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Oncological research overview in the European Union. A 5-year survey

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Abstract

This study evaluates the distribution of papers published by European Union (EU) authors in oncological journals from 1996 to 2000, and compares the results with those of a previous study carried out in 1995. The impact of oncological research in the EU is compared with that of the United States (US) and the world, and research trends are highlighted through an analysis of keywords. Data on articles published in oncological journals (ISI Subject Category = ONCOLOGY) selected from Current Contents/Life Science and Current Contents/Clinical Medicine (1996–2000) on the weekly diskette version were downloaded. Mean Impact Factor (IF), source country population and gross domestic product (GDP) were analysed. A special-purpose software to determine the most commonly used keywords was utilised. From 1996 to 2000, 66 021 papers were published in the world in oncological journals: 35.5% came from the EU (UK, Italy, Germany, France and The Netherlands ranking the highest) and 38.8% from the US. The total number of EU papers increased from 4063 in 1995 to 4843 in 2000. Compared with the previous study, no important changes were seen, with the top five countries in 1995 maintaining their ranking in 2000. However, some small countries (Denmark, Norway and Ireland) fared worse in 2000, while others (France, Germany and Greece) improved their position. The mean IF for the EU papers was 2.9 compared with 4.0 in the US. The mean IF increased for all of the nations. In particular, while France and Germany showed a very positive performance trend in their respective IFs, countries such as Norway, Denmark and Italy showed less improvement. The analysis of keywords appearing in articles written in 2000 showed that the leading fields of research were breast cancer in the diseases category of keywords, cisplatin and platinum compounds in the drugs category, radiotherapy in the treatment category and apoptosis in the experimental studies category. Variety in the use of keywords should be avoided, and journal editors should encourage their standardisation.

Keywords: Neoplasms; Bibliometrics; Europe

1. Introduction

Despite the decrease in overall cancer incidence and mortality rates, the disease remains a major problem in all developed countries, ranking only second to cardiovascular diseases as the main cause of the 60 million deaths occurring every year worldwide. Recent data show that, even though death rates for all cancers combined continue to decline, the number of cancer cases can be expected to rise over the coming decades because of the aging of the population [1]. Thus, cancer will remain a major public health problem that profoundly affects millions of people each year and that accounts for 6–15% of the total health expenditure in developed countries [2]. To overcome the cancer burden, research-related efforts being made around the world in the search for new therapies and preventive approaches are numerous, committing considerable resources, both human and financial.

Throughout Member States of the European Union (EU), cancer research funding is progressively becoming less national and more international. During most

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competitive grant application processes used to allocate research funding, one of the pivotal parameters evaluated is the applicant's research track record measured in terms of scientific output. Therefore, tools and means to accurately evaluate oncological scientific activity become necessary. Not only is the knowledge of a country's scientific output useful for authorities allocating resources, it also benefits the scientific community, becoming a source of information that enables a country to define its position with respect to competitors and, in turn, to better exploit opportunities arising in all scientific fields.

To perform such evaluation, the analysis of citations has been introduced. Citation analysis is defined as the count of the number of times an article is cited as a reference in other articles, and is based on the general assumption that the number of citations reflects an article's influence and notoriety and, hence, its quality. This kind of analysis can be performed using the databases produced by the Institute for Scientific Information (ISI), which evaluates the papers published in more than 1400 medical journals and each year publishes an index (Journal Citation Reports (JCR)) based on the cited articles [3]. In recent years, many studies based on citation analysis have been carried out to complement other types of indicators. These studies evaluate the activities of a scientist, a research unit, an institution, a country, or else take into consideration the identification of research fronts, or the historical development of a discipline or a domain of science [4–11].

On this premise, and aware of the utility of science evaluation in order to stimulate scientific research, we performed an analysis of papers published in the period 1996–2000 in the journals listed by the Journal Citation Reports in the category ONCOLOGY and correlated them with the bibliometric parameter mean Impact Factor (IF) and socioeconomic variables, i.e. the source country population and its gross domestic product (GDP). We also analysed the frequency of keywords used in cancer research literature in order to identify, if possible, the main research trends. The analysis also correlated data with a previous one performed in 1995 [7].

