CITATION ANALYSIS FOR FIVE SERBIAN AUTHORS IN WEB OF SCIENCE, SCOPUS AND GOOGLE SCHOLAR

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Abstract: Citation analysis for five Serbian authors from different scientific fields was performed for the period 1998-2006 according to their full bibliographies in two commercial databases (Web of Science and Scopus) and one freely available on the Internet (Google Scholar). The results show big differences between numbers of citations gathered in those databases, suggesting that citation analysis in the Web of Science should not be used as a main indicator for scientific performance for Serbian authors, at least not in all scientific disciplines. The most relevant results from Web of Science, the resource used officially for citation analysis in Serbia, were acquired for an author working in oncology, and the least relevant for computer sciences.

Introduction

Scientometrics and its subfield bibliometrics are disciplines of the science of science, aiming to provide research tools for measurement and explanation of the production and dissemination of scientific knowledge. The short definition of bibliometrics by van Raan says: "Bibliometrics is the quantitative study of the written output of science." Bibliometric analyses make the science more transparent. The founders of the discipline were Derek de Sola Price and Vasiliy Vasilevich Nalimov, but it became popular only after the development of citation indexes (1961) and establishment of the Institute for Scientific Information by their "father" Eugene Garfield. The main idea in citation analysis is that citations are the real reflection of the impact of published scientific results, and that the majority of important information will be found in the core, highly cited journals. Designed as a tool to search information, it was not planned to become a universal tool for the estimation of scientific results. Nevertheless, citation analysis is often used as a tool for evaluating the performance and measuring the impact of scientists, institutions, journals, regions etc. That leads to changes in the behaviour of scientists when deciding where to publish their results, and even in editorial policy of scientific journals. As mentioned in the article by Colin Steele et al. "*The impact game is certainly being played by the major parties and it seems that the main focus is arguably no longer the effective dissemination of knowledge, but rather gains in the reward system*".[1] The rejection rate of journals with high impact factor is now often over 90%, but Thompson ISI on its website notes that about 2000 journals account for 85% of published and 95% of cited articles.

There are a lot of different opinions about the real significance of citation analysis results, but it is heavily used all over the world for "measuring" science. One of the recent papers by van Raan, that gives argumentation why is it not legitimate to use citation data from Web of Science (WoS) for institutional ranking, has a very explicit title "Fatal Attraction".[2] Another paper by Peter Weingart discusses the impact of the use of bibliometric data from the Web of Science on scientific communities in states that use them for funding allocation, like Spain, Finland, Australia and Great Britain. The author emphasizes the danger of the virtual monopoly of a commercial enterprise, Thompson ISI, on the trends in science.[3] It would be wise always to remember a quotation by Eugene Garfield "It is true, of course, that citation counts will not identify significance that is unrecognized by the scientific community. They are, after all, nothing more, nor less, than a reflection of that community's work and interest. To go beyond that is to begin questioning the validity of the community's perception of things, which is another area that calls for peer judgments". (From Citation Indexing – Its Theory and Application in Science, Technology and Humanities, New York, John Wiley, 1979)

Citations Databases

Dana Roth in her paper about the emergence of competitors to the Web of Science analyzed all databases that have the possibility to search citations.[4] The main resource was, and still is, Web of Science, but, after the emergence of Google Scholar and Scopus late in 2004, it is not the only resource.

Google Scholar is a freely available database that includes peer-reviewed papers, theses, books, preprints, abstracts, technical reports from academic publishers, repositories with preprints and published digitized materials, library catalogues etc. Search results are displayed according to relevance based on the full text, author, publication source and frequency of citations to that text. Google has not published the list of sources for Scholar, so we know only that Elsevier did not give its data to Google, and that the grey literature will be probably better represented by Google Scholar. The fact is that the database and its use are growing and that Google is willing to cooperate with libraries. The link resolver for KoBSON is already included in Google Scholar, enabling users from Serbia to find full texts for which the Consortium for coordinated acquisition for Serbia, KoBSON, paid the access from its research libraries. The Union catalogue of Serbian libraries COBISS.Sr with more than 1.6 million records is also linked to Google Scholar.

