLISIONS;P PLUS PB COLLISIONS;P-PB COLLISIONS;HIGH-ENERGY PROTON-NUCLEUS COLLISIONS;	PHYSICS	6
MIXED TYPE CUBIC-QUARTIC FUNCTIONAL EQUATION;ADDITIVE CAUCHY FUNCTIONAL EQUATION;GENERALIZED HYERS-ULAM STABILITY;ADDITIVE FUNCTIONAL EQUATION;	MATHEMATICS	6
PRECISE REAL-TIME FOUR POINT SINGLE SINUSOID SIGNALS INSTANTANEOUS FREQUENCY ESTIMATION METHOD;SINGLE SINE WAVE PARAMETERS ESTIMATION METHOD BASED;	ENGINEERING	5
NONLINEAR FRACTIONAL DIFFERENTIAL EQUATIONS;P-TYPE FRACTIONAL NEUTRAL DIFFERENTIAL EQUATIONS;FRACTIONAL NEUTRAL DIFFERENTIAL EQUATIONS;	MATHEMATICS	4
76 TEV;ROOT S(NN)=2;JET MOMENTUM DEPENDENCE;PBPB COLLISIONS;INCLUSIVE JET SUPPRESSION	PHYSICS	4
GEV AU PLUS AU COLLISIONS SERVE;76 TEV PB + PB COLLISIONS;AU PLUS AU COLLISIONS;76 TEV LEAD-LEAD COLLISIONS;RELATIVISTIC HEAVY-ION COLLISIONS	PHYSICS	4

The following three *Research Fronts* are sub-specialties where Romania has significant and direct contribution to the core papers:

1. PLANCK 2013 RESULTS;PLANCK DATA;PLANCK ALL-SKY COMPTON PARAMETER MAP;PLANCK CATALOGUE;
2. COUPLED COMMON FIXED POINT RESULTS;COUPLED FIXED POINT THEOREMS;COMMON FIXED POINT RESULTS;COMMON FIXED POINT THEOREMS;
3. CONTINUED FRACTION APPROXIMATION;GAMMA FUNCTION;NEW QUICKER SEQUENCE CONVERGENT;NEW ASYMPTOTIC EXPANSION;

The first front belongs to the ESI field of Space Science, while the latter two belong to Mathematics. It is important to point out that based on the SWOT analysis in Section 2.4. Space Science was identified as an research opportunity for Romania, and Mathematics a disciplinary strength.

3. Comparative Bibliometrics

This Section compares Romania's research output and performance to that of comparator countries selected by UEFISCDI. The comparator countries were chosen by UEFISCDI and represent a mixture of peer and aspirational targets for research performance. As such these countries are expected to perform better than Romania in some areas, and comparably to Romania in others. The selected comparator countries are: Czech Republic, Poland, Slovenia, Turkey, and Hungary.

3.1 How do publication output and research impact of Romania compare against comparator countries?

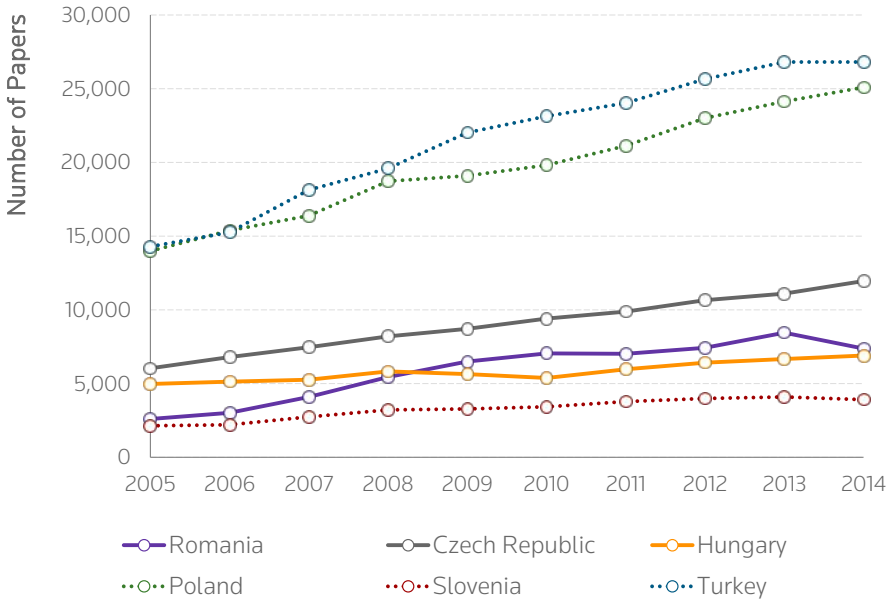


Figure 3.1.1 Publication output by Romania and comparator countries, 2005-2014

On an aggregate level, Turkey published the highest number of research papers (N = 161,112) while Slovenia the lowest (N = 24,895). In terms of percentage change over this ten year period, Romania led with a 184 % increase in publication output, followed by Czech Republic, 98 %, and Turkey, 88 %.

Table 3.1.1 Output of papers by country, 2005-2014

Publication Year	Romania	Czech Republic	Hungary	Poland	Slovenia	Turkey
2005	2,596	6,031	4,975	13,994	2,140	14,293
2006	3,012	6,805	5,138	15,384	2,205	15,260
2007	4,097	7,473	5,258	16,393	2,737	18,136
2008	5,451	8,209	5,823	18,724	3,210	19,600
2009	6,496	8,709	5,648	19,096	3,284	22,025
2010	7,049	9,410	5,386	19,824	3,419	23,144
2011	7,022	9,884	5,976	21,126	3,783	24,034
2012	7,427	10,656	6,424	23,011	3,986	25,665
2013	8,458	11,103	6,669	24,138	4,089	26,822
2014	7,381	11,958	6,903	25,092	3,912	26,818

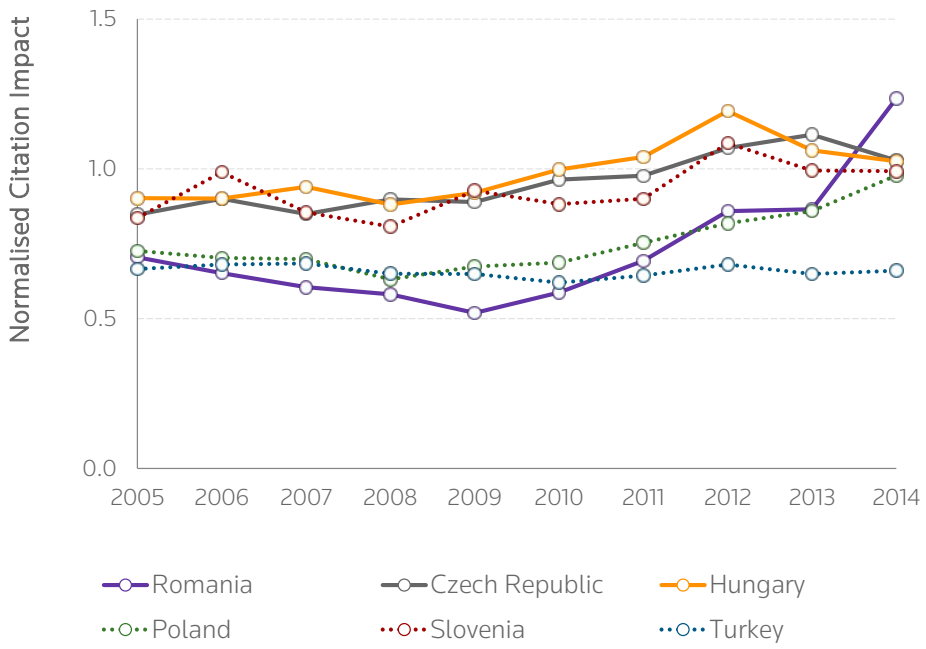


Figure 3.1.2 Average normalised citation impact (NCI) of papers by Romania and comparator countries, 2005-2014. Average world citation impact is set at NCI = 1.0

Citation trends of Romania and comparator countries share much similarity with one another. Notably, between 2005 and 2010, NCI for all six countries have stayed between 0.5 and 1.0. Since 2011, average NCIs for Czech Republic and Hungary have managed to surpass and stay above the world average citation impact. In 2014, Romania has experienced a 43 % increase in citation impact compared to 2013, and that year also marked the countries first in passing the world average citation impact mark.

Table 3.1.2 Average normalised citation impact of papers by country, 2005-2014

Publication Year	Romania	Czech Republic	Hungary	Poland	Slovenia	Turkey
2005	0.71	0.85	0.90	0.73	0.84	0.67
2006	0.65	0.90	0.90	0.70	0.99	0.68
2007	0.61	0.85	0.94	0.70	0.86	0.68
2008	0.58	0.90	0.88	0.63	0.81	0.65
2009	0.52	0.89	0.92	0.67	0.93	0.65
2010	0.59	0.96	1.00	0.69	0.88	0.62
2011	0.69	0.98	1.04	0.75	0.90	0.64
2012	0.86	1.07	1.19	0.82	1.09	0.68
2013	0.87	1.11	1.06	0.86	0.99	0.65
2014	1.24	1.03	1.03	0.98	0.99	0.66

3.2 How do publication output and research impact of Romania compare against comparator countries when Romania's top 10 ESI fields are examined?

Table 3.2.1 Top 10 Essential Science Indicators research fields in which Romania had the highest volume of publications, and the comparison with other countries in the same ESI categories. The category with the highest output is highlighted in **Red**.