2. Methods

Data from articles appearing in oncological journals (ISI Subject Category = ONCOLOGY) were selected from Current Contents/Life Science and Current Contents/Clinical Medicine (1996–2000) on the weekly diskette version. For purposes of comparison, we considered as biomedical papers all those included in these databases. Bibliographic items with ISSN and nominal edition years 1996–2000 were downloaded. The study included all peer-reviewed papers, editorials, reviews, technical notes and letters to the editor, but excluded journal supplements containing abstracts or meeting reports.

For purposes of this study, the European Union (EU) was defined as the 15 official Member States plus Norway, given its inclusion in the European Economic Area (EEA) and in all calculations concerning the EU issued by the Statistical Office of the European Communities (Eurostat) [12]. Papers from England, Scotland, Northern Ireland, and Wales were grouped under the heading United Kingdom (UK). Data on world and US productivity were also compared.

The corresponding author's country was considered the country of origin of the article. It was necessary occasionally to manually identify the country source of a given article after consulting other bibliographic sources. Due to the lack of specific data, the country of origin of approximately 3% of the analysed articles, mainly unsigned editorials, remained unknown.

For each country, the number of publications and the sum of the relevant IF were calculated and reported as mean IF in the paper.

The resident population (expressed in millions of inhabitants) and gross domestic product (expressed in current billion United States (US) dollars) were retrieved for each country from Eurostat annual statistical reviews.

For purposes of the study, keywords were defined as comma-separated items of one or more words. All keywords (year 2000), both those reported by the authors and those attributed by ISI, were identified and their frequency was calculated using a special purpose program. Different keywords with identical meaning and misspelled keywords were grouped and considered as a single keyword.

Up-to-date (yet partial) data are currently reported on http://www.Cilnews.unige.it.

3. Results

Quantitative analysis shows that in the 5-year period from 1996 to 2000, a total of 66 021 papers were published in oncological journals throughout the world (Table 1); of these, 23 462 (35.5%) originated from the EU and 25,646 (38.8%) from the US. In Europe, the leading countries were the UK (20.3%) and Italy (18.1%), followed by Germany (15.2%), France (12.7%) and The Netherlands (9.1%). All European countries were represented. The total number of papers increased persistently (19.2%) from 4063 in 1995 to 4843 in 2000.

For purposes of comparison, a total of 1 798 666 papers were published in the world medical literature in the same period, 37.2% of which originated in Europe and 36.1% in the US.

Table 1
Number of published papers

Country	Oncological papers						Total papers	% (E = 100)	Biomedical papers						Total papers	% (UE = 100)	% oncological papers
	1995	1996	1997	1998	1999	2000			1995	1996	1997	1998	1999	2000			
World	11 117	12 610	12 634	13 129	13 745	13 903	66 021	–	309 684	350 661	349 766	361 563	365 892	370 784	1 798 666	–	3.7
USA	4523	4893	4882	5111	5297	5463	25 646	–	118 565	130 338	128 383	129 886	129 589	130 771	648 967	–	4.0
EU	4063	4697	4602	4545	4775	4843	23 462	100	116 224	131 184	130 555	135 107	136 569	136 301	669 716	100	3.5
UK	778	984	917	821	1016	1022	4760	20.3	31 932	34 860	33 452	34 254	34 650	35 005	172 221	25.7	2.8
Italy	761	901	865	874	757	841	4238	18.1	11 243	13 408	13 165	13 527	13 565	13 830	67 495	10.1	6.3
Germany	580	645	660	715	747	800	3567	15.2	20 326	23 926	24 065	25 681	26 296	26 259	126 227	18.8	2.8
France	558	594	616	617	595	546	2968	12.7	17 327	19 169	19 102	19 635	19 568	18 710	96 184	14.4	3.1
The Netherlands	410	428	413	376	462	467	2146	9.1	7536	8188	8206	8375	8402	8385	41 556	6.2	5.2
Sweden	288	310	289	261	308	262	1430	6.1	6322	6700	6828	6815	6736	6535	33 614	5.0	4.3
Spain	117	162	144	167	169	175	817	3.5	6535	8154	8275	8828	8942	8912	43 111	6.4	1.9
Belgium	97	101	113	140	120	144	618	2.6	3367	3785	3804	4015	3906	3836	19 346	2.9	3.2
Austria	93	91	110	153	131	110	595	2.5	2166	2650	2927	3031	3165	3179	14 952	2.2	4.0
Finland	91	102	118	94	149	115	578	2.5	2700	2949	3090	2984	3178	3151	15 352	2.3	3.8
Denmark	106	124	118	107	92	113	554	2.4	2893	3007	3056	3145	3164	3172	15 544	2.3	3.6
Norway	91	137	104	112	95	90	538	2.3	1666	1673	1661	1712	1773	1811	8630	1.3	6.2
Greece	54	79	91	82	88	121	461	2.0	985	1231	1309	1537	1521	1719	7317	1.1	6.3
Ireland	26	21	26	19	25	24	115	0.5	821	986	1039	1006	990	1022	5043	0.8	2.3
Portugal	13	13	16	7	20	10	66	0.3	390	472	543	530	688	734	2967	0.4	2.2
Luxembourg	2	5	2	2	1	3	13	0.1	15	26	33	32	25	41	157	0.0	8.3

