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## Impact of open access on citation of scholarly publications in the field of civil engineering

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### Abstract

The development of science is accompanied by growth of scholarly publications, primarily in the form of articles in peer-reviewed journals. Scientific work is often evaluated through the number of scientific publications in international journals and their citations. This article discusses the impact of open access (OA) on the number of citations for an institution from the field of civil engineering. We analyzed articles, published in 2007 in 14 international journals with impact factor, which are included in the Journal Citation Reports (JCR) subject category "Civil Engineering". The influence of open access on the number of citations was analyzed. The aim of our research was to determine if open access articles from the field of civil engineering receive more citations than non-open access articles. Based on the value of impact factor and ranking in quartiles, we also looked at the influence of the rank of journals on the number of citations, separately for OA and NonOA articles, in databases Web of Science (WOS), Scopus and Google Scholar (GS). For 2026 studied articles we found out that 22 % of them were published as OA articles. They received 29 % of all citations in the observed period. We can conclude by the significance level 5% or less that in the databases WOS and Scopus the articles from top ranked journals (first quartile) achieved more citations than NonOA articles. This argument can be confirmed for some other journals from second quartile as well, while for the journals ranked into the third quartile it can't be confirmed. This could be confirmed only partly for journals from the second quartile, and would not be confirmed for journals ranked into the third quartile. This shows that open access is not a sufficient condition for citation, but increases the number of citations for articles published in journals with high impact.

**Key words:** scholarly publications, civil engineering, open access, citation.

## Introduction

The development of science is followed by the growth of scientific publications primarily in the form of articles in peer-reviewed scientific journals. Swan (2010) notes that a million scientific articles were published in 23 000 journals in one year. According to Björk (2011) the annual scientific production in 2010 is 1.5 million articles in 30 000 journals indexed in Ulrich's database, which does not include several thousands of journals outside the Anglo-Saxon language area.

Scientific journals present a very important part of scientific communication. The number of articles published in peer-reviewed high impact journals and the number of citations the articles receive are important indicators for the evaluation of scientific work in many countries (Kurtz et al. 2005), also in Slovenia.

Open access is an established way of publishing the results of scientific research, especially among physicists, chemists and in medicine (McVeigh 2004; Suber 2007). Björk and Turk (2000) conducted a survey among 239 researchers around the world and found out that on average researchers read over 100 open access documents per year. Researchers often use electronic sources at their work, but they are very rarely willing to share the results of their research through the Internet. The analyses of open access articles in the databases WOS and Scopus (Björk et al. 2010) revealed that around 20 % of publications are openly accessible, but the authors must pay a fee to the publishers. In analysis of articles, which were published in 2008, Björk et al. (2010) found out that 8.5 % of all articles are freely accessible on the journal websites and further 11.9 % of articles were found as the last peer-reviewed author manuscripts accessible via open repositories and authors' web sites. In 2010 on average a total of 20.4 % of articles were openly accessible (Björk et al. 2010).

In line with the global trend of growth of OA publications and findings on its impact on citations, we decided to investigate the global production of articles in the field of civil engineering. We studied their citations, separately for open access articles, and for those that are not openly accessible.

## Review of publications about several citation databases

Firstly we examined three bibliographic databases. WOS ([http://wokinfo.com/products\\_tools/multidisciplinary/webofscience/](http://wokinfo.com/products_tools/multidisciplinary/webofscience/)) has the longest history of article indexing, SCI expanded covers scientific publications since 1900. It is the best tool for retrospective analysis (Bar-Ilan 2010). Most of the WOS indexed scientific publications are produced in Anglo-Saxon area. This weakness was partially eliminated in 2007 with the inclusion of many journals from around the world. At that time also some journals published in Slovenia were included (Koler-Povh and Žumer 2012).

On 3<sup>rd</sup> of November 2004 Elsevier started its database Scopus, and on 18<sup>th</sup> of November 2004 the Google Scholar (GS) was launched (Bar-Ilan 2008). The database Scopus (<http://www.info.sciverse.com/Scopus>) covers material from 1996 onwards. Its main difference compared to WOS is additional indexing of conference and patent publications. Publications published outside the Anglo-Saxon area are also included in Scopus, 15 % of Scopus journals are published in languages other than English (De Moya-Anegón et al. 2007).

