

HIGHLY CITED PAPERS IN SLOVENIA

Abstract. *Despite some criticism and the search for alternative methods of citation analysis it's an important bibliometric method, which measures the impact of published research results. In the last decade, special attention has been paid to highly cited papers, publications representing the highest quality, scientific excellence. In two studies, we have studied the highly cited papers in Slovenian co-authorship published in journals indexed in the bibliographic databases Web of Science and Scopus. These are defined as papers ranking by the number of citations among the top per cent in a given research field. The first hypothesis was that highly cited publications co-authored by Slovenian researchers are published in the top quarter ranked journals in a given field of research, and the second that these papers are written in international collaboration and that Slovenian authors are a minority among the authors. The hypothesis that Slovenian authors form a minority in international co-authored teams was confirmed only in the case of the top one per cent most cited publications, but not in the case of publications in the top ten per cent most cited publications. The use of indicators related to most prestigious journals for the evaluation purposes is particularly well suited when growth in the number of publications is high, but the impact is not corresponding, as is the case in Slovenia.*

Keywords: *bibliometric indicators; highly cited papers; international co-authorship; Slovenia*

Introduction

The debate on how to measure scientific quality, i.e. the quality of scientific research, has been going on for decades. Using citations as absolute proof of quality is of course controversial (Južnič, 2000), even if it is used as

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an indicator for assessing the quality of research work, both directly (citations of individual posts) and indirectly (impact factor), JIF or other related criteria used in science evaluation procedures. This is precisely what excites controversy and debate, as it is a mechanism that can affect the success or failure of individual researchers in obtaining research funds, promotion, and other similar benefits. Therefore, bibliometric methods are an often discussed topic, especially in social sciences, as social scientists often refer to the criteria and indicators used in the evaluation as being discriminatory to social sciences and humanities, often because they do not take into account the use of local (non-English) language in this area of research. An important question is what is understood as the content or feature of scientific research.

Scientific research can be defined in different ways, depending on which segment of the process someone would like to highlight. Science is primarily a foundation beyond what is today called production of (new) knowledge in the society and the basis of its progress and welfare. Science can be highlighted also as a driver of economic, technological and social development, or a process of discovering new and unveiling hidden. Scientific research can be defined as an activity through which we educate top experts and professionals, who are capable of the most demanding jobs and tasks in society.

There is another possible definition of scientific activities, i.e. as information activities. A scientist uses "information", which he/she has obtained through his/her research work, together with the information received from the work (usually published) of other scientists and researchers as evidence to justify and support the findings. Therefore, science can now be understood as information activities (collection, processing and dissemination of information). Basically, science has always been such an activity, but it has not been until today's modern era that the critical mass is large enough to make this feature of science sufficiently visible and noticeable.

The basic characteristic of this information process, which is often described as the process of scientific information and communication, is the form. This is normally held and runs through the publication of scientific results, which enables the verifiability and repeatability of research and thus the reliability and accuracy of the results obtained. Both of which contributes to the development of science, and, consequently, to the technological, economic and social development, and supplements the contribution towards a certain general scientific knowledge.

Scientists publish their results mostly as papers in international scholar journals. The papers pass through the evaluation procedures (peer review) and are checked before publication, as the top scientific journals publish only a small part of the received articles. The second part of the evaluation

and quality control of scientific research consists in the use of these publications by other scientists, which is reflected in their citations.

All areas of social services need a system of evaluation, quality control and performance. In scientific research, there is more of this, because this control is systematic, constant, and above all, independent and transparent. This is done despite the fact that scientific research is not a routine activity, and therefore the results cannot easily be measured and evaluated. Very clear rules of scientific excellence, which are international and ubiquitous, allow this. This of course would not be possible without global integration of science that allows virtually unlimited international integration and cooperation.

In recent decades, bibliometrics has been created as one of the basic research methods in information science (often in the syntagm library and information science). In many ways it is losing its connection to the social science base and becoming more technical, empirical and objective. It forgets that science is a social phenomenon, and also that social phenomena are the basic elements of its research – citations are also a social phenomenon. Contemporary trends in bibliometrics, linking classical bibliometric exploration of social networks in science (Cronin, 2008) and Altmetrics are important harbingers of new trends, which might reconnect social dimensions back into the bibliometrics.