USA, United States of America; EU, European Union; UK, United Kingdom. Data in shaded areas = data from the 1995 survey.

The percentage of oncological papers with respect to the whole world medical literature was 3.7%, 3.5% coming from Europe and 4.0% from the US. The percentage of oncological papers compared with the total number of medical papers was highest in Luxembourg (8.3), Italy and Greece (6.3), Norway (6.2), and The Netherlands (5.2), while it was lower in Spain (1.9), Portugal (2.2), Ireland (2.3), the UK and Germany (2.8).

Analysis based on the mean IF from 1996 to 2000 (Table 2) showed that it ranged from 2.1 for Greece and Luxembourg to 3.2 for The Netherlands and Finland, with a mean value for the EU of 2.9.

The mean IF was higher in the world (3.2) and in the US (4.0).

The ratio between the number of papers and the country population in millions of inhabitants (Table 3) was 19.5 in the US and 12.5 in the EU. In the EU, Sweden ranked first (32.5), followed by The Netherlands (27.9), Norway (24.7), Finland (22.7), Denmark (21.2), the UK (16.3), Italy and Austria (14.8).

The ratio between the number of papers published in the oncological journals and the GDP (Table 4) showed that the EU scored 0.6 and the US 0.7. In the EU, Sweden and the Netherlands ranked first (1.2), followed by Finland (1.0), Greece and the UK (0.9), Norway (0.8), Denmark and Italy (0.7).

Table 2
Mean impact factor

Country	Oncological papers						Mean
	1995	1996	1997	1998	1999	2000	
World	2.7	3.0	3.0	3.1	3.4	3.6	3.2
USA	3.3	3.8	3.7	3.8	4.2	4.3	4.0
EU	2.4	2.6	2.6	2.7	3.0	3.3	2.9
The Netherlands	2.9	3.2	2.8	3.0	3.4	3.8	3.2
Finland	2.6	3.1	3.0	3.4	3.0	3.5	3.2
UK	2.8	2.9	2.9	2.8	2.9	3.2	2.9
France	2.0	2.4	2.6	2.7	3.1	3.8	2.9
Sweden	2.5	2.7	2.8	2.7	2.9	3.4	2.9
Germany	2.1	2.7	2.7	2.7	3.2	3.1	2.9
Austria	2.4	2.7	3.0	2.7	2.8	3.1	2.9
Belgium	2.3	2.2	2.5	2.7	3.3	3.5	2.8
Norway	2.6	2.6	2.6	2.7	3.1	3.2	2.8
Spain	2.1	2.6	2.8	2.7	3.0	3.1	2.8
Denmark	2.4	2.5	2.7	3.0	2.8	2.9	2.8
Italy	2.2	2.4	2.3	2.5	2.9	3.1	2.6
Portugal	1.6	1.7	2.1	3.5	2.4	2.3	2.4
Ireland	2.0	1.6	2.3	2.8	2.9	2.3	2.4
Luxembourg	1.2	1.5	2.4	1.1	3.5	2.0	2.1
Greece	1.3	1.6	1.9	1.8	2.4	2.5	2.1

USA, United States of America; EU, European Union; UK, United Kingdom. Data in shaded area = data from the 1995 survey.