		CHE	MTS	PHY	MAT	CLM	ENG	ENE	SSS	BBI	CPS
Number of Papers	Romania	**10,746**	9,298	7,734	5,583	4,716	4,230	2,573	2,136	1,639	1,395
	Czech Republic	**14,401**	5,077	11,040	3,815	10,053	4,591	2,848	2,391	5,477	1,857
	Hungary	**7,676**	1,820	7,120	3,260	7,770	2,660	1,318	1,787	3,802	1,202
	Poland	**31,936**	11,186	27,516	8,485	26,071	16,873	7,894	3,154	10,142	3,390
	Slovenia	3,749	2,618	3,835	1,485	**4,129**	3,518	932	2,365	1,419	845
	Turkey	18,356	10,980	10,623	6,952	**66,043**	21,844	5,943	9,220	6,723	4,428

Essential Science Indicator (ESI) Category Code	ESI Category Name
CHE	CHEMISTRY
MTS	MATERIALS SCIENCE
PHY	PHYSICS
MAT	MATHEMATICS
CLM	CLINICAL MEDICINE
ENG	ENGINEERING
ENE	ENVIRONMENT/ECOLOGY
SSS	SOCIAL SCIENCES, GENERAL
BBI	BIOLOGY & BIOCHEMISTRY
CPS	COMPUTER SCIENCE

Based on the analysis, it appears that much of the research effort has been placed in the area of Chemistry for Romania, Czech Republic, and Poland. Conversely, Hungary, Slovenia, Turkey seems to focus more in the field of Clinical Medicine.

Table 3.2.2 The average normalised citation impact of Romania's top 10 ESI research fields (by publication volume), and the comparison with other countries in those same categories. The category with the highest average NCI is highlighted in **Red**.

Average normalized citation impact	CHE	MTS	PHY	MAT	CLM	ENG	ENE	SSS	BBI	CPS
Romania	0.46	0.35	**1.07**	1.04	0.98	0.93	0.49	0.58	0.48	0.67
Czech Republic	0.89	0.77	**1.30**	0.94	1.27	0.87	1.16	0.65	0.73	0.78
Hungary	0.81	0.74	**1.59**	0.75	1.19	0.77	0.94	0.88	0.82	0.89
Poland	0.65	0.60	0.97	0.87	0.92	0.57	0.56	0.74	0.59	**0.98**
Slovenia	0.79	0.81	**1.63**	0.96	0.78	0.78	1.04	0.51	0.98	1.20
Turkey	0.74	0.74	1.08	**1.09**	0.48	0.95	0.52	0.65	0.57	1.00

Essential Science Indicator (ESI) Category Code	ESI Category Name
CHE	CHEMISTRY
MTS	MATERIALS SCIENCE
PHY	PHYSICS
MAT	MATHEMATICS
CLM	CLINICAL MEDICINE
ENG	ENGINEERING
ENE	ENVIRONMENT/ECOLOGY
SSS	SOCIAL SCIENCES, GENERAL
BBI	BIOLOGY & BIOCHEMISTRY
CPS	COMPUTER SCIENCE

For Romania and all of the 5 comparator countries, research in Physics seems to be well-recognized and well-cited. This is followed by research in Mathematics for Romania and Turkey, and Clinical Medicine for Czech Republic and Hungary.

4. Annex 1: The complete set of ESI Research Fronts to which Romania has contributed at least one core paper

Research Front Description	ESI Field Description	Number of papers produced by Romania
PLANCK 2013 RESULTS;PLANCK DATA;PLANCK ALL-SKY COMPTON PARAMETER MAP;PLANCK CATALOGUE;	SPACE SCIENCE	30
COUPLED COMMON FIXED POINT RESULTS;COUPLED FIXED POINT THEOREMS;COMMON FIXED POINT RESULTS;COMMON FIXED POINT THEOREMS;	MATHEMATICS	12
CONTINUED FRACTION APPROXIMATION;GAMMA FUNCTION;NEW QUICKER SEQUENCE CONVERGENT;NEW ASYMPTOTIC EXPANSION;	MATHEMATICS	7
LOCAL FRACTIONAL VARIATIONAL ITERATION METHOD;LOCAL FRACTIONAL VARIATION ITERATION METHOD;FRACTAL HEAT CONDUCTION PROBLEM SOLVED;	MATHEMATICS	6
02 TEV PROTON-LEAD COLLISIONS;P PLUS PB COLLISIONS;P-PB COLLISIONS;HIGH-ENERGY PROTON-NUCLEUS COLLISIONS;	PHYSICS	6
MIXED TYPE CUBIC-QUARTIC FUNCTIONAL EQUATION;ADDITIVE CAUCHY FUNCTIONAL EQUATION;GENERALIZED HYERS-ULAM STABILITY;ADDITIVE FUNCTIONAL EQUATION;	MATHEMATICS	6
PRECISE REAL-TIME FOUR POINT SINGLE SINUSOID SIGNALS INSTANTANEOUS FREQUENCY ESTIMATION METHOD;SINGLE SINE WAVE PARAMETERS ESTIMATION METHOD BASED;	ENGINEERING	5
NONLINEAR FRACTIONAL DIFFERENTIAL EQUATIONS;P-TYPE FRACTIONAL NEUTRAL DIFFERENTIAL EQUATIONS;FRACTIONAL NEUTRAL DIFFERENTIAL EQUATIONS;	MATHEMATICS	4
76 TEV;ROOT S(NN)=2;JET MOMENTUM DEPENDENCE;PBPB COLLISIONS;INCLUSIVE JET SUPPRESSION	PHYSICS	4
GEV AU PLUS AU COLLISIONS SERVE;76 TEV PB + PB COLLISIONS;AU PLUS AU COLLISIONS;76 TEV LEAD-LEAD COLLISIONS;RELATIVISTIC HEAVY-ION COLLISIONS	PHYSICS	4
MODIFIED KORTEWEG-DE VRIES EQUATION;NON-TOPOLOGICAL SOLITON SOLUTIONS;MULTIPLE SOLITON SOLUTIONS;COUPLED KORTEWEG-DE VRIES EQUATIONS;	MATHEMATICS	4
CONSTRAINING ANOMALOUS HIGGS BOSON INTERACTIONS;HIGGS BOSON DATA;LHC HIGGS DATA;HIGGS BOSON CANDIDATE;	PHYSICS	3
21ST CENTURY CLIMATE CHANGE THREATENS MOUNTAIN FLORA UNEQUALLY;CLIMATE CHANGE;EUROPES MOUNTAIN SUMMITS;MOUNTAIN VEGETATION;	ENVIRONMENT/ ECOLOGY	3
P PLUS PB COLLISIONS;ROOT S(NN)=5 TEV;02 TEV;ROOT S(NN)=5;CHARGED PARTICLES	PHYSICS	3

Research Front Description	ESI Field Description	Number of papers produced by Romania
HABENULAR ALPHA 5 NICOTINIC RECEPTOR SUBUNIT SIGNALLING CONTROLS NICOTINE INTAKE;NICOTINIC RECEPTOR GENE VARIANTS;	MOLECULAR BIOLOGY & GENETICS	3
PARTIALLY ORDERED METRIC SPACES;QUADRUPLE FIXED POINT THEOREMS;TRIPLED FIXED POINT THEOREMS;CONTRACTIVE TYPE MAPPINGS;	MATHEMATICS	3
DECAY B-S(0) -> J/PSI PHI;FLAVOR-TAGGED DECAY B-S(0)-> J/PSI PHI;B-S(0) -> J/PSI PI(+) PI(-)DECAYS;B-S(0) -> J/PSI K+K-;B-S(0)-> J/PSI PHI DECAYS	PHYSICS	3
B -> K (AU) MU (+) MU (-) ANOMALY;331 MODELS FACING NEW B -> S MU(+)MU(-) DATA;B -> K* MU(+) MU(-) ANOMALY;RARE DECAYS B -> K *L(+)L(-);B -> K* FORM FACTORS	PHYSICS	3
ADVANCED NON-SQUAMOUS NON-SMALL-CELL LUNG CANCER (PARAMOUNT);ADVANCED NON-SMALL-CELL LUNG CANCER;MAINTENANCE PEMETREXED PLUS;CISPLATIN PLUS PEMETREXED;PEMETREXE	CLINICAL MEDICINE	3
DOUBLE-DIFFUSIVE NATURAL CONVECTIVE BOUNDARY LAYER FLOW;DOUBLE-DIFFUSIVE NATURAL CONVECTIVE BOUNDARY-LAYER FLOW;NATURAL CONVECTIVE BOUNDARY-LAYER FLOW;	ENGINEERING	2
GEOGRAPHIC OBJECT-BASED IMAGE ANALYSIS;OBJECT-BASED IMAGE ANALYSIS;MULTI-SCALE IMAGE SEGMENTATION;OBJECT BASED IMAGE ANALYSIS;	GEOSCIENCES	2
PHASE 3 RANDOMISED DOUBLE-BLIND ACTIVE-CONTROLLED TRIAL;R5 HIV-1 INFECTION;RESISTANT HIV-1 INFECTION;SECOND-GENERATION INTEGRASE STRAND TRANSFER INHIBITOR DOLUT	CLINICAL MEDICINE	2
TRIEBEL-LIZORKIN-TYPE SPACES INCLUDING Q SPACES;FUNCTION SPACES CONNECTING TRIEBEL-LIZORKIN SPACES;NEW HARDY SPACES;MUSIELAK-ORLICZ HARDY SPACES;	MATHEMATICS	2
LARGE EXTRA DIMENSIONS;MISSING TRANSVERSE MOMENTUM;DARK MATTER CANDIDATES;MISSING TRANSVERSE ENERGY;	PHYSICS	2
STANDARD MODEL HIGGS BOSON DECAYING;STANDARD MODEL HIGGS BOSON;ROOT S=7 TEV;PP COLLISION DATA;DECAY CHANNEL H -> ZZ -> 4L	PHYSICS	2
TRAUMA REQUIRING MASSIVE TRANSFUSION;MAJOR TRAUMA TRANSFUSION (PROMMTT);BLEEDING TRAUMA PATIENTS;MAJOR TRAUMA PATIENTS;466 MASSIVELY TRANSFUSED CIVILIAN TRAUMA	CLINICAL MEDICINE	2
INTERVAL-VALUED INTUITIONISTIC FUZZY SOFT SETS;INTERVAL-VALUED FUZZY SOFT SETS;GENERALISED FUZZY SOFT SETS;FUZZY SOFT SETS;	MATHEMATICS	2