Latest trends in bibliometric research are also important for sociology. The equation citations = quality is no longer valid (if it ever was). That is why we gain so much more importance from exploring phenomena in scientific research, such as prestigious scientific awards, membership in editorial boards of top journals, reputable conferences and highly cited papers. The latter are interesting primarily because there is no doubt about the fact that highly cited scientific papers have certain quality. For scientists who write such papers there is no doubt that they are worth receiving financial support for their research work (Nicholson and Ioannidis, 2012). However, there are also exceptions; highly cited papers need not necessarily bring something new, but they are written in a massive co-authorship, which brings only checked facts (Rodriguez – Navarro, 2012). Such papers (with hundreds of “authors”) should normally be excluded from bibliometric analysis, because we cannot judge on their actual visibility, and even less, evaluate the contribution of individual authors.

Evaluation studies of research and scientific advances are increasingly focusing on highly cited publications, i.e. publications representing the highest quality, scientific excellence (van Leeuwen et al., 2003; Adams, 2005). These are the papers that fall, by their number of citations in the top 1 percent (or 10 percent) of papers published in certain period and in the research area. Why such interest in such publications? Mainly because the

analyses show that these publications have an important analytical framework – both in terms of transparency and the possibility of comparisons that provide new, more useful indicators for identifying scientific excellence at various levels. Having realized this, ten years ago, authors now pay attention to the need for further studies in order to test the usefulness of this indicator for the analysis of research policies, and evaluate scientific achievements (Thijssen et al., 2002). Analyses of individual research institutions, such as the analysis of the publications of researchers at the University of Beijing, show that they are highly cited articles of particular importance for the reputation and status of the scientific institutions (Zhu, 2004). Aksnes and Sivertsen (2004) found that the average citation by countries in different fields of science depends to a large extent on a few highly cited papers. The characteristic of highly cited articles also lies in the fact that they are very readily cited (Adams, 2005).

How do papers become highly cited? Most of the researchers are interested in how international cooperation affects high citation. Persson (2010) notes that the most highly cited papers in Sweden were written in domestic co-authorship. Their proportion in international co-authorship in the structure of highly cited publications ranged between 17 and 29 per cent. The results from the study of highly cited papers for Norway in the period 1981–1996 are different (Aksnes, 2003). Almost two-thirds (63 per cent) of highly cited papers were in international co-authorship. Aksnes notes that the Norwegian cooperation with foreign scientists is almost a prerequisite for high-impact research, and further, that if it is at 63 per cent of total international co-authorship; the concept of “highly cited publications of Norwegian researchers” is somewhat problematic. Highly cited papers are usually published in scholar journals with high impact. In order to analyse the extent to which this occurs in the publications of Norwegian authors, the impact factor of the journal was compared with the average for the area in which the journal is indexed. Only 9 per cent of highly cited articles were published in journals with impact factor less than the average in the area. This is a small number, but nevertheless it shows that the publication in the high-impact scholar journal is not a prerequisite for high citations.

International cooperation may also have other dimensions, as was shown by the analysis of publications of research results in Taiwan, analysed over the period 2000–2009. Taiwan is ranked among the top 30 countries in the world, according to the number of highly cited publications. There is also a noticeable growth of such papers in comparison with the neighbouring countries in Asia, where such growth could not be detected. In recent years, Taiwan has increasingly cooperated with other European countries, where production of highly cited publications is relatively high, and this can also be the cause of such growth (Miyairi, Chang, 2012).

International co-authorship of papers by researchers from Slovenia is increasing rapidly. The impact of international cooperation of Slovenian authors, the status of their papers and their impact (measured by the number of citations received) in the period 2004–2008 in the fields of physics, chemistry, biology, biotechnology and medical science was analysed. The results showed that the effects of these two factors differ between fields of research; the effect of international co-authorship on the impact (citations) was found in the field of medicine, but was not confirmed in the field of physics (Pečlin et al., 2012). A survey by two Slovenian sociologists showed that the internationalization of research in social sciences is growing, thanks to the evaluation mechanisms and Expert System Public Research Agency; however, there are still significant obstacles that other sciences do not have or do not know (Kramberger, Mali, 2010).