3.1. Research topics

A total of 13 898 different keywords were attributed by authors publishing in oncological journals in 2000, while a total of 10 511 were attributed by the ISI database software. Among the author's keywords, only 26% were cited more than twice, and 3.1% were cited more than 10 times; among ISI's keywords, 32.8% were cited more than twice and 4.4% more than 10 times. Mis-

Table 3
Ratio between the number of papers and country population

Country	Oncological papers						Mean
	1995	1996	1997	1998	1999	2000	
World	2.2	2.5	2.4	2.3	2.4	2.4	2.4
USA	17.3	18.8	18.8	19.3	20.0	20.6	19.5
EU	10.9	12.6	12.3	12.1	12.7	12.9	12.5
Sweden	33.1	35.7	32.8	29.5	34.8	29.6	32.5
The Netherlands	27.1	28.3	26.9	24.2	29.8	30.1	27.9
Norway	21.2	31.9	23.9	25.6	21.7	20.5	24.7
Finland	18.2	20.4	23.2	18.3	29.1	22.4	22.7
Denmark	20.6	24.1	22.6	20.3	17.5	21.5	21.2
UK	13.4	16.9	15.7	14.0	17.3	17.4	16.3
Italy	13.3	15.8	15.1	15.2	13.2	14.7	14.8
Austria	11.6	11.4	13.7	19.0	16.3	13.6	14.8
Belgium	9.7	10.1	11.2	13.8	11.8	14.2	12.2
France	9.9	10.5	10.9	10.9	10.5	9.6	10.5
Greece	5.3	7.7	8.9	7.8	8.4	11.6	8.9
Germany	7.1	7.9	8.1	8.7	9.1	9.8	8.7
Ireland	7.4	6.0	7.4	5.2	6.9	6.6	6.4
Luxembourg	0.0	13.0	5.2	0.0	2.4	7.2	5.6
Spain	3.0	4.2	3.7	4.3	4.3	4.5	4.2
Portugal	1.3	1.3	1.6	0.7	2.0	1.0	1.3

USA, United States of America; EU, European Union; UK, United Kingdom. Data in shaded areas = data from the 1995 survey.

Table 4
Ratio between the number of papers and the gross domestic product (GDP)

Country	Oncological papers						Mean
	1995	1996	1997	1998	1999	2000	
World	0.5	0.6	0.5	0.5	0.5	0.5	0.5
USA	0.7	0.8	0.7	0.7	0.7	0.7	0.7
EU	0.5	0.6	0.6	0.5	0.6	0.6	0.6
Sweden	1.3	1.4	1.4	1.0	1.2	1.0	1.2
The Netherlands	1.3	1.4	1.2	1.0	1.2	1.2	1.2
Finland	1.0	1.1	1.2	0.8	1.2	0.9	1.0
Greece	0.7	1.0	1.2	0.7	0.7	1.0	0.9
UK	0.7	0.9	0.9	0.7	0.9	0.9	0.9
Norway	0.8	1.2	0.9	0.7	0.6	0.6	0.8
Italy	0.6	0.8	0.7	0.7	0.6	0.7	0.7
Denmark	0.8	0.9	0.8	0.6	0.5	0.6	0.7
Austria	0.5	0.5	0.5	0.7	0.6	0.5	0.6
Belgium	0.5	0.5	0.5	0.5	0.5	0.5	0.5
France	0.4	0.5	0.5	0.5	0.4	0.4	0.5
Ireland	0.6	0.5	0.5	0.3	0.4	0.3	0.4
Germany	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Spain	0.2	0.3	0.3	0.3	0.3	0.3	0.3
Luxembourg	0.0	0.4	0.1	0.0	0.1	0.2	0.1
Portugal	0.2	0.2	0.2	0.1	0.2	0.1	0.1

USA, United States of America; EU, European Union; UK, United Kingdom. Data in shaded areas = data from the 1995 survey.

spelled or non-standardised keywords were frequently found. The lack of standardisation among keywords assigned by authors greatly hampered our analysis, since the use of synonymous terms, spelling variations, abbreviations, and more or less specific terms made the exact interpretation of the author's intended meaning difficult.

Nevertheless, because keywords are commonly used to identify references about a subject in a bibliographic search, we analysed, re-arranged and re-assembled them in order to generate a list of the most often cited terms, thus providing a means to measure current research trends in the field.

Table 5 reports the top keywords related to disease types, drugs, treatments and research topics and related techniques.