Research Front Description	ESI Field Description	Number of papers produced by Romania
PLANCK EARLY RESULTS;PLANCK MISSION;PLANCK PRE-LAUNCH STATUS;PLANCK;EARLY RELEASE COMPACT SOURCE CATALOGUE	SPACE SCIENCE	2
ACUTE DECOMPENSATED HEART FAILURE;ROSE ACUTE HEART FAILURE RANDOMIZED TRIAL;ACUTE HEART FAILURE (RELAX-AHF) DEVELOPMENT PROGRAM CORRELATION;	CLINICAL MEDICINE	2
ROOT S=7 TEV PP COLLISIONS;ROOT S=7 TEV PROTON-PROTON COLLISIONS;MISSING TRANSVERSE MOMENTUM;MISSING TRANSVERSE ENERGY;	PHYSICS	2
RANDOMIZED PHASE III TRIAL COMPARING CHEMOTHERAPY PLUS;PREVIOUSLY UNTREATED ADVANCED GASTRIC CANCER (EXPAND);RANDOMISED PHASE 3 TRIAL;OPEN-LABEL PHASE 3 TRIAL;	CLINICAL MEDICINE	2
METASTATIC COLORECTAL CANCER PATIENTS;13 WILD-TYPE METASTATIC COLORECTAL CANCER;CHEMOTHERAPY-REFRACTORY METASTATIC COLORECTAL CANCER;	CLINICAL MEDICINE	2
LAST INTERGLACIAL PERIOD;LAST INTERGLACIAL STAGE;LAST INTERGLACIAL;ANTARCTIC ICE CORE CHRONOLOGY (AICC2012);	GEOSCIENCES	2
LOW-COST FUZZY CONTROLLERS;FUZZY CONTROL;EVOLUTIONARY OPTIMIZATION-BASED TUNING;SERVO SYSTEMS;	COMPUTER SCIENCE	2
E(+)E(-) -> PI PI J/PSI;E(+)E(-) -> PI(+)PI(-) J/PSI;CHARGED CHARMONIUMLIKE STRUCTURE Z(C) (4020);E(+)E(-) -> PI D(D)OVER-BAR*;CHARGED CHARMONIUMLIKE STRUCTURE	PHYSICS	2
MHD NATURAL CONVECTION HEAT TRANSFER;CU-WATER NANOFLUID HEAT TRANSFER;MHD CUO-WATER NANOFLUID FLOW;MHD NANOFLUID FLOW;	ENGINEERING	2
76 TEV;PB-PB COLLISIONS;ROOT S(NN)=2;CENTRALITY DEPENDENCE;CENTRALITY DETERMINATION	PHYSICS	2
NONLINEAR FRACTIONAL DIFFERENTIAL EQUATION;PARTIALLY ORDERED METRIC SPACES;PARTIALLY ORDERED BANACH SPACES;	MATHEMATICS	2
COUPLED COINCIDENCE POINT THEOREMS;COUPLED FIXED POINT THEOREMS;MIXED MONOTONE NONLINEAR OPERATORS;PHI-CONTRACTIVE MIXED MONOTONE MAPPINGS;	MATHEMATICS	2
REACTIVE DIVIDING-WALL COLUMN;DIVIDING WALL COLUMNS;BTX DIVIDING-WALL COLUMN;DIVIDING-WALL COLUMNS;	ENGINEERING	2
ROOT S=7 TEV;CHARGED-PARTICLE MULTIPLICITY MEASUREMENT;PROTON-PROTON COLLISIONS;ROOT S=0;36 TEV	PHYSICS	2

Research Front Description	ESI Field Description	Number of papers produced by Romania
NONALCOHOLIC FATTY LIVER DISEASE (NAFLD);NONALCOHOLIC FATTY LIVER DISEASE;VIVO LIVER FIBROSIS EVALUATION;NON-ALCOHOLIC FATTY LIVER DISEASE;	CLINICAL MEDICINE	2
ENDOUROLOGICAL SOCIETY URETEROSCOPY GLOBAL;CLINICAL RESEARCH OFFICE;URETERAL WALL INJURIES RESULTING;MULTIPLE URETERAL LOCATIONS;	CLINICAL MEDICINE	2
NEW BOSON;STANDARD MODEL HIGGS BOSON;NEW PARTICLE;LHC;OBSERVATION	PHYSICS	2
TWO HEAT CONDUCTING MICROPOLAR THERMOELASTIC SOLIDS;THIRD-ORDER MULTI-POINT BOUNDARY VALUE PROBLEM;POROUS MICROPOLAR BODIES;IMPERFECT BOUNDARY;	MATHEMATICS	2
B-+/- -> PI(+)PI(-)PI(+/-) DECAYS;B-+/- -> K+K-PI(+/-);CP VIOLATION;DECAYS;B-S(0) MESONS	PHYSICS	2
LHCB RICH DETECTOR;LHCB DETECTOR;LHCB MUON SYSTEM;LHCB OUTER TRACKER;	CHEMISTRY	2
OPTIMAL HOMOTOPY ASYMPTOTIC METHOD APPLIED;OPTIMAL HOMOTOPY ASYMPTOTIC METHOD;FOURTH-GRADE FLUID PAST;SOLVING NONLINEAR EQUATIONS;	ENGINEERING	2
SOLVING MULTI-TERM FRACTIONAL ORDERS DIFFERENTIAL EQUATIONS;SOLVING MULTI-TERM FRACTIONAL DIFFERENTIAL EQUATIONS;	MATHEMATICS	2
OPTIMAL HOMOTOPY ASYMPTOTIC METHOD APPLIED;OPTIMAL HOMOTOPY ASYMPTOTIC METHOD;FOURTH-GRADE FLUID PAST;SOLVING NONLINEAR EQUATIONS;HEAT TRANSFER	MATHEMATICS	2
CLINICAL USE;EFSUMB GUIDELINES;ULTRASOUND ELASTOGRAPHY;CLINICAL APPLICATIONS;RECOMMENDATIONS	CLINICAL MEDICINE	2
EUROBSERVATIONAL RESEARCH PROGRAMME ATRIAL FIBRILLATION (EORP-AF) PILOT GENERAL REGISTRY;RE-LY ATRIAL FIBRILLATION REGISTRY;ATRIAL FIBRILLATION MANAGEMENT;ATRIA	CLINICAL MEDICINE	2
GUAIAC FAECAL OCCULT BLOOD TESTS;FULL SUPPLEMENT PUBLICATION;COLORECTAL CANCER SCREENING;COMPARING PARTICIPATION RATES;EUROPEAN GUIDELINES	CLINICAL MEDICINE	1
PHASE II/III SYSTEMIC LUPUS ERYTHEMATOSUS EVALUATION;SYSTEMIC LUPUS ERYTHEMATOSUS RESULTS;MODERATE/SEVERE ACTIVE SYSTEMIC LUPUS ERYTHEMATOSUS;MODERATELY-TO-SEVE	CLINICAL MEDICINE	1

Research Front Description	ESI Field Description	Number of papers produced by Romania
HUMAN EPIDERMAL GROWTH FACTOR RECEPTOR 2-POSITIVE METASTATIC BREAST CANCER;ADVANCED HUMAN EPIDERMAL GROWTH FACTOR RECEPTOR 2-POSITIVE BREAST CANCER;	CLINICAL MEDICINE	1
STATIONARY REFERENCE FRAME GRID SYNCHRONIZATION SYSTEM;DISTORTED GRID CONDITIONS;ADVERSE GRID CONDITIONS;GRID SYNCHRONIZATION;	ENGINEERING	1
EXPLORING CROSS-SECTORAL CLIMATE CHANGE IMPACTS;INTERACTIVELY MODELLING LAND PROFITABILITY;CROSS-SECTORAL WATER ALLOCATION SCHEMES;	GEOSCIENCES	1
MAGNETICALLY RECYCLABLE MAGNETITE-CERIA (NANOCAT-FE-CE) NANOCATALYST;MAGNETICALLY RECYCLABLE NANOCATALYST SYSTEMS;MAGNETICALLY RECYCLABLE NANOCATALYSTS;	CHEMISTRY	1
HIERARCHICAL ZEOLITE CATALYSTS;HIERARCHICAL ZEOLITES;AMMONIA SELECTIVE CATALYTIC REDUCTION ACTIVITY;CATALYTIC NOX ABATEMENT SYSTEMS;	CHEMISTRY	1
HIGH BLOOD PRESSURE;DIFFERENT FIXED-DOSE COMBINATION THERAPIES;REDUCING BLOOD PRESSURE;PATIENTS 80 YEARS;	CLINICAL MEDICINE	1
ST-ELEVATION ACUTE CORONARY SYNDROMES INTENDED;ACUTE CORONARY SYNDROMES INTENDED;PATIENT OUTCOMES (PLATO) TRIAL SUBGROUP ANALYSIS;	CLINICAL MEDICINE	1
ALLERGIC RHINITIS;ASTHMA (ARIA) 2008 UPDATE (IN COLLABORATION;ASTHMA (ARIA) GUIDELINES;RHINITIS;	IMMUNOLOGY	1
WILD-TYPE KRAS EXON 2 METASTATIC COLORECTAL CANCER;METASTATIC COLORECTAL CANCER (FIRE-3);METASTATIC COLORECTAL CANCER;RANDOMIZED PHASE 3;	CLINICAL MEDICINE	1
FRACTIONAL PARTIAL DIFFERENTIAL EQUATIONS;FRACTIONAL ORDER DERIVATIVES;FRACTIONAL DERIVATIVES;FRACTIONAL DERIVATIVES-NEW LAGRANGE MULTIPLIERS;	MATHEMATICS	1
DIFFERENT FLORAL ORIGIN HONEYS;MONOFLORAL CUBAN HONEYS;MONOFLORAL HONEYS;PHENOLIC COMPOUNDS EXTRACTS;PORTUGUESE HONEY SAMPLES;	AGRICULTURAL SCIENCES	1
ULIPRISTAL ACETATE;UTERINE FIBROIDS;LEUPROLIDE ACETATE;FIBROID TREATMENT;	CLINICAL MEDICINE	1
MULTIDRUG RESISTANT PULMONARY TUBERCULOSIS TREATMENT REGIMENS;MULTIDRUG-RESISTANT PULMONARY TUBERCULOSIS;MULTIDRUG-RESISTANT TUBERCULOSIS;	CLINICAL MEDICINE	1