Multidisciplinary bibliographic databases WOS and Scopus enable searches of scientific articles published in international journals and provide information about their citations. For those that are freely available they also allow access to the full text. In the last two decades WOS has been used for the evaluation of research work in Slovenia (Južnič et al. 2010). In 2013 the Slovenian Research Agency intends to join the Scopus database as well. The GS database is accessible to all who are connected to the Internet from all over the world, and since its establishment in 2004 it has been widely used worldwide. Searching in GS is easy, the response time is short, and GS is very popular among all generations of Internet users. As stated by Jacso

(2005, 2006) and Kousha and Thelwall (2007), GS generated the references from different OA publications like (non-reviewed) preprints and (reviewed) postprints from many repositories. This could affect the multiple counting of the same publication and on quantitative indicators. Also the indication of the publication date in Google and GS is not necessary correct. Also the citations may be counted to the wrong article (i.e. because of type mistakes). Jacso (2006) concluded, that Google and GS can't replace the seeking tools of ISI/Thomson Reuters database WOS.

There are many studies that compare these three databases. Their most important finding was that Scopus and WOS overlap to a certain extent. Scopus showed greater coverage of the scientific production in the fields of engineering and science, whereas WOS showed this for the fields of social and humanistic sciences (Bar-Ilan 2008; Björk et al. 2010). Kousha and Thelwall (2007) found out that the proportion of overlapped documents between WOS and GS is rather low, e. g. for chemistry only 33 %. Gavel et al. (2008) analyzed the coverage of journals by WOS and Scopus and found out that 64 % of Scopus journals are not included in the WOS database, while only 16 % of journals from WOS are not included in Scopus. For the publications of two Portuguese universities in 2006 and their citations in these two databases, Vieira et al. (2009) found that 66 % of publications were included in both of the two databases, while 33 % of publications were only in one or the other database.

Bar-Ilan (2010) compared the three databases (WOS, Scopus and GS) according to the number of citations and found out that GS provides the largest number of citations. She notes, however, that in GS citations of different types of publications are often attributed to a wrong publication. She also argues that it is necessary to adapt the choice of database to research purpose, as noted by Meho and Yang (2007) in their study of publications from the field of librarianship. There is also the problem with citing and cited articles, as citations of the same article may appear on several web pages and are counted several times (Vaughan and Shaw 2008). As stated by Jacso (2005), between the systems Google and GS the latter is more suitable for academic research.

## **Review of research - OA impact on citation**

There are many findings about the impact of open access of publications on their citation. Lawrence (2001) set a strong claim that OA articles receive three times as many citations as those which are published in payable journals. Since then many studies have been published, reporting that open access increases visibility of publications and that OA publications get more citations than those published in payable journals (Harnad and Brody 2004; Antelman 2004). However, there are also some publications which have not confirmed the link between OA and greater number of citations, since there are many other factors that influence the citation (Craig et al. 2007; Norris et al. 2009; Miguel et al. 2011). Some analyses show that open access is only one of many factors that affect the total number of citations (Kurtz et al. 2005; Craig et al. 2007; Davis et al. 2008; Gargouri et al. 2010). Other influential factors are journal's impact factor, its prestige, the number of authors and their reputation, quality of publications, the impact of scientific disciplines, and others. Harnad et al. (2004) interpreted that articles are published openly accessible because they are often cited, but they are not often cited because they are openly accessible. They explain that articles are published openly accessible (on the author's web-sites or on the web sites of journals or stored in repositories) because they are often searched (such as study material or because of current topics). Similarly, Metcalf (2006) was convinced that authors take care of their own promotion by uploading their own articles at many different places. Similar findings were also observed by Kurtz et al. (2005), Davis and Frommerth (2007), Moed (2007). Kurtz et al. (2005) argued that openly accessible articles are more visible and therefore more cited than those that are not openly accessible. Xia et al. (2011) argues that OA articles are cited more because of their free access, which makes

them more visible and more accessible. Similar are findings by Davis et al. (2008) who explained that open access publications reach a wider audience, also non-academic users. Gargouri et al. (2010) analysed of 27 197 articles published in internationally peer-reviewed journals with impact factors and they found out that the results of the total citations in different scientific disciplines show significant effect of open access on citations, as in all scientific disciplines OA publications reached more citations compared with those not openly accessible. The open access gives the users the possibility to make the right choice between the two existing forms of publication, OA (free of charge) or NonOA (payable).

Some researchers soon realized problems by studying the impact of open access on citations caused by different methodologies. Therefore, Harnad and Brody (2004) stated that in order to determine the impact of open access on citations it is necessary to compare the number of citations of individual articles. Antelman (2004) was even more precise by emphasizing that the methodology was the most reliable when comparing the impact of OA from the same issue of a journal on citation.