The Scopus database is prepared by Elsevier, the main competitor of Thompson ISI in the market for information products. The database covers nearly 15.000 journals, mostly from medicine, natural and social sciences. It is possible to find citations in the literature published after 1996. For cited publications that are part of the Scopus database it is possible to retrieve all authors in the paper by using in Searching the option "Citation tracking" and for others the option REFAUTH for the first author should be used.

There is a growing literature comparing those tools for citation analysis. Richard Belew in his paper analyzed the data about citations of 203 publications by six authors in Web of Science and Google Scholar. The number of citations for those publications was over 4,000 for both databases, but the overlap between them was relatively small. Publications in books and conference proceedings are much more likely to be found in Google Scholar, and journal articles are better represented in ISI.[5] Daniel Pauly and Konstantinos Stergiou in December 2005 published their results concerning citation analyses performed in Thompson ISI Citation Index and Google Scholar. They compared citation of three papers by three authors in mathematics, chemistry, physics, computing science, molecular biology, ecology, fisheries, oceanography, geosciences, economics and psychology – 99 articles. For the period 1925-1989 the citation counts were proportional, but ISI returned twice as many citations as Google Scholar. For the period 1990-2004 the number of citations was nearly the same in both databases. Authors concluded that free access to Google Scholar data will give to the whole community the possibility to get insight into science policy issues, much more than ever before.[6] Kayvan Kousha and Mike Thelwall compared the citing of 1650 articles from 108 open access journals covering biology, chemistry, physics, computer science, economics, education, sociology and psychology, 55 of them were indexed in the ISI Web of Science. About half of them were exclusively available online. The significant correlation was found between

ISI and Google Scholar citation count in all disciplines. Google Scholar gave more citations for social sciences and computer science, probably because of the presence of online published conference papers in Google Scholar.[7] In the study of benchmarking the literature from social sciences and humanities according to Web of Science and other resources, it was concluded that those sciences are underestimated in Web of Science, especially if published in languages other than English and in disciplines that are not journal-oriented.[9] That is the reason not to use Web of Science as a unique source of data for benchmarking in social sciences and humanities.

There are few recently published papers that compare Thompson/ISI citation indexes, Scopus and Google Scholar. In a case study comparing the citation counts provided by Web of Science, Scopus and Google Scholar from the Journal of the American Society for Information Science and Technology (JASIST) published in 1985 and 2000, the results showed that Web of Science provided the largest citation number for 1985 and Google Scholar for 2000.[8] It is emphasized that Google Scholar should give a full account of what material is indexed and how often is updated, if it should be considered a true scholarly resource in the sense that Web of Science and Scopus are. Peter Jacso[10] compared the distribution of records among the components of Web of Science, showing that 77% are from science, 14% from social science and 9% from arts and humanities. In Scopus, 60% of records are from health and life sciences, 25% from mathematics, physics, chemistry and engineering, 13% from biology and biotechnical sciences and 2% from social sciences. Web of Science has nearly 9000 journals on the list, and Scopus nearly 15000. Google does not offer publishers or journal lists or the data about the time-span or disciplinary distribution of records. The author performed a search in all three databases for the documents citing the well-known paper "Citation Indexes for Science: A New Dimension in Documentation through Association of Ideas." by Eugene Garfield, published in the journal *Science* in 1955. The results were as follows: WoS 83, Scopus 76 and Google Scholar 82, but only 33 papers were present in all three databases. Half of the papers in Google Scholar had links to full texts. The other search for citations of the 30 most cited papers from *Current Science* 1996-2001 in Scopus showed that all of them were found in WoS and only half of them in Google Scholar. The author emphasizes that bibliometric searches are well facilitated in WoS and Scopus and practically non-existent in Google Scholar. In another paper by the same author the individual and aggregate citation scores in WoS and Google Scholar for the 22 volumes of *Asian Pacific Journal of Allergy and Immunology* were compared. The results showed that the number of papers retrieved was 675 for WoS and 680 for GS, but the number of citations was 1355 in WoS and 595 in GS. That was probably because some journals with very high impact factors are not included in Google Scholar.[11] The argumentation why Google Scholar can not replace commercial databases for correct bibliometric research is given in the article published in Online Information Review.[12]