Research Front Description	ESI Field Description	Number of papers produced by Romania
ZERO ISCHEMIA ANATOMICAL PARTIAL NEPHRECTOMY;ZERO ISCHEMIA PARTIAL NEPHRECTOMY;LAPAROSCOPIC PARTIAL NEPHRECTOMY CASES;LAPAROSCOPIC PARTIAL NEPHRECTOMY;	CLINICAL MEDICINE	1
HIERARCHICAL ENERGY MANAGEMENT SYSTEM;STAND-ALONE HYBRID SYSTEM BASED;STAND-ALONE PV/HYDROGEN/BATTERY-BASED HYBRID SYSTEM;STAND-ALONE POWER SYSTEM;	ENGINEERING	1
OPTICAL SOLITON PERTURBATION;NONLINEAR SCHRODINGERS EQUATION;NON-KERR LAW MEDIA;NANO FIBERS	ENGINEERING	1
ABOVE-GROUND WOODY CARBON SEQUESTRATION MEASURED;NONSTRUCTURAL CARBON;WOODY PLANTS;FIVE EDDY-COVARIANCE SITES;NET ECOSYSTEM PRODUCTIVITY	PLANT & ANIMAL SCIENCE	1
SUICIDAL BEHAVIOR;SUICIDAL IDEATION;WORLD MENTAL HEALTH SURVEYS;CROSS-NATIONAL ANALYSIS;MENTAL DISORDERS	SOCIAL SCIENCES, GENERAL	1
DISCRETE SEQUENTIAL FRACTIONAL BOUNDARY VALUE PROBLEMS;DISCRETE FRACTIONAL BOUNDARY VALUE PROBLEMS;NONLINEAR HIGHER ORDER PERTURBED FRACTIONAL DIFFERENTIAL EQUATIONS;	MATHEMATICS	1
PLACEBO PLUS DOCETAXEL;DOCETAXEL PLUS PLACEBO;RANDOMISED PHASE 3 TRIAL;DOCETAXEL PLUS NINTEDANIB;RAMUCIRUMAB PLUS DOCETAXEL	CLINICAL MEDICINE	1
FRACTIONAL PARTIAL DIFFERENTIAL EQUATIONS;FRACTIONAL ORDER DERIVATIVES;FRACTIONAL DERIVATIVES;FRACTIONAL DERIVATIVES-NEW LAGRANGE MULTIPLIERS;ATTRACTOR ONE-DIME	ENGINEERING	1
HADRON COLLIDERS;HADRONIC TOP-QUARK PAIR PRODUCTION;TOP PAIR PRODUCTION;TOP PLUS PLUS;TOP-PAIR PRODUCTION	PHYSICS	1
HELIUM-BURNING RED GIANT STARS;SOLAR-TYPE STARS;RED-GIANT STARS;GRAVITY-DOMINATED MIXED MODES;GRAVITY MODES	SPACE SCIENCE	1
CIRCULATING LONG NONCODING RNA;CARDIAC FIBROBLAST-DERIVED MICRORNA PASSENGER STRAND-ENRICHED EXOSOMES;LONG NONCODING RNA CHRF;LONG NONCODING RNA MALAT1;PATHOLOG	CLINICAL MEDICINE	1
INFLAMMATORY BOWEL DISEASE;CROHNS DISEASE;NONMELANOMA SKIN CANCER;RISK;ANTI-TUMOUR NECROSIS FACTOR-ALPHA THERAPY	CLINICAL MEDICINE	1
CLASSICAL ENTROPY GENERATION ANALYSIS;ENTROPY GENERATION ANALYSIS;ENTROPY GENERATION;INTERNAL HEAT GENERATION;NANOFLUID FLOW	ENGINEERING	1

Research Front Description	ESI Field Description	Number of papers produced by Romania
THREE SYNCHRONIZED GREENLAND ICE-CORE RECORDS;EXTENDED INTIMATE(1) EVENT STRATIGRAPHY;INTIMATE EVENT STRATIGRAPHY;LAST 60;	GEOSCIENCES	1
76 TEV;PB-PB COLLISIONS;J/PSI SUPPRESSION;SUPPRESSION;EXCITED UPSILON STATES	PHYSICS	1
2013 AMBULATORY BLOOD PRESSURE MONITORING RECOMMENDATIONS;AMBULATORY MONITORING REDUCES CARDIOVASCULAR RISK;AMBULATORY BLOOD PRESSURE REGULATION;	BIOLOGY & BIOCHEMISTRY	1
CHRONIC HEPATITIS C VIRUS GENOTYPE 1 INFECTION (QUEST-1);CHRONIC HEPATITIS C VIRUS GENOTYPE 1 INFECTION (QUEST-2);PEGYLATED INTERFERON ALFA 2A PLUS RIBAVIRIN;	CLINICAL MEDICINE	1
ACUTE CORONARY SYNDROME;MAJOR CORONARY EVENTS;SOLID-TIMI 52 RANDOMIZED CLINICAL TRIAL;VISTA-16 RANDOMIZED CLINICAL TRIAL;STABLE CORONARY HEART DISEASE	CLINICAL MEDICINE	1
SPECIFIC SIRT1 ACTIVATION MIMICS LOW ENERGY LEVELS;RESVERATROL AMELIORATES AGING-RELATED METABOLIC PHENOTYPES;ACUTE RESVERATROL SUPPLEMENTATION;HIGH-DOSE RESVER	CLINICAL MEDICINE	1
HIGH-RISK PERMANENT ATRIAL FIBRILLATION;PERSISTENT ATRIAL FIBRILLATION;ATRIAL FIBRILLATION;SEVERE HEART FAILURE;HEART FAILURE	CLINICAL MEDICINE	1
REAL MAXIMUM POWER POINT TRACKING METHOD;MAXIMUM POWER POINT TRACKING TECHNIQUES;MAXIMUM POWER POINT TRACKING TECHNIQUE;DISTRIBUTED MAXIMUM POWER POINT TRACKING	ENGINEERING	1
PARTIAL METRIC FIXED POINT RESULTS;ORDERED PARTIAL METRIC SPACES;PARTIAL METRIC SPACES;PARTIALLY ORDERED METRIC SPACES;PARTIAL HAUSDORFF METRIC	MATHEMATICS	1
FLUCLOXACILLIN-INDUCED LIVER INJURY;DRUG-INDUCED LIVER INJURY;AMOXICILLIN-CLAVULANATE-INDUCED LIVER INJURY;DRUG-SPECIFIC T CELLS PROVIDES;	CLINICAL MEDICINE	1
FRACTIONAL-ORDER NEURAL NETWORKS;NONLINEAR DYNAMICS;DYNAMIC ANALYSIS;CHAOS;	COMPUTER SCIENCE	1
HUMAN HEPATOCELLULAR CARCINOMA PROGRESSION;HEPATOCELLULAR CARCINOMA;MICRORNA-101;C-MYC-MEDIATED EPIGENETIC SILENCING;CYTOSTATIC DRUG SENSITIVITY	CLINICAL MEDICINE	1
ACUTE MYOCARDIAL INFARCTION (HORIZONS-AMI);ACUTE MYOCARDIAL INFARCTION (CARESS-IN-AMI);ACUTE ST-SEGMENT-ELEVATION MYOCARDIAL INFARCTION;	CLINICAL MEDICINE	1
HEAT WAVES AFFECT MORTALITY;2006 CALIFORNIA HEAT WAVE;EUROPEAN HEAT WAVE;2006 HEAT WAVE;	SOCIAL SCIENCES, GENERAL	1

Research Front Description	ESI Field Description	Number of papers produced by Romania
TRANSMITTED HIV DRUG RESISTANCE;LOW-FREQUENCY HIV-1 DRUG RESISTANCE MUTATIONS;MINORITY HIV-1 DRUG RESISTANCE MUTATIONS;HIV DRUG RESISTANCE;	PHARMACOLOGY & TOXICOLOGY	1
POLYBROMINATED DIPHENYL ETHER (PBDE) FLAME RETARDANTS;POLYBROMINATED DIPHENYL ETHERS (PBDES);POLYBROMINATED DIPHENYL ETHERS;	ENVIRONMENT/ ECOLOGY	1
SPLIT FEASIBILITY PROBLEM;NONSPREADING TYPE MAPPING;STRONG-CONVERGENCE THEOREMS;HILBERT SPACES;	MATHEMATICS	1
POROUS ORGANIC MOLECULAR MATERIALS;POROUS ORGANIC MOLECULAR CRYSTALS;POROUS ORGANIC CAGE NANOCRYSTALS;DYNAMIC COVALENT CHEMISTRY;DYNAMIC COMBINATORIAL CHEMISTRY	CHEMISTRY	1
ISCHEMIC HEART DISEASE EVOLVING KNOWLEDGE;ISCHAEMIC HEART DISEASE;CORONARY PATHOPHYSIOLOGY;PATHOPHYSIOLOGY;	CLINICAL MEDICINE	1
ACTIVE RELAPSING MULTIPLE SCLEROSIS (CHOICE STUDY);RELAPSING MULTIPLE SCLEROSIS (THE REBIF;REAL-WORLD RELAPSING MULTIPLE SCLEROSIS POPULATION;	CLINICAL MEDICINE	1
LIGHT TOP PARTNERS;LIGHT COMPOSITE HIGGS;FIRST TOP PARTNER HUNTERS GUIDE;TOP PARTNER SEARCHES;LEPTON PLUS JETS FINAL STATE	PHYSICS	1
ACCURATE EXPERIMENTAL NUCLEAR REACTION DATA LIBRARY (EXFOR);NUCLEAR REACTION DATA CENTRES (NRDC);MODERN NUCLEAR DATA EVALUATION;1 NUCLEAR DATA;	PHYSICS	1
MAGNETIC CATALYSIS (AND INVERSE CATALYSIS);INVERSE MAGNETIC CATALYSIS;STRONG MAGNETIC FIELD;EXTERNAL MAGNETIC FIELD;	PHYSICS	1
GUAIAC FAECAL OCCULT BLOOD TESTS;FULL SUPPLEMENT PUBLICATION;COLORECTAL CANCER SCREENING;COMPARING PARTICIPATION RATES;EUROPEAN GUIDELINES	SOCIAL SCIENCES, GENERAL	1
2011 FUKUSHIMA DAI-ICHI NUCLEAR POWER PLANT ACCIDENT;FUKUSHIMA DAI-ICHI NUCLEAR POWER PLANT ACCIDENT;FUKUSHIMA DAIICHI NUCLEAR POWER PLANT ACCIDENT;	ENVIRONMENT/ ECOLOGY	1
GENERALIZED LOGARITHMIC MEAN;GENERALIZED LOGARITHMIC MEANS;NEUMAN-SANDOR MEAN;SCHWAB-BORCHARDT MEAN;NEUMAN-SANDOR MEANS	MATHEMATICS	1
FIXED POINT THEORY;FIXED POINT THEOREM;CYCLIC (I CENTER DOT-PSI)-CONTRACTIONS;CYCLIC GENERALIZED CONTRACTIONS;CYCLIC WEAK PHI-CONTRACTION	MATHEMATICS	1
HEPATITIS C VIRUS EPIDEMIOLOGY;SYSTEMATIC;ASIA;AUSTRALIA;CANADA	CLINICAL MEDICINE	1