In this study, we set up the hypothesis that the highly cited papers (co-) authored by Slovenian researchers were published in highly influential and impact scholar journals (ranking among the top quarter in the WoS category), that they were written mainly in international co-authorship, and that co-authors from Slovenia were the minority in the international co-authored groups. As a source of data on citations, we used both bibliographic databases, WoS and Scopus, as they differ in their scope (Bartol et al., 2012). Data on citations from the two bases are connected by scientific bibliographies, which are part of the Slovenian information system of current research (SIC-RIS), through the COBISS system.

Methodology

Our research consists of two studies. The first deals with the scientific papers in scholar journals indexed in WoS bibliographic database, namely those classified according to the number of citations in the top percentage of most cited papers in the field. The required number of citations for ranking among the highly cited papers differs regarding the specific research area, and depending on the year of publication. A country that has more than one per cent of highly cited publications among all scientific publications, exceeds the global average. The share of less than one per cent is indicating a different degree of lagging behind the global average. We analysed 153 scientific papers (co-)authored by Slovenian researchers in the period 2000–2010 and cited in the same period, according to the Web of Science. For illustrative purposes, here is a list of the required number of citations needed for a scientific paper to be placed among the top percentage in a particular field of research. Of course, the required number depends largely on the research area. Differences in the required number of citations for articles published in the last year considered among research areas are not

substantial (between three and seven publications), whereas they are significant in older publications. So for instance, for a scientific paper published in 2000 in the research field of mathematics to rank among the highly cited, 55 citations are needed, and in the field of molecular biology and genetics, 369 citations.

Highly cited publications were then divided into the following five categories:

- (A) all co-authors are from Slovenian research organisations,
- (B) the majority of the co-authors are from Slovenian research organisations,
- (C) one foreign author in the Slovenian co-authored group,
- (D) authors from Slovenia are the minority in the co-authored group, and
- (E) only one of the co-authors is from Slovenia.

Table 1: THE REQUIRED NUMBER OF CITATIONS IN THE SPECIFIC RESEARCH FIELDS FOR LISTING OF THE PUBLICATION IN THE TOP PERCENTAGE OF MOST CITED PUBLICATIONS BY YEAR OF PUBLICATION, AND THE NUMBER OF PUBLICATIONS IN SLOVENIAN CO-AUTHORSHIP IN 2000–2010

Research field	2003	2008	2013	2000–2010
Agricultural Sciences	121	53	2	8
Biology and Biochemistry	241	121	4	4
Chemistry	175	104	3	10
Clinical Medicine	216	108	3	22
Computer Science	77	49	2	7
Economics and Business	156	55	3	1
Engineering	87	47	2	21
Environment/Ecology	185	96	4	5
Geosciences	141	73	4	3
Immunology	291	169	4	0
Materials Science	150	81	3	6
Mathematics	60	33	2	2
Microbiology	210	104	3	2
Molecular Biology and Genetics	395	204	4	0
Multidisciplinary	108	163	7	0
Neuroscience and Behaviour	259	128	4	0
Pharmacology and Toxicology	184	98	3	4
Physics	141	76	4	37
Plant and Animal Science	125	59	3	6
Psychiatry/Psychology	211	83	4	5
Social Sciences, general	93	40	3	1
Space Science	217	112	5	9

Source: <http://esi.webofknowledge.com>

In our second study, we analysed the scientific papers co-authored by Slovenian authors in journals indexed in the Scopus bibliographic database. In this case, we made a selection based on the number of citations obtained among the 10 per cent most cited papers published in 2008, in a particular field of research. The citation window comprises the year of publication, i.e. 2008 and three subsequent years.

Highly cited publications in Slovenian co-authorship, i.e., those from the top 10 per cent most cited publications in a given field of research, were again divided into the following categories:

- (A) all co-authors are from Slovenian research organisations,
- (B) co-authors from one Slovenian and one foreign research organisation,
- (C) co-authors from several Slovenian and one foreign research organisations,
- (D) co-authors from Slovenian research organisations are in the minority,
- (E) co-authors from several foreign and one Slovenian research organisations, and
- (F) co-authors from Slovenian research organisations are in the majority.