Nisa Bakkalbasi et al. in the paper from June 2006 compared citation counts for articles from 11 journals from oncology and 11 from condensed matter physics for 1993 and 2003, to test the hypothesis that the different publication coverage in those three databases will lead to different citation counts. For oncology in 1993 and condensed matter physics for 1993 and 2003 Web of Science returned the highest average number of citations, and Scopus returned the highest number for oncology 2003. All three databases returned some unique material. The conclusion is that none of those databases covers the entire set of citing articles, and any two of three tools would find the majority, but not all citing material.[13] After a comparison of Scirus, Google Scholar and Pub Med published in the professional journal for medical librarianship in Canada, the authors concluded that Medline is better for sophisticated search, but Google Scholar is quick and easy to use, and can be recommended for users who are not affiliated with universities or big hospitals.[14]

Two authors, Kiduk Yang and Lokman Meho, produced software for analyzing combined data about citations from multiple database citation searches. They compared and analyzed the citations found for two professors from the School of Library and Information Science. The study showed that Web of Science should not be used alone for individual authors, because in Scopus and Google Scholar there was found a considerable number of valuable citations that were not found in ISI citation databases. It is important to be aware of differences between databases, and technical problems in citation counts from Google Scholar. The authors concluded that other sources should also be considered to find citations for individual authors.[15]

Method

Science Citation Index and its expanded edition in Web of Science were for a long time the only existing resources for gathering data about citations for bibliometric use in Serbia. From 2005 it became possible also to gather data about citations of Serbian authors from Scopus. The access to Scopus and Web of Science is limited to the academic community. Google Scholar is available in Serbia to everybody who has Internet access.

Citation analysis became an important issue in the new millennium in Serbia. The national Ministry of Science uses the number of citations according to the Web of Science and impact factor of journals in which Serbian authors publish their scientific papers as the most important indicator in evaluating their scientific performance. As expected for a small scientific community, Serbia does not have many highly cited authors. Because of that fact it was interesting to see the difference between results of citation counts for the same authors in different databases. From the papers mentioned above it is possible to conclude that there exist differences between results from those databases. Those differences could be very important in a small community like Serbia, with small absolute number of citations. The results of this study, however incomplete, could be used as indices of the relevance and completeness of citation data for Serbia in commercial databases and in Google Scholar.

The Department for Scientific Information and Development of the Library System at the University Library "Svetozar Markovic" in Belgrade prepares for Serbian authors the bibliographies of papers that cite their works as a part of its regular activities. The authors submit to the library their full bibliographies, and librarians perform search for citations in Science Citation Index 1980-1999 on CD ROM and from year 2000 in Web of Science. Librarians compare the data in the authors' bibliography with the data in ISI citation databases, exclude autocitations and prepare the bibliographies of citing papers. Those data are used in the processes of election for university positions, membership in professional academies and the Serbian Academy of Science and Arts, selection of projects for financing by the state Ministry of Science, etc.

In August 2006 research on all three databases was conducted for five Serbian authors from Belgrade to find the works that cite any of their publications for the period 1998-2006. Researchers were chosen from the group of authors whose bibliographies of cited items according to the Web of Science were previously prepared on demand and stored in the library. All the data were updated on August 15th 2006 in the database Web of Science. To get the material for the comparative study, the searching of citations belonging to those authors was performed according to their bibliographies on the same date in databases Scopus and Google Scholar.