Research Front Description	ESI Field Description	Number of papers produced by Romania
HIGH PERFORMANCE AMBIPOLAR ORGANIC FIELD EFFECT TRANSISTORS;AIR-STABLE FIELD-EFFECT TRANSISTORS;HYDROGEN-BONDED SEMICONDUCTING PIGMENTS;NATURAL PIGMENT;	MATERIALS SCIENCE	1
FIVE SUSCEPTIBILITY LOCI;TERT-CLPTM1L LOCUS ASSOCIATE;GENOME-WIDE ASSOCIATION;SEQUENCE VARIANTS;CANCER TYPES	MOLECULAR BIOLOGY & GENETICS	1
MILD COGNITIVE IMPAIRMENT;SUBJECTIVE COGNITIVE IMPAIRMENT;ALZHEIMERS DISEASE NEUROIMAGING INITIATIVE SUBJECTS;ALZHEIMERS DISEASE PATHOLOGY;	NEUROSCIENCE & BEHAVIOR	1
7 TEV PP COLLISIONS;DIJET MASS DISTRIBUTION;DIJET MASS SPECTRUM;ROOT S=7 TEV COLLECTED;PP COLLISION DATA	PHYSICS	1
FRACTIONAL SUBEQUATION METHOD;SOLVING FRACTIONAL RICCATI DIFFERENTIAL EQUATION;MODIFIED VARIATIONAL ITERATION METHOD;ADOMIAN POLYNOMIALS;KLEIN-GORDON EQUATIONS	MATHEMATICS	1
GENERALIZED PHI-WEAK CONTRACTIONS;FIXED POINT THEORY;COMMON FIXED POINT;PHI)-WEAK CONTRACTIONS;	MATHEMATICS	1
GENOTYPE 1 HEPATITIS C VIRUS INFECTION (LONESTAR);CHRONIC HEPATITIS C GENOTYPE 1;HEPATITIS C VIRUS GENOTYPE 1 NULL RESPONDERS;HEPATITIS C VIRUS GENOTYPE 1;	CLINICAL MEDICINE	1
ADVANCED NON-SMALL-CELL LUNG CANCER;NON-SMALL-CELL LUNG CANCER;SECOND-LINE TREATMENT;RANDOMISED MULTICENTRE;	CLINICAL MEDICINE	1
ADVANCED NONSQUAMOUS NON-SMALL-CELL LUNG CANCER;ADVANCED NON-SMALL-CELL LUNG CANCER (ZODIAC);ADVANCED NON-SMALL-CELL LUNG CANCER;	CLINICAL MEDICINE	1
METASTATIC CASTRATION-RESISTANT PROSTATE CANCER;IMMUNE-MEDIATED ABSCOPAL EFFECT;ABSCOPAL EFFECT;CANCER TREATMENT;SINGLE-DOSE RADIOTHERAPY	CLINICAL MEDICINE	1
ACUTE CORONARY SYNDROME RESULTS;ACUTE CORONARY SYNDROME;ACUTE CORONARY SYNDROMES (ATLAS ACS-TIMI 46);ACUTE CORONARY SYNDROMES;	CLINICAL MEDICINE	1
FULL TUNGSTEN WALL;FUSION POWER REACTOR STRUCTURAL MATERIALS;INITIAL ITER-LIKE WALL EXPERIMENTS;ITER PLASMA-FACING COMPONENTS;	ENGINEERING	1
HOT EXTREMES;HOT DAYS;ASYMMETRIC EUROPEAN SUMMER HEAT PREDICTABILITY;INVESTIGATING SOIL MOISTURE-CLIMATE INTERACTIONS;DRY SOUTHERN WINTERS	GEOSCIENCES	1
PHASE III RANDOMIZED TRIAL COMPARING;RECURRENT INTRACRANIAL GLIOBLASTOMA;RECURRENT GLIOBLASTOMA;PHASE III;RANDOMIZED TRIAL	CLINICAL MEDICINE	1

Research Front Description	ESI Field Description	Number of papers produced by Romania
CENTRAL EUROPEAN LOW MOUNTAIN RANGE;CRYPTIC BIODIVERSITY LOSS LINKED;GLOBAL CLIMATE CHANGE;STONEFLY DINOCRAS CEPHALOTES;DISPERSAL POTENTIAL	SOCIAL SCIENCES, GENERAL	1
COMPARATIVE PROTEOMIC ANALYSIS;CELL CULTURE DEPENDS;EXTRACELLULAR MATRIX PROTEIN;HUMAN LUNG TELOCYTES;TELOPODES (TELOCYTE PROLONGATIONS)	MOLECULAR BIOLOGY & GENETICS	1
MISSING TRANSVERSE ENERGY;MISSING TRANSVERSE MOMENTUM;SEARCH;JETS;ROOT S=7 TEV PROTON-PROTON COLLISIONS	PHYSICS	1
5-FLAVOR NEXT-TO-NEXT-TO-LEADING ORDER PARTON DISTRIBUTION FUNCTIONS;INCLUSIVE E(+/-)P SCATTERING CROSS SECTIONS;DEEP-INELASTIC-SCATTERING DATA;QCD ANALYSIS;HAD	PHYSICS	1
METASTATIC RENAL CELL CARCINOMA;METASTATIC RENAL-CELL CARCINOMA;CROSS-OVER TRIAL ASSESSING TREATMENT PREFERENCE;PHASE III TRIAL;PATIENTS	CLINICAL MEDICINE	1
INFLAMMATORY BOWEL DISEASE;CROHNS DISEASE;EUROPE;COMMERCIALLY INSURED US POPULATION;ECCO-EPICOM INCEPTION COHORT	CLINICAL MEDICINE	1
IDIOPATHIC MEMBRANOUS NEPHROPATHY;PRIMARY MEMBRANOUS NEPHROPATHY;MEMBRANOUS NEPHROPATHY;PHOSPHOLIPASE A2 RECEPTOR AUTOANTIBODIES;ANTI-PHOSPHOLIPASE A(2) RECEPTO	CLINICAL MEDICINE	1
EULAR SCLERODERMA TRIALS;SYSTEMIC SCLEROSIS;RESEARCH (EUSTAR) DATABASE;RESEARCH GROUP (EUSTAR);	CLINICAL MEDICINE	1
2500 DEG(2) SOUTH POLE TELESCOPE SURVEY;2008 SOUTH POLE TELESCOPE OBSERVATIONS;ALL-SKY EARLY SUNYAEV-ZELDOVICH CLUSTER SAMPLE;SUNYAEV-ZELDOVICH-SELECTED GALAXY	SPACE SCIENCE	1
UNIDIRECTIONAL NONLINEAR PT-SYMMETRIC OPTICAL STRUCTURES;PT-SYMMETRIC MIXED LINEAR-NONLINEAR OPTICAL LATTICES;PT-SYMMETRIC OPTICAL LATTICES;	PHYSICS	1
ECOSYSTEM METABOLISM;STREAM ECOSYSTEM FUNCTIONING;STREAM METABOLISM;ALLOCHTHONOUS ORGANIC MATTER DYNAMICS;	PLANT & ANIMAL SCIENCE	1
LOW DENSITY LIPOPROTEIN (LDL) SUBCLASSES;CLINICAL SIGNIFICANCE;DYSFUNCTIONAL HDL;EXPERT PANEL STATEMENT;RAISING HIGH-DENSITY LIPOPROTEIN CHOLESTEROL (HDL-C)	PHARMACOLOGY & TOXICOLOGY	1
MUSSEL-INSPIRED POLYDOPAMINE COATING;MUSSEL-INSPIRED POLYDOPAMINE CAPSULES;MUSSEL-INSPIRED POLYMER COATING;ONE-STEP MULTIPURPOSE SURFACE FUNCTIONALIZATION;	CHEMISTRY	1