Some studies in different subject areas have revealed that self-archiving (Gargouri et al. 2010) and open accessibility (Lin 2007; Lin 2009) substantially increase citation impact, but the citation advantage effect of OA publications varies between disciplines (Norris et al. 2008). The conclusions of Moed (2007) for the articles in solid state physics are the same as Kurtz's (Kurtz et al. 2005) for the articles in astronomy. Kurtz et al. (2005) founded out, that the early-view bias (OA articles are visible immediately after reviewing processes, much earlier than the printed version, published in printed journal) and self-selection bias (authors put their most qualitative articles into repository arXiv) are those in astronomy, which influenced on higher citations of articles, the OA-bias is less important. Moed (2007) concluded the same for the articles in solid state physics, studied into arXiv database. The early-view effect and the quality-effect caused the higher citation of articles reither than OA effect. Eysenbach (2006) published the results of analysis of articles in hybrid OA journal Proceedings of the National Academy of Sciences (PNAS). While OA status was found to remain a significant predictor, there were also other factors, such as the number of authors of an article and funding from competitive grants.

## **The research question**

The research question is: Do open access articles reach more citations than NonOA articles, published in the same journal, in the fields of civil engineering?

The hypotheses are:

1. The value of journal's rank affects number of citations.
2. The fact that an article is published in OA has important effect on articles' impact in the same journal.
3. Data and results vary according to databases WOS, Scopus and GS.

## **Materials and methods**

We analyzed all the articles, published in 14 JCR journals, in which also the researchers from University of Ljubljana, Faculty of Civil and Geodetic Engineering (UL FGG) published their articles. All 14 journals are a part of ISI/Thomson Reuters Subject Group "Civil Engineering" that included 88 journals in 2007. It was found out that the scientists of UL FGG published the majority of articles in journals ranked into the upper half, measured by ISI/Thomson Reuters JCR journal ranking by relevant subject groups (Koler-Povh et al. 2011).

## Presentation of journals

All the studied journals and articles were published in English. Six journals are ranked into the first quartile, five journals are in the second quartile, two are in the third and only one is in the fourth quartile. The values of IF for the studied journals in 2007 were between 2.161 and 0.23. In the JCR subject group Civil engineering they were ranked from 2<sup>nd</sup> (JHydro) to 73<sup>th</sup> (SteelComStr). The analyzed journals are listed in Table 1.

**Table 1:** List of analyzed journals

No.	Journal abr. title	Journal full title	ISSN	Publisher	Published since	IF 2007	JCR rank	JCR quartile
1	JHydro	Journal of Hydrology	0022-1694	Elsevier	1963	2.161	2	1
2	JHydroEng	Journal of Hydrologic Engineering	1084-0699	ASCE	1996	1.314	4	1
3	EarthEng&StrDyn	Earthquake Engineering & Structural Dynamics	0098-8847	Wiley	1972	1.386	5	1
4	StrSaf	Structural Safety	0167-4730	Elsevier	1982	1.075	11	1
5	Comp&Str	Computers & Structures	0045-7949	Elsevier	1971	0.934	16	1
6	Build&Env	Building and Environment	0360-1323	Elsevier	1976	0.852	22	1
7	JStrEng	Journal of Structural Engineering	0733-9445	ASCE	1983	0.791	26	2
8	JCompCivEng	Journal of Computing in Civil Engineering	0887-3801	ASCE	1987	0.707	30	2
9	JConStRes	Journal of Constructional Steel Research	0143-974X	Elsevier	1980	0.664	32	2
10	AutCon	Automation in Construction	0926-5805	Elsevier	1992	0.609	35	2
11	ThWalStr	Thin-Walled Structures	0263-8231	Elsevier	1983	0.552	40	2
12	StrEng&Mech	Structural Engineering & Mechanics	1225-4568	Techno-Press	1993	0.361	62	3
13	Comp&Concr	Computers & Concrete	1598-8198	Techno-Press	2004	0.351	63	3
14	Steel&ComStr	Steel and Composite Structures	1229-9367	Techno-Press	2001	0.230	73	4

Inside each quartile group we sorted the journals by the value of impact factors. In this way we built the basic article categories for the analysis of journal ranking influences on article citations. We divided the articles of each journal into two groups: OA articles and NonOA articles. To determine the open access of articles the GS database was used. The search was conducted outside the domain of the University of Ljubljana as we emulated a user who uses the GS tool for the Internet access to scholarly information and has no access to the journals subscribed by the libraries of the University of Ljubljana. In the databases WOS, Scopus and GS we determined the number of citations (including self-citations) for each article, published in these journals in 2007. The studied period of article citation was from publishing in 2007 till the end of August 2012. The share of open access articles is 22 %. In most cases the OA status stems from the fact that authors leave manuscripts in open institutional repositories or on their web sites (green OA). Rarely, they are the publisher versions on the publishers' web sites (gold OA or hybrid OA business model).