Four active authors were chosen from the group of cited authors for the disciplines they be-long: psychology (Opalic P.), zoology (Kalezic M.), oncology (Paunovic I.) and computer sciences (Jovanovic Z.). The authors were in the group of middle-cited for the fields of social sciences, natural sciences, medicine and technical sciences for the last ten years period. As a special case for comparison, Milutin Milankovitch (1879-1958), professor of applied mathematics and astronomy from the University of Belgrade, founder of the mathematical theory of climatic change, was also chosen, because his scientific works from the first half of the twentieth century were and still are regarded with the highest respect. It was interesting to see if this world respect would be so clearly visible from the list of his citations in Scopus and Google Scholar. Autocitations were excluded from the search results for all authors in all databases.

Results and discussion

At first the data collected from Web of Science and Scopus were compared. The results show that the overlapping of those databases is significant, but not absolute. In all cases there is a part of data that are present in only one of those databases. For a small scientific community with a small number of citations on average, those numbers can make a big difference if interpreted mechanically during the performance evaluation process.

Table 1: Number of citations in Web of Science and Scopus

Author/ Discipline	Citations in WOS	Citation in Scopus	Unique citations	Over-lapping	Total citat.
Opalic/ Psychology	14 (77.78%)	13 (72.22%)	4 Scopus + 5WOS = 9 (50%)	9 (50%)	18
Kalezic/ Zoology	85 (72.03%)	69 (58.47%)	33 Scopus + 19 WOS = 52 (44.07%)	66 (55.93%)	118
Paunovic/ Oncology	66 (78.57%)	67 (79.76%)	18 Scopus +7 WOS = 25 (29.76%)	59 (70.23%)	84
Jovanovic/ Computer sciences	32 (72.7 2%)	29 (65.91%)	12 Scopus +15 WOS = 27 (61.36%)	17 (38.64%)	44
Milankovic/ Geosciences	293 (83.01%)	292 (82.72%)	60 Scopus + 61 WOS = 121 (34.28%)	232 (65.72%)	353

In the case of psychology, Scopus has covered one German journal that is not covered by WoS, and in WoS there was one proceeding, not covered by Scopus. In the case of zoology, the difference is even bigger. In WoS there are one proceedings and 8 journals that are not covered by Scopus, and in Scopus there are 26 journals that are not covered by WoS. One journal (Amphibia reptilia) is present in both databases, but not the same volumes. In the case of oncology, there are 6 journals covered by WoS and not by Scopus, and 18 journals covered by Scopus and not by WoS. Nine of those journals are not in English, or are national journals (Czech, Polish, Serbian, Chinese etc.). In the case of computer science, Scopus is not covering some very important resources like IEEE Transactions series, Lecture Notes in Computer etc. WoS is not covering 10 journals, two of them Chinese. In the case of Geosciences there are 61 resources in WoS that are not covered by Scopus and 60 in Scopus that are not covered by WoS, but the most important international journals with high impact factor are present in both databases.

It can be concluded that both databases give relevant data about citedness, and the main difference is that some important proceedings and international journals are not covered by Scopus and some national or regional journals are not covered by Web of Science. Overlapping is the best in medical sciences, as Scopus has very good coverage of medical sciences and in geosciences where there are a lot of multidisciplinary journals included in both databases. In psychology and zoology overlapping is about 50%, and in computer science it is only 38%. That is not a satisfactory percent, meaning that when those databases are used as scientometric tools for evaluationage of scientists from small scientific communities working in classical biological disciplines, social and technical sciences, the results should be considered very carefully.

The emergence of Google Scholar, the free database developed by Google, changed the situation, because now everybody has the access to data about cited literature in the Google database. To get a better picture of citation analysis results than could be expected from Google Scholar, the search for citations of the same authors was performed in Google Scholar. The results are given in Table 2 and 3.

zoology, computer sciences and geosciences are present in both databases. For geosciences we expect that the result for an active author would be different, because much of the older literature, especially books, which cited professor Milankovitch is present in Google Scholar.