Research Front Description	ESI Field Description	Number of papers produced by Romania
CENTRAL EUROPEAN LOW MOUNTAIN RANGE;CRYPTIC BIODIVERSITY LOSS LINKED;GLOBAL CLIMATE CHANGE;STONEFLY DINOCRAS CEPHALOTES;	PLANT & ANIMAL SCIENCE	1
SUICIDAL BEHAVIOR;SUICIDAL IDEATION;WORLD MENTAL HEALTH SURVEYS;CROSS-NATIONAL ANALYSIS;	PSYCHIATRY/ PSYCHOLOGY	1
ASYNCHRONOUS SPIKING NEURAL P SYSTEMS;FUZZY REASONING SPIKING NEURAL P SYSTEM;TISSUE MEMBRANE SYSTEMS;SOLVING CONSTRAINED MANUFACTURING PARAMETER OPTIMIZATION	COMPUTER SCIENCE	1
COUPLED COMMON FIXED POINT RESULTS;GENERALIZED PARTIALLY ORDERED G-METRIC SPACES;COUPLED FIXED POINT RESULTS;COMMON FIXED POINT RESULTS;	MATHEMATICS	1
PARTIALLY ORDERED METRIC SPACES;ORDERED METRIC SPACES;FIXED POINT THEOREMS;PARTIALLY ORDERED SETS;FIXED POINT THEOREM	MATHEMATICS	1
LOW DENSITY LIPOPROTEIN (LDL) SUBCLASSES;CLINICAL SIGNIFICANCE;DYSFUNCTIONAL HDL;EXPERT PANEL STATEMENT;RAISING HIGH-DENSITY LIPOPROTEIN CHOLESTEROL (HDL-C)	BIOLOGY & BIOCHEMISTRY	1
HEART FAILURE LESSONS LEARNED;HOSPITALIZED HEART FAILURE REGISTRIES;HEART FAILURE;AMERICAN HEART ASSOCIATION;POLICY STATEMENT	CLINICAL MEDICINE	1
LAMIVUDINE-RESISTANT CHRONIC HEPATITIS B;TENOFOVIR DISOPROXIL FUMARATE;CHRONIC HEPATITIS B;PATIENTS;NO DETECTABLE RESISTANCE	CLINICAL MEDICINE	1
GOOD CLINICAL PRACTICE RECOMMENDATIONS;ULTRASOUND (CEUS);UPDATE 2012;WFUMB-EFSUMB INITIATIVE;UPDATE 2011	CLINICAL MEDICINE	1
ATRIAL FIBRILLATION ABLATION;ATRIAL FIBRILLATION;PATIENTS;CARDIOVERSION;WARFARIN	CLINICAL MEDICINE	1
FIRST-GENERATION ANTIPSYCHOTIC DRUGS;ANTIPSYCHOTIC DRUGS;FIRST-EPISODE SCHIZOPHRENIA;SCHIZOPHRENIA;SECOND-GENERATION ANTIPSYCHOTICS	CLINICAL MEDICINE	1
ACUTE INTERMEDIATE-RISK PULMONARY EMBOLISM;INTERMEDIATE-RISK PULMONARY EMBOLISM;SUBMASSIVE PULMONARY EMBOLISM;MODERATE PULMONARY EMBOLISM;	CLINICAL MEDICINE	1
METRIC SPACE;FIXED POINT RESULTS;FIXED POINT THEOREMS;METRIC SPACES;	MATHEMATICS	1
FLASH FLOOD WARNING BASED;SELECTED EXTREME FLASH FLOODS;EUROPEAN FLASH FLOODS;FLOOD RISK MANAGEMENT;SOIL MOISTURE CONDITIONS	ENGINEERING	1

Research Front Description	ESI Field Description	Number of papers produced by Romania
ECOSYSTEM METABOLISM;STREAM ECOSYSTEM FUNCTIONING;STREAM METABOLISM;ALLOCHTHONOUS ORGANIC MATTER DYNAMICS;	ENVIRONMENT/ ECOLOGY	1
SUICIDAL BEHAVIOR;SUICIDAL IDEATION;WORLD MENTAL HEALTH SURVEYS;CROSS-NATIONAL ANALYSIS;MENTAL DISORDERS;	CLINICAL MEDICINE	1

5. Annex 2: Bibliometrics and Citation analysis

Bibliometrics are about publications and their citations. The academic field emerged from 'information science' and now usually refers to the methods used to study and index texts and information.

Publications cite other publications. These citation links grow into networks, and their numbers are likely to be related to the significance or impact of the publication. The meaning of the publication is determined from keywords and content. Citation analysis and content analysis have therefore become a common part of bibliometric methodology. Historically, bibliometric methods were used to trace relationships amongst academic journal citations. Now, bibliometrics are important in indexing research performance.

Bibliometric data have particular characteristics of which the user should be aware, and these are considered here.

Journal papers (publications, sources) report research work. Papers refer to or 'cite' earlier work relevant to the material being reported. New papers are cited in their turn. Papers that accumulate more citations are thought of as having greater 'impact', which is interpreted as significance or influence on their field. Citation counts are therefore recognised as a measure of impact, which can be used to index the excellence of the research from a particular group, institution or country.

The origins of citation analysis as a tool that could be applied to research performance can be traced to the mid-1950s, when Eugene Garfield proposed the concept of citation indexing and introduced the Science Citation Index, the Social Sciences Citation Index and the Arts & Humanities Citation Index, produced by the Institute of Scientific Information (currently the IP & Science business of Thomson Reuters).[4]

We can count citations, but they are only 'indicators' of impact or quality – not metrics. Most impact indicators use average citation counts from groups of papers, because some individual papers may have unusual or misleading citation profiles. These outliers are diluted in larger samples.

DATA SOURCE

The data we use come from the Thomson Reuters *Web of Science*™ databases which give access not only to journals but also to conference proceedings, books, patents, websites, and chemical structures, compounds and reactions. It has a unified structure that integrates all data and search terms together and therefore provides a level of comparability not found in other databases. It is widely acknowledged to be the world's leading source of citation and bibliometric data. The *Web of Science* focuses on research published in journals, conferences and books in science, medicine, arts, humanities and social sciences.

The *Web of Science* was originally created as an awareness and information retrieval tool but it has acquired an important primary use as a tool for research evaluation, using citation analysis and bibliometrics. Data coverage is both current and retrospective in the sciences, social sciences, arts and

[4] Garfield, E (1955) Citation Indexes for Science – New dimension in documentation through association of ideas. *Science*: **122**, 108-111.

humanities, in some cases back to 1900. Within the research community this data source was previously referred to by the acronym 'ISI'.

Unlike other databases, the *Web of Science* and underlying databases are selective, that is: the journals abstracted are selected using rigorous editorial and quality criteria. The authoritative, multidisciplinary content covers over 12,000 of the highest impact journals worldwide, including Open Access journals, and over 150,000 conference proceedings. The abstracted journals encompass the majority of significant, frequently cited scientific reports and, more importantly, an even greater proportion of the scientific research output which is cited. This selective process ensures that the citation counts remain relatively stable in given research fields and do not fluctuate unduly from year to year, which increases the usability of such data for performance evaluation.

Thomson Reuters has extensive experience with databases on research inputs, activity and outputs and has developed innovative analytical approaches for benchmarking and interpreting international, national and institutional research impact.

DATABASE CATEGORIES

The source data can be grouped in various classification systems. Most of these are based on groups of journals that have a relatively high cross-citation linkage and naturally cluster together. Custom classifications use subject maps in third-party data such as the OECD categories set out in the Frascati manual.

Thomson Reuters frequently uses the broader field categories in the Essential Science Indicators system and the finer journal categories in the Web of Science. There are 22 fields in Essential Science Indicators and 254 fields in Web of Science. In either case, our bibliometric analyses draw on the full range of data available in the underlying database, so analyses in our reports will differ slightly from anything created 'on the fly' from data in the web interface.

The lists of journal categories in these systems are attached at the end of this document.

Most analyses start with an overall view across the data, then move to a view across broad categories and only then focus in at a finer level in the areas of greatest interest to policy, programme or organisational purpose.

ASSIGNING PAPERS TO ADDRESSES

A paper is assigned to each country and each organisation whose address appears at least once for any author on that paper. One paper counts once and only once for each assignment, however many address variants occur for the country or organisation. No weighting is applied.

For example, a paper has five authors, thus:

Author	Organisation	Country		
Gurney, KA	Univ Leeds	UK	Counts for Univ Leeds	Counts for UK
Adams, J	Univ Leeds	UK	No gain for Univ Leeds	No gain for UK
Kochalko, D	Univ C San Diego	USA	Counts for UCSD	Counts for USA
Munshi, S	Gujarat Univ	India	Counts for Gujarat Univ	Counts for India
Pendlebury, D	Univ Oregon	USA	Counts for Univ Oregon	No gain for USA

So this one paper with five authors would be included once in the tallies for each of four universities and once in the tallies for each of three countries.

Work carried out within Thomson Reuters, and research published elsewhere, indicates that fractional weighting based on the balance of authors by organisation and country makes little difference to the conclusions of an analysis at an aggregate level. Such fractional analysis can introduce unforeseen errors in the attempt to create a detailed but uncertain assignment. Partitioning credit would make a greater difference at a detailed, group level but the analysis can then be manually validated.