Results

The first study – the top percentage of most cited publications in the field

Highly cited papers in Slovenian co-authorship came from eighteen research fields. The most highly cited papers were in the field of physics, 24 per cent, followed by 14.4 per cent in clinical medicine, third was the field of engineering with 13.7 per cent of papers. Research fields with more than five per cent publications were chemistry (6.5 per cent), space science (5.9 per cent) and agricultural sciences (5.2 per cent).

The value of bibliometric indicator, which indicates to what extent the country exceeds or lags behind the world average (1 per cent of highly cited publications of all scientific publications) for Slovenia in the observed period, was 0.66 per cent, which ranks Slovenia only 21st among the EU Member States.

In the structure of publications with Slovenian co-authorship dominated groups where the international team of co-authors “hosted” a Slovenian. Such publications amounted to almost 41 per cent. Followed publications where international teams including Slovenian minority and those published exclusively with Slovenian co-authorship. Among all highly cited publications with Slovenian co-authorship there were only 18 per cent of publications with Slovenian authorship, and 82 per cent of total Slovenian researchers in collaboration with colleagues from abroad.

Table 2: THE SHARE OF HIGHLY CITED PUBLICATIONS IN THE STRUCTURE OF ALL SCIENTIFIC PUBLICATIONS OF THE EU MEMBER STATES, 2000–2010

Denmark	1.85 %	France	1.25 %	Lithuania	0.77 %
Netherlands	1.81 %	Italy	1.14 %	Greece	0.76 %
England	1.70 %	Estonia	1.03 %	Slovenia	0.66 %
Belgium	1.56 %	Spain	1.02 %	Cyprus	0.62 %
Sweden	1.48 %	Luxembourg	0.97 %	Latvia	0.61 %
Austria	1.41 %	Hungary	0.93 %	Poland	0.59 %
Germany	1.40 %	Portugal	0.88 %	Slovakia	0.52 %
Ireland	1.39 %	Malta	0.78 %	Romania	0.45 %
Finland	1.28 %	Czech Republic	0.77 %	Bulgaria	0.44 %

Table 3: HIGHLY CITED PUBLICATIONS (1 %) WITH SLOVENIAN CO-AUTHORSHIP WITH REGARD TO THE COMPOSITION OF CO-AUTHORSHIP

Type of co-authorship	Share in %
All co-authors are from the Slovenian research organisations	18 %
The majority of the co-authors are from Slovenian research organisations	9 %
One foreign author in the Slovenian co-authored group	5 %
Authors from Slovenia are the minority in the co-authored group	27 %
Only one of the co-authors is from Slovenia	41 %

Specifically, we looked further into highly cited publications in international co-authorship with Slovenians as first authors. Such publications comprised 19 per cent of total Slovenian highly cited publications in international co-authorship. The vast majority (85 per cent) were published in journals ranking among the upper quarter of journals in each WoS category; in 21 cases, they were published in journals listed below the upper quarters in each WoS category. The same high proportion of publications among the top 25 per cent of journals was noted in the areas stated in the case of publications with exclusive Slovenian co-authorship, even more (88 per cent) in the case of publications in international co-authorship with the Slovenians as first authors.

The second study – the upper ten per cent of most cited publications in the field

The results of the second study show that, in the structure of all the publications in journals indexed in the Scopus bibliographic database, Slovenia has 9.5 per cent of such publications, which ranks it by the number

of citations among the 10 per cent most cited publications in the area. The average of twenty-seven EU Member States is 11.67 per cent, and with its share of highly cited publications in the structure of all its publications, Slovenia occupies the 18th place among the EU Member States.

Considering the relationship of Slovenia to other EU Member States and the EU-27 average indicator of the number of highly cited publications per million inhabitants, it can be stated that in 2004 Slovenia reached the European average, while in 2008 the average was already exceeded by more than 37 per cent. Among the publications in journals indexed in the Scopus bibliographic database in 2008, there are 400 publications with Slovenian co-authorship having the status of highly cited publications. Most of them are from the research fields of physics and astronomy, 20 per cent from clinical medicine and biomedical research, 19 per cent from information and communication technologies, 12 per cent and 11 per cent from engineering. In the structure of publications with Slovenian co-authorship, groups with only Slovenian authors and co-authored groups with co-author/s of a research organisation from Slovenia participating in major international co-authored teams dominated.