From the Table 3 we can see that overlapping between Google Scholar and Scopus is the same or even smaller than its overlapping with Web of Science.

It was interesting to see how many unique citations were present in each database. The results are shown in the Table 4.

The biggest percent of unique records is for computer sciences – 78%, and the majority of those records were from Google Scholar. The next on the list is the number of unique records for geosciences, but that was to be expected because of the older literature involved. The percentage varies, but the main fact is that for all fields in all

Table 2: Number of citations in Web of Science and Google Scholar

Author/ Discipline	Citations in WOS	Citation in Google Scholar	Unique citations	Over-lapping	Total citations
Opalic/ Psychology	14	10	18 75%	6 25%	24 100%
Kalezic/ Zoology	85	60	85 73.9%	30 26.1%	115 100%
Paunovic/ Oncology	66	76	51 53.1%	45 46.9%	96 100%
Jovanovic/ Computer sciences	32	76	52 68.4%	24 31.6%	76 100%
Milankovic Geoscience	293	391	537 81.7%	120 18.3%	657 100%

From Table 2 we can see that the overlapping between Web of Science and Google Scholar was less than 50% for all scientists and that only between 1/3 and 1/4 of citations for psychology,

Table 3: Number of citations in Scopus and Google Scholar

Author/ Discipline	Citations in Scopus	Citation in Google Scholar	Unique citation	Over-lapping	Total citations
Opalic/ Psychology	13	10	17 73.9%	6 26.1%	23 100%
Kalezic/ Zoology	69	60	84 65.1%	45 34.9%	129 100%
Paunovic/ Oncology	67	76	61 57%	46 43%	107 100%
Jovanovic/ Computer sciences	29	76	67 77.9%	19 22.1%	86 100%
Milankovic/ Geosciences	292	391	524 79.9%	132 20.1%	656 100%

databases existed unique records, whose number varies from 6 to 50%. Those data suggest that for a small scientific community with low absolute figures of citations it would be recommendable to use more than one resource for gathering data about citations. The impact of gathering citations from the other two databases compared with Web of Science for chosen authors is shown in Table 5. It is obvious from those results that the difference is not at all small.

On the next table the results of the search of overlap between all three databases are disposed, showing that the overlapping is very different for different databases and disciplines.

The overlap is pretty small, varying from 70% between Web of Science and Scopus for oncology to 15% between all three databases for computer sciences. Generally the overlap between Web of Science and Scopus is much bigger for all fields than the overlap between any of those databases and Google Scholar. It is probably because Google Scholar covers much more materials from digital repositories, digitized books, conference materials, library catalogues etc.

Table 4: Unique Citations Found in Each Database

Discipline	Web of Science		Scopus		Google Scholar		Total	
	Number	%	Number	%	Number	%	Number	%
Psychology N=28	5	17.9	4	14.3	4	14.3	13	46.4
Zoology N=148	19	12.8	33	22.3	11	7.4	63	42.6
Oncology N=114	7	6.1	18	15.8	27	23.7	52	45.6
Computer Sciences N=96	15	15.6	12	12.5	48	50	75	78.1
Geosciences N=717	61	8.5	60	8.4	233	32.5	354	49.4

For psychology and computer sciences the difference is 200%, for zoology 74%, for oncology 72%, and for geosciences 144%. For geosciences the result would be different for an active author. It is obvious that the number of gathered citations is much bigger if additional databases are used, not just Web of Science, and that the percentage of increase of values is in all cases over 70%. When dealing with small numbers of citations, it is very important to have that fact in mind.