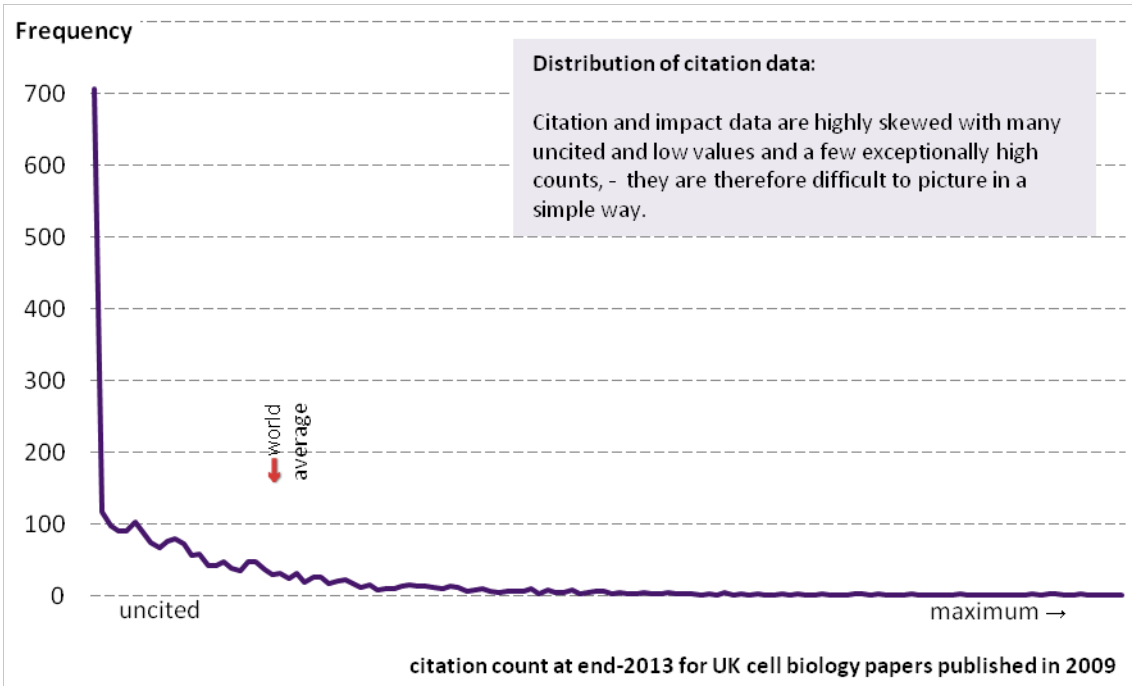
CITATION COUNTS

A publication accumulates citation counts when it is referred to by more recent publications. Some papers get cited frequently and many get cited rarely or never, so the distribution of citations is highly skewed.

Why are many papers never cited? Certainly some papers remain uncited because their content is of little or no impact, but that is not the only reason. It might be because they have been published in a journal not read by researchers to whom the paper might be interesting. It might be that they represent important but 'negative' work reporting a blind alley to be avoided by others. The publication may be a commentary in an editorial, rather than a normal journal article and thus of general rather than research interest. Or it might be that the work is a 'sleeping beauty' that has yet to be recognised for its significance.

Other papers can be very highly cited: hundreds, even thousands of times. Again, there are multiple reasons for this. Most frequently cited work is being recognised for its innovative significance and impact on the research field of which it speaks. Impact here is a good reflection of quality: it is an indicator of excellence. But there are other papers which are frequently cited because their significance is slightly different: they describe key methodology; they are a thoughtful and wide-ranging review of a field; or they represent contentious views which others seek to refute.

Citation analysis cannot make value judgments about why an article is uncited nor about why it is highly cited. The analysis can only report the citation impact that the publication has achieved. We normally assume, based on many other studies linking bibliometric and peer judgments, that high citation counts correlate on average with the quality of the research.



The figure shows the skewed distribution of more or less frequently cited papers from a sample of UK authored publications in cell biology. The skew in the distribution varies from field to field. It is to compensate for such factors that actual citation counts must be normalised, or rebased, against a world baseline.

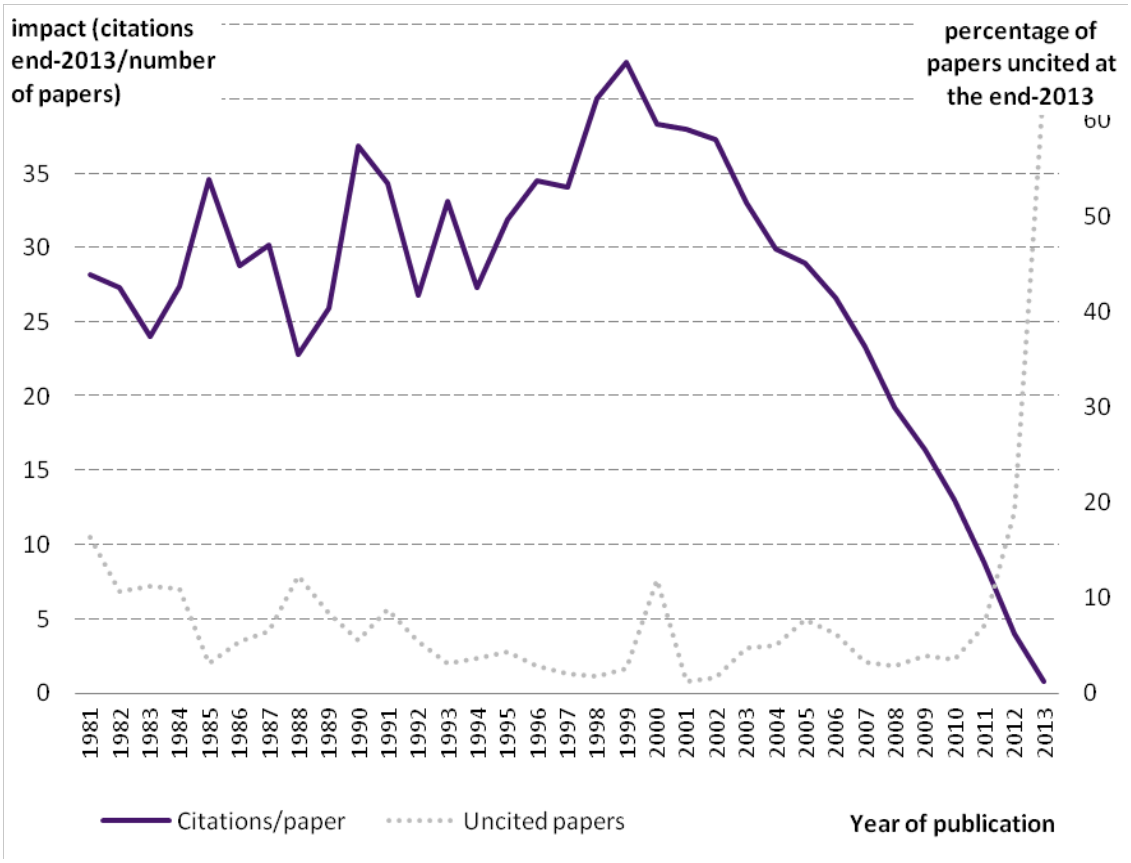
We do not seek to account separately for the effect of self-citation. If the citation count is significantly affected by self-citation then the paper is likely to have been infrequently cited. This is therefore only of consequence for low impact activity. Studies show that for large samples at national and organisational level the effect of self-citation has little or no effect on the analytical outcomes and would not alter interpretation of the results.

TIME FACTORS

Citations accumulate over time. Older papers therefore have, on average, more citations than more recent work. The graph below shows the pattern of citation accumulation for a set of 33 journals in the journal category ***Materials Science, Biomaterials***. Papers less than eight years old are, on average, still accumulating additional citations. The citation count goes on to reach a plateau for older sources.

The graph shows that the percentage of papers that have never been cited drops over about five years. Beyond five years, between 5% and 10% or more of papers remain uncited.

Account must be taken of these time factors in comparing current research with historical patterns. For these reasons, it is sometimes more appropriate to use a fixed five-year window of papers and citations to compare two periods than to look at the longer term profile of citations and of uncitedness for a recent year and an historical year.



DISCIPLINE FACTORS

Citation rates vary between disciplines and fields. For the UK science base as a whole, ten years produces a general plateau beyond which few additional citations would be expected. On the whole, citations accumulate more rapidly and plateau at a higher level in biological sciences than physical sciences, and natural sciences generally cite at a higher rate than social sciences.

Papers are assigned to disciplines (journal categories or research fields) by Thomson Reuters, bringing cognate research areas together. The journal category classification scheme has been recently revised and updated. Before 2007, journals were assigned to the older, well established Current Contents categories which were informed by extensive work by Thomson and with the research community since the early 1960s. This scheme has been superseded by the 252 *Web of Science*℠ journal categories which allow for greater disaggregation for the growing volume of research which is published and abstracted.

Papers are allocated according to the journal in which the paper is published. Some journals may be considered to be part of the publication record for more than one research field. As the example below illustrates, the journal *Acta Biomaterialia* is assigned to two journal categories: ***Materials Science, Biomaterials*** and ***Engineering, Biomedical***.

Very few papers are not assigned to any research field and as such will not be included in specific analyses using Normalised citation impact data. The journals included in the Thomson Reuters databases and how they are selected are detailed here http://scientific.thomsonreuters.com/mjl/.

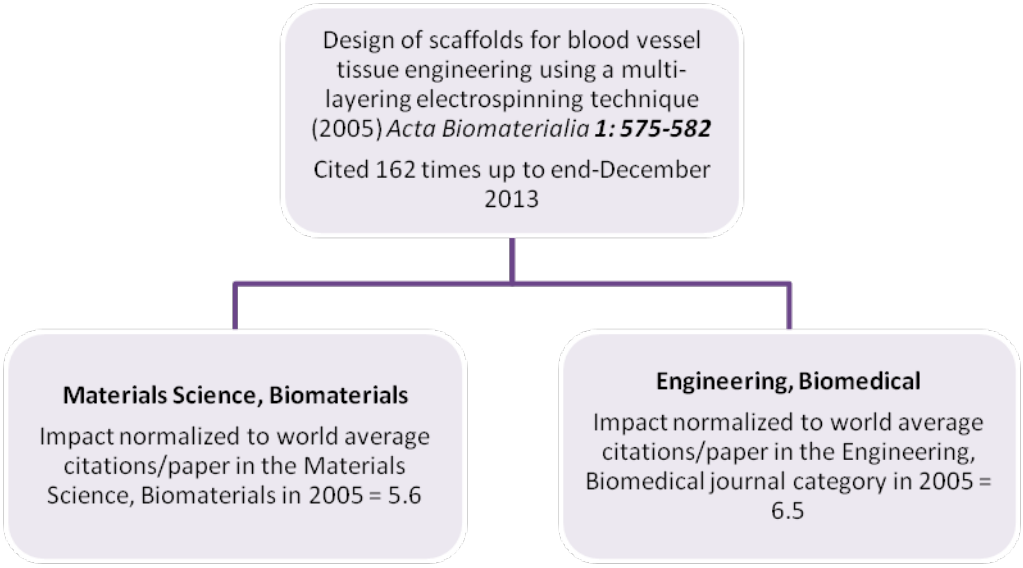
Some journals with a very diverse content, including the prestigious journals *Nature* and *Science* were classified as ***Multidisciplinary*** in databases created prior to 2007. The papers from these ***Multidisciplinary*** journals are now re-assigned to more specific research fields using an algorithm based on the research area(s) of the references cited by the article.