Table 5
Analysis of keywords for oncology publications

	Number of occurrences
Diseases	
Breast cancer	837
Colorectal cancer	400
Lung cancer	379
Head and neck cancer	335
Prostate cancer	295
Uterine cancer	294
Sarcoma	260
Ovarian cancer	254
Melanoma	215
Lymphoma	185
Drugs	
Cisplatin and platinum compounds	221
Taxol (paclitaxel) and analogues	169
5-Fluorouracil	117
Interleukins	90
Interferon	79
Gemcitabine (deoxycytidine)	67
Tamoxifen	63
Cyclophosphamide/ifosfamide	63
Doxorubicin	50
Retinoic acid	39
Treatments	
Radiotherapy	813
Chemotherapy	542
Combined therapy	213
Surgery	160
Immunotherapy	87
Gene therapy	59
Chemoprevention	42
Palliative care	36
Hyperthermia	33
Hormonal therapy	28
Research topics and related techniques	
Apoptosis	273
p53	269
Metastasis	187
Immunohistochemistry	180
Angiogenesis	164
Tumour suppressor genes	156
Tumour markers	116
Cell cycle	93
PCR	93
Proliferation	90
Vascular endothelial growth factor	88

PCR, polymerase chain reaction.

4. Discussion

The geographical breakdown of the oncological literature output resulting from the present analysis has a trend that is fairly similar to that which we reported in 1995 [7]. Our analysis shows that the US holds the leading position. It is noteworthy, however, that in the overall biomedical field, EU scientists published more papers than researchers from the United States (37.2% versus 36.1%), with a regular increase in the years studied. These findings are in keeping with an ISI analysis revealing a drop from 40.5 to 36.5% in papers from the US compared with world output over the period 1981–1996, and an increase from 30.5 to 36.2% of papers coming from EU countries during the same time period [13]. Although traceable to demographics (Europe grew from 10 to 15 countries in the analysed period), the trend of a decline in the US lead and an increase of EU output seems to be a real phenomenon. On the contrary, the US continues to hold its advantage over the EU in oncology, with 38.8% versus 35.5% of published papers in comparison with world output, with a mean increase with respect to 1995 of 20.8% versus 19.2%. However, taking into account the great differences between Europe and the US in the availability of research funding, this is not a poor showing. The US mean impact value also remains higher than that of the EU (4.0 versus 2.9).

In the 5-year period analysed, the trend observed in other disciplines of an outstanding value of UK scientific output, that reveals both the preminence of their scientific culture and language, was also confirmed in the field of cancer research. The analysis of published articles was influenced by the language of the papers, since it was based on the ISI databases which mainly covers English language journals. Nations with a strong tradition of publishing in their native languages, such as France and Germany, may be penalised in comparative studies that draw on databases including only a few non-English language journals.

The top five countries for number of published papers were the UK, Italy, Germany, France and The Netherlands; this result matched that of the 1995 analysis. The remaining countries also retained their previous ranking with the exception of Denmark, which fell from eighth to eleventh place. Almost all of the EU countries increased their oncological output in the years examined. Greece doubled its output, but also Spain, Belgium, Germany and the UK substantially increased the number of papers published in 2000 compared with those published in 1995 (over 30%).

The ratio of oncological papers to all medical literature was highest in Luxembourg, Italy, Greece, Norway, The Netherlands and Sweden. With the exception of Luxembourg, which had no papers in 1995, the ranking of the nations remained nearly the same.

The Netherlands, Finland, the UK, France, Sweden, Germany and Austria are at the top for mean IF. Interestingly, the mean IF for all countries showed an increase compared with 1995, with France almost doubling its mean IF in 2000, but also Greece, Belgium, Germany and Spain recording an increase greater than or equal to 1. Particularly, the IF of Greece and Spain could confirm the growing interest of these nations in clinical medicine. Although the first three positions are held by the same countries as in the 1995 survey, some countries such as France and Germany improved their ranking, while others, such as Norway, Denmark and Italy fared worse.

Sweden, The Netherlands, Norway, Finland and Denmark show the highest ratios between scientific publications and number of inhabitants. The five top-ranking countries were the same as in the 1995 analysis, with little variation among the remaining countries (Greece performed somewhat better, Ireland somewhat worse).