Overlap between all three databases for the author from psychology is 21.4%. There were 46.4% of citations present in only one database. That fact means that data about the number of citations for an author in social sciences and humanities are not at all sufficient to make estimation about the reception of his/her works in the

Table 5: Impact of multi-sourcing of citations on Web of Science results

Source(s)	Opalic/ Psychology		Kalezic/ Zoology		Paunovic/ Oncology		Jovanovic/ Computer sciences		Milankovic/ Geosciences	
	No. Citat.	+ % diff.	No. Citat.	+% diff.	No. Citat.	+% diff.	No. Citat.	+% diff.	No. Citat.	+% diff.
WoS	14		85		66		32		293	
WoS+Scopus	18	28.6	118	38.8	84	27.3	44	37.5	353	20.5
WoS+Google Scholar	24	71.4	115	35.3	96	45.4	84	162.5	657	124.2
Scopus+Google Scholar	23	64.3	84	-1.2	97	47	86	168.7	657	124.2
WoS+Scopus+ Google Scholar	28	200	148	74.1	114	72.7	96	200	717	144.7

Table 6: Citation overlap among databases

Source(s)	Opalic/ Psychology		Kalezic/ Zoology		Paunovic/ Oncology		Jovanovic/ Computer sciences		Milankovic/ Geosciences	
	No. Citat.	Over-lap%	No. Citat.	Over-lap%	No. Citat.	Over-lap%	No. Citat.	Over-lap%	No. Citat	Over-lap%
WoS+ Scopus	18	9 50%	118	66 55,9%	84	59 70,2%	44	17 38,6%	353	232 65,7%
WoS+ Google Scholar	24	6 25%	115	30 26,1%	96	45 46,9%	76	24 31,6%	657	120 18,3%
Scopus+ Google Scholar	23	6 26,1%	84	45 34,9%	97	46 43%	86	19 22,1%	657	132 20%
WoS+Scopus+ Google Scholar	28	6 21,4%	148	26 17,6%	114	43 37,7%	96	15 15,6%	717	85 11,9%

world scientific literature, and that those data could be used only with some other indicators in combination. The best resource for citations was WoS with 50% of the total number of citations.

Overlap between all three databases for the author from zoology was 17.6%. There were 42.6% of citations that were present in only one database. That fact also means that data about the number of citations for an author in classical biology disciplines are not sufficient to make estimation about his/her place in the world of science, because each database covers about the half of existing citations. The best resource for citations was WoS with 57.4% of the total number of citations.

Overlap between all three databases for the author from oncology was the best – 37.3%. There were 45.6% of citations present in only one database, and in all databases the percentage of present citations was over 50%. That fact means that the data about the number of citations in medical and life sciences are pretty representative in all three databases. Google Scholar gave a little more citations than WoS or Scopus, but the difference was about 8% between Google Scholar and commercial databases, and insignificant – less then 1% - between WoS and Scopus.

Overlap for active scientist in computer sciences was the worst – only 22.1%. There were 78.1% citations that were present in only one database. The important fact is that in Google Scholar 79% of citations were present, and in commercial databases that percentage was a little over 30%. That fact could mean that computer science literature is not well covered in commercial databases.