Table 4: HIGHLY CITED PUBLICATIONS (10%) WITH SLOVENIAN CO-AUTHORSHIP WITH REGARD TO THE COMPOSITION OF CO-AUTHORSHIP

Type of co-authorship	Share in %
All co-authors from the Slovenian research organisations	42 %
Co-authors from one Slovenian and one foreign research organisation	14 %
Co-authors from Slovenian and one foreign research organisations	5 %
Co-authors from foreign and one Slovenian research organisations	29 %
Co-authors from Slovenian research organisations are in the minority	7 %
Co-authors from Slovenian research organisations are in the majority	3 %

Discussion and conclusion

According to our presumption, highly cited publications with Slovenian co-authorship involved mainly publications made by international co-authored teams. However, the result obtained in the case of highly cited publications from the top 10 per cent of most cited publications in the field has not confirmed our presumption. As many as 42 per cent of those publications are made exclusively in Slovenian co-authorship, and further 8 to 22 per cent mainly with Slovenian or “equivalent” co-authorship between Slovenian researchers and their colleagues from abroad. The hypothesis that Slovenian authors constitute a minority in international co-authored teams

can thus be confirmed in the case of publications from the top percentage of most cited publications. Slovenians as first authors feature in 33 per cent of all highly cited publications from the top percentage of most cited publications in the research field, and in 59 per cent in the case of highly cited publications from the top 10 per cent of most cited publications in the field. We were only able to test and confirm our hypothesis that highly cited publications in Slovenian (co-)authorship involved publications in highly ranked journals (ranking among the top quarter in WoS category), in the case of highly cited publications from the top percentage of most cited publications in individual research fields.

The results obtained in the case of highly cited publications from the top percentage of most cited publications in the field are similar to those stated by Aksnes in his study of highly stated publications for Norway in the period 1981-1996 (Aksnes, 2003). Indeed we find that 82 per cent of highly cited publications with the participation of Slovenian researchers have international co-authorship, and that 85 per cent of articles with Slovenian co-authorship are published in best ranking journals or top quarter journals in individual fields. The number of high-impact (highly cited) articles is not directly related to the total number of articles, as found by the researchers from Taiwan, since there are only two big countries (USA and UK) among those with more than 1.5 per cent of highly cited articles in the structure of all the articles, all the rest being smaller European countries (Miyairi, Chang, 2012). Slovenia could range among the latter, should this become part of our research policy and strategy.

This may only happen if we pay more attention to highly cited articles in the future. According to some renowned researchers in the field of bibliometrics/scientometrics, the share of highly cited articles - be it those ranking among the top percentage high-impact articles in the world, top 10 per cent, or top quarter of highest impact in the structure of all articles published - can provide a suitable alternative to the present criteria for measuring the impact of journals such as the journal impact factor (JIF) (Leydesdorff, 2012). This is a relatively simple indicator, which allows different uses and provides a good supplement to other, more established bibliometric indicators. Interesting are also the possibilities of predicting high citation, which can be effectively predicted, at least in certain fields such as physics (Newman, 2013).

The present analysis has shown that increased use of the bibliometric indicator of highly cited publications could be justified also in Slovenia. Such use would also encourage focusing on changed patterns of publishing or scientific communication and information. What matters is the quality of publication, not just "accumulating" publications with an average or even below average impact. Citation as the indicator of impact and importance of a publication is influenced by various factors that are not necessarily related

to the scientific quality of this publication. This influence decreases considerably in highly cited publications, where it can be said with higher certainty that it involves actual influence and impact. Also the criteria or weights for evaluating differently, and above all more correctly, international cooperation in science, should be resolved. Publications with Slovenian researchers as the leading authors should be weighted differently than publications (often with massive co-authorship) where Slovenian authors represent just one of many co-authors.

The established relationship between highly cited publications and international cooperation also opens a few further research fields. However, such research would also require different methodological approaches. For Slovenia, which has a relatively small number of such publications, case study on a representative sample could be a solution.

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