Sweden and The Netherlands, followed by Finland, Greece, the UK, Norway, Denmark and Italy, show the highest ratios between scientific publications and GDP. However, some changes with respect to the 1995 survey were noticed. Despite the trend of smaller countries continuing to perform better than larger ones, Denmark and Ireland dropped while Greece rose in the rankings. Most Nordic nations continue to rank very well, showing a small, but qualitatively excellent, output. A better utilisation of resources and a higher percentage of the GDP assigned to research may explain this finding.

A final consideration regards the analysis of keywords, which revealed a high degree of dispersion in the use of terms. In fact, only 2.4% of keywords are cited more than 10 times and 25% more than twice. This problem affects many biomedical disciplines [6–8]. We believe that editors should adopt measures that encourage the introduction of a standard set of keywords that both facilitates information retrieval from computerised sources and provides a tool with which the evolution of research can be uniformly studied. Our analysis seems to offer a good picture of current research trends in the oncological field. Indeed, the most commonly used keywords for diseases very closely reflects the incidence itself of the neoplastic diseases, with breast cancers ranking at the top, followed by colorectal and lung cancers. Among drugs, interest focused on the chemotherapeutic agents most widely used in current clinical settings, with little change compared with the 1995 survey being observed. The most often cited keyword for treatment was radiotherapy (including conformal radiotherapy and brachytherapy), but other terms that reveal emerging fields of study, e.g. gene therapy, which in 1995 had a very low number of occurrences, were also present. Finally, the prevailing trend seen in basic studies regards the widespread application of molecular

biology to experimental oncology studies in terms of both phenomena studied and techniques used. Apoptosis, or programmed cell death, is the most widely studied field in experimental research.

4.1. Study limitations

Our study took into account only those journals classified by the ISI as oncological, and did not consider oncological research studies appearing in other scientific publications. Oncological research spans a wealth of disciplines: many basic cancer research articles may be published in basic discipline journals (e.g. biochemistry, immunology), and cancer clinical studies may appear in categories covering general subjects (e.g. medicine, pharmacology) or dealing with systems or organs (e.g. respiratory system, digestive system). Nevertheless, we have already shown that the inclusion of journals falling outside the ISI category of oncology is liable to several methodological problems [14]. We therefore decided to restrict our study to publications in speciality journals for the purposes of consistency and because the method is simple and easily reproducible. In fact, our main aim was to compare scientific output across the EU and to evaluate publication trends. We are currently developing a method to identify the scientific background of authors that may contribute to overcome this problem, by matching keywords, names of the authors and the institution of origin.

Difficulty was also encountered in the identification of authors' corresponding addresses, i.e. the geographical location of their affiliation. If the author's address is reported inaccurately, a margin of error in data extraction is possible [15]. Most likely, the methodology based on corresponding address does not adequately reflect international cooperation. However, in this case it should also be remembered that we are dealing with large numbers, and that an internationally authored work usually entails a rotation of referent/corresponding writers. The validity of our results can therefore be safely assumed.

A further limitation is the means to measure the quality of output, and the lack thereof led to the admittedly minimally sophisticated method that was used in our study [16,17]. Research evaluation is currently the focus of substantial debate throughout the world in light of the need of research evaluators and funding agencies to develop methods for the allocation of resources. The method that emphasises citation frequency as a gauge of the impact of published papers is obviously neither a flawless or invulnerable method, nor does it provide a complete picture of the research product. Ideally, an exhaustive survey should seek to combine data from different databases on both keywords by identifying the subject of analysis and authors' affiliation. Moreover, it could be used and compared with different bibliometric indicators, taking into account other parameters, such as resources (i.e. personnel and infrastructures), levels of investment, policy goals, effects on research targets (i.e. technology, systems, education, social structure), expressions of knowledge other than published papers (i.e. patents and trained students), and finally the cultural evolution of a nation. However, statistical reports in these fields are difficult to retrieve, and are almost never homogeneous. The fact that even the contents of Eurostat cannot provide such data is a telling example of the drawbacks faced. While some forms of impact are tangible, others are not so clear and are difficult to identify and quantify. Despite these limitations, the method entailing the count of citations in scientific journals remains the most accessible and most reproducible basis of investigation in practice.

In conclusion, a descriptive analysis that compares the specific performance of nations in terms of research productivity is both an essential step in the understanding of science policies and a source of useful information. The assessment of scientific output enables a country to define its position with respect to its competitors, and can be utilised to identify strategies to adopt in order to improve the distribution of resources and, in turn, the quality of its research.

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