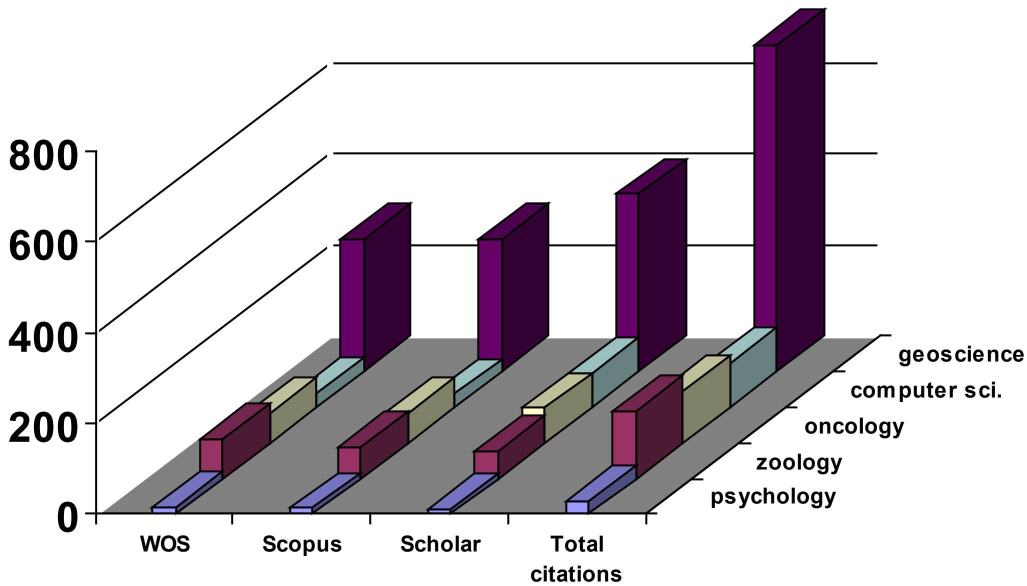
For Geosciences the overlap was only 11.9% and 49.4% of citations were present in only one database. That is the result of the fact that we gathered citations from last 8 years from commercial databases, and from Google Scholar it is very difficult to pose that limit, so we collected them all. The other important fact is that Google Scholar includes older books, proceedings and journals, and since Professor Milankovic published his works between 1905 and 1957 it could be expected that he was cited in older literature. But the fact is that all three databases collected over 40% of the existing citations, so it could be concluded that geosciences are covered approximately on the same level as zoology.

The number of citations in each database and total number of different citations for each author is shown of the Graph. 1.

Conclusion

The results of this study, although not big enough to make it possible to give some definitive conclusions, indicate that the data from Web of Science are not enough for performing really relevant bibliometric researches for individual scientists in Serbia. The differences of the

Graph. 1: Number of citations in databases and total number of different citations



scope of both commercial databases and Google Scholar resulted in big differences in the total number of citation for observed authors. Author Opalic P. from psychology had 14 citations in WoS instead of 28 citations from all three databases. Author Kalezic M. from zoology had 85 citations in WoS instead of 148 citations from all three databases. Author Paunovic I. from oncology had 66 citations in WoS instead of 114 citations in all three databases. Author Jovanovic Z. from computer science had 32 citations from WoS instead of 96 citations in all three databases. Geoscientist Milutin Milankovic had 293 citations in WoS instead of 717 in all three databases.

At the moment only a few journals from Serbia are included in WoS and in Scopus. There are some more journals with open access from Serbia, which are automatically included in Google Scholar. If the number of Serbian journals included in commercial databases or with open access would grow, that would change the visibility of papers published in them and increase the chances that those papers would be read and perhaps cited. In an investigation of citedness of articles with open access compared with articles with paid access from the same journal, it was concluded that the impact of open access articles was higher and that they were cited without delay[16].

Very important in that context is the establishment of a Serbian Citation Index which would index locally published journals classified as periodicals of scientific character.

We may conclude that citation analysis for individual scientists in Serbia should be used as relevant information in the process of their scientific performance evaluation only if the analysis includes data from all relevant existing resources, not just from Web of Science. It is the fact that the most important results of world science will appear in Web of Science, since Garfield[18] in 1997 showed that 2,000 journals of the Science Citation Index generated over 80% of all citations. Considering the fact that WoS already covers the most prestigious and the most cited journals, the doubling in journals would only increase the total number of citations a little bit. That is why in Scopus, with twice as many journals as WoS, the number of found citations in our study is not much bigger. For a small scientific community as Serbian is, the big success is to publish articles in journals covered by WoS and to be cited in those journals, but the absolute number of those citations should not be overestimated and other sources of citation data should also be considered, especially in scientific disciplines that are regional specific as history, geography etc.

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