NORMALISED CITATION IMPACT

Because citations accumulate over time at a rate that is dependent upon the field of research, all analyses must take both field and year into account. In other words, because the absolute citation count for a specific article is influenced by its field and by the year it was published, we can only make comparisons of indexed data after normalising with reference to these two variables.

We only use citation counts for reviews and articles in calculations of impact, because document type influences the citation count. For example, a review will often be cited more frequently than an article in the same field, but editorials and meeting abstracts are rarely cited and citation rates for conference proceedings are extremely variable. The most common normalisation factors are the average citations per paper for (1) the year and (2) either the field or the journal in which the paper was published. This normalisation is also referred to as 'rebasing' the citation count.

Impact is therefore most commonly analysed in terms of 'Normalised impact', or NCI. The following schematic illustrates how the Normalised citation impact is calculated at paper level and journal category level.



This article in the journal *Acta Biomaterialia* is assigned to two journal categories: ***Materials Science, Biomaterials*** and ***Engineering, Biomedical***. The world average baselines for, as an example, ***Materials science, Biomaterials*** are calculated by summing the citations to all the articles and reviews published worldwide in the journal *Acta Biomaterialia* and the other 32 journals assigned to this category for each year, and dividing this by the total number of articles and reviews published in the journal category. This gives the category-specific Normalised citation impact (in the above example the category-specific NCI_F for ***Materials Science, Biomaterials*** is 5.6 and the category-specific NCI_F for

Engineering, Biomedical is higher at 6.5). Most papers (nearly two-thirds) are assigned to a single journal category whilst a minority are assigned to more than 5.

Citation data provided by Thomson Reuters are assigned on an annual census date referred to as the Article Time Period. For the majority of publications the Article Time Period is the same as the year of publication, but for a few publications (especially those published at the end of the calendar year in less main-stream journals) the Article Time Period may vary from the actual year of publication.

World average impact data are sourced from the Thomson Reuters National Science Indicators baseline data for 2013.

MEAN NORMALISED CITATION IMPACT

Research performance has historically been indexed by using average citation impact, usually compared to a world average that accounts for time and discipline. As noted, however, the distribution of citations amongst papers is highly skewed because many papers are never cited while a few papers accumulate very large citation counts. That means that an average may be misleading if assumptions are made about the distribution of the underlying data.

In fact, almost all research activity metrics are skewed: for research income, PhD numbers and publications there are many low activity values and a few exceptionally high values. In reality, therefore, the skewed distribution means that average impact tends to be greater than and often significantly different from either the median or mode in the distribution. This should be borne in mind when reviewing analytical outcomes.

The average (Normalised) citation impact can be calculated at an individual paper level where it can be associated with more than one journal category. It can also be calculated for a set of papers at any level from a single country to an individual researcher's output. In the example above, the average citation impact of the *Acta Biomaterialia* paper can be expressed as ((5.6 + 6.5)/2) = 6.1.

IMPACT PROFILES®

We have developed a bibliometric methodology[5] that shows the proportion of papers that are uncited and the proportion that lie in each of eight categories of relative citation rates, Normalised (rebased) to world average. An Impact Profile® enables an examination and analysis of the strengths and weaknesses of published outputs relative to world average and relative to a reference profile. This provides much more information about the basis and structure of research performance than conventionally reported averages in citation indices.

Papers which are "highly-cited" are often defined in our reports as those with an average citation impact (NCI_F) greater than or equal to 4.0, i.e. those papers which have received greater than or equal to four times the world average number of citations for papers in that subject published in that year. This differs from Thomson Reuters database of global highly-cited papers, which are the top 1% most

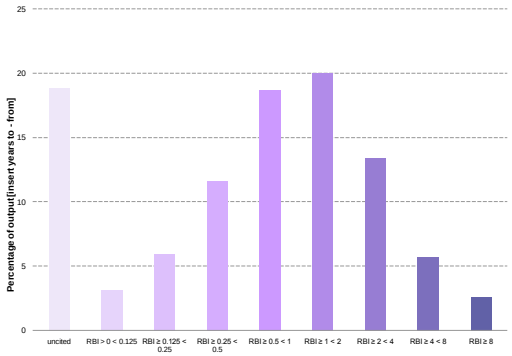
[5] Adams J, Gurney K & Marshall S (2007) Profiling citation impact: A new methodology. *Scientometrics* **72**: 325-344.

frequently cited for their field and year. The top percentile is a powerful indicator of leading performance but is too stringent a threshold for most management analyses.

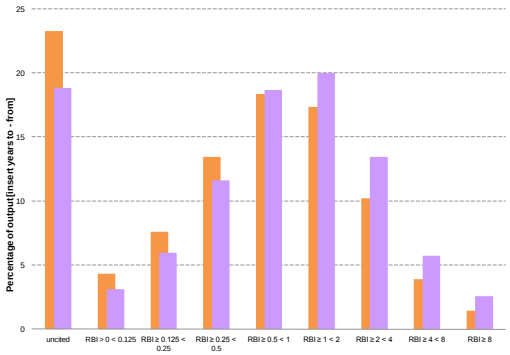
The proportion of uncited papers in a dataset can be compared to the benchmark for the UK, the USA or any other country. Overall, in a typical ten-year sample, around one-quarter of papers have not been cited within the 10-year period; the majority of these are, of course, those that are most recently published.

The Impact Profile® histogram can be presented in a number of ways which are illustrated below.

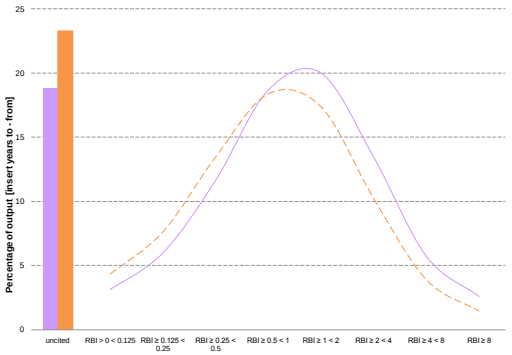
A



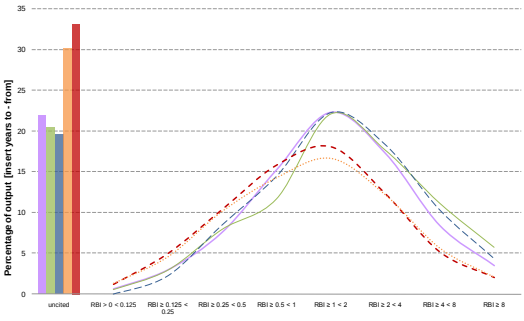
B



C



D



A: is used to represent the total output of an individual country, institution or researcher with no benchmark data. Visually it highlights the numbers of uncited papers (weaknesses) and highly cited papers (strengths).

B & **C**: are used to represent the total output of an individual country, institution or researcher (**client**) against an appropriate benchmark dataset (**benchmark**). The data are displayed as either histograms (B) or a combination of histogram and profile (C). Version C prevents the 'travel' which occurs in histograms where the eye is drawn to the data most offset to the right, but can be less easy to interpret as categorical data.

D: illustrates the complexity of data which can be displayed using an Impact Profile®. These data show research output in defined journal categories against appropriate benchmarks: **client, research field**

X; client, research field Y; client, research field Z; benchmark, research field X+Y; benchmark, research field, Z.

Impact Profiles® enable an examination and analysis of the balance of published outputs relative to world average and relative to a reference profile. This provides much more information about the basis and structure of research performance than conventionally reported averages in citation indices.

An Impact Profile® shows what proportion of papers are uncited and what proportion are in each of eight categories of relative citation rates, Normalised to world average (which becomes 1.0 in this graph). Normalised citation rates above 1.0 indicate papers cited more often than world average for the field in which that journal is categorised and in their year of publication.

Attention should be paid to:

- The proportion of uncited papers on the left of the chart
- The proportion of cited papers either side of world average (1.0)
- The location of the most common (modal) group near the centre
- The proportion of papers in the most highly-cited categories to the right, (≥4 x world, ≥8 x world).

WHAT ARE UNCITED PAPERS?

It may be a surprise that some journal papers are never subsequently cited after publication, even by their authors. This accounts for about half the total global output for a typical, recent 10-year period. We cannot tell why papers are not cited. It is likely that a significant proportion of papers remain uncited because they are reporting negative results which are an essential matter of record in their field but make the content less likely to be referenced in other papers. Inevitably, other papers are uncited because their content is trivial or marginal to the mainstream. However, it should not be assumed that this is the case for all such papers.

There is variation in non-citation between countries and between fields. For example, relatively more engineering papers tend to remain uncited than papers in other sciences, indicative of a disciplinary factor but not a quality factor. While there is also an obvious increase in the likelihood of citation over time, most papers that are going to be cited will be cited within a few years of publication.

WHAT IS THE THRESHOLD FOR 'HIGHLY CITED'?

Thomson Reuters has traditionally used the term 'Highly Cited Paper' to refer to the world's 1% of most frequently cited papers, taking into account year of publication and field. In rough terms, UK papers cited more than eight times as often as relevant world average would fall into the Thomson Highly Cited category. About 1-2% of papers (all papers, cited or uncited) typically pass this hurdle. Such a threshold certainly delimits exceptional papers for international comparisons but, in practice, is an onerous marker for more general management purposes.

After reviewing the outcomes of a number of analyses, we have chosen a more relaxed definition for our descriptive and analytical work. We deem papers that are in the world's top 10% of most frequently cited papers, taking into account year of publication and field, to be relatively highly-cited for national comparisons.