In all 14 journals 2 026 scholarly articles, such as research articles, original articles, review articles, case studies, were published. All of them are indexed in WOS, Scopus and GS. A lot of publications were short communications, some of them were eight pages long, therefore we included them if they had two pages

or more. Publications such as discussion, letter to the editor, editors' announcement, calendar, subject index were excluded from our research.

### **Presentation of studied articles**

In all 14 studied journals there were 2 026 articles published in 2007. Two journals, ranked into the first quartile (Build&Env in JHydrol) published more than 400 articles each and they present the most reliable data source for our research. On the other hand, three journals included less than 30 articles: (StrSafety 1<sup>st</sup> quartile), Comp&Concr (2<sup>nd</sup> quartile) and SteelComStr (4<sup>th</sup> quartile). In the first quartile 1 253 articles were published, in the second 586 articles, in the third quartile 158 and in the fourth quartile 29 articles were published (Table 2).

**Table 2:** Number of articles by journals and two categories - OA and NonOA

No.	Journal title - abr.	OA articles	Share [%]	NonOA articles	Share [%]	Total articles	JCR quartile
1	JHydrol	146	33	302	67	448	I
2	JHydroEng	19	28	50	72	69	I
3	EarthEng&StrDyn	35	29	86	71	121	I
4	StrSaf	7	30	16	70	23	I
5	Comp&Str	41	27	112	73	153	I
6	Build&Env	52	12	387	88	439	I
Total I		300	24	953	76	1253	
7	JStrEng	44	24	143	76	187	II
8	JCompCivEng	11	23	37	77	48	II
9	JConStRes	14	10	125	90	139	II
10	AutCon	29	32	61	68	90	II
11	ThWalStr	18	15	104	85	122	II
Total II		116	20	470	80	586	
12	StrEng&Mech	19	15	110	85	129	III
13	Comp&Concr	6	21	23	79	29	III
Total III		25	16	133	84	158	
14	Steel&ComStr	1	3	28	97	29	IV
Total		442	22	1584	78	2026	

## Results

The results show the number of citations for each article of each journal in the period from publishing in 2007 till the end of August 2012. We realized, that 2,026 studied articles in this period obtained 65,240 citations. 29 % of all citations are obtained by OA articles (Table 3).



**Table 3:** The total number of articles and their citations

Number of	OA	Share [%]	NonOA	Share [%]	Total	Share [%]
articles	442	22	1584	78	2026	100
citations	18937	29	46303	71	65240	100
citations per article	43		29		32	

As shown in Table 3, 22 % of OA articles received 29 % of all citations. On average each article was cited 32 times. On average OA articles received 43 citations while NonOA articles were cited 29 times.

In the journal SteelComStr (4<sup>th</sup> quartile) only one of 29 articles is OA. The analysis of the impact of open access on the article citation in this journal is therefore meaningless. Therefore, this journal was excluded from further analyses.

### Median

Based on the median of the number of citations we found out that in most journals the median is higher for OA articles. Data are shown below separately by databases. The maximum value of median (34) is reached by OA articles in the journal StrSaf (1<sup>st</sup> quartile), while the values in Scopus and GS are the same.

**In WOS** the median of citations of OA articles is higher in 10 journals, in all journals from the first quartile and in 3 journals from the second quartile. In the journal StrSaf (1<sup>st</sup> quartile) the ratio between median values of citations OA vs NonOA is the highest (5). There are 3 journals, where OA articles received fewer citations than NonOA articles. They are ranked into the second quartile (JCompCivEng), and the third quartile (ThWalStr and Comp&Concr). The difference in median is only either 0.5 or 1.

**In Scopus** the median of citations of OA articles is higher in 11 journals. Only in two journals (JHydroEng, 1<sup>st</sup> quartile and JConStRes, 2<sup>nd</sup> quartile) the NonOA articles received more citations than OA articles. In these two cases the difference in median is only either 0.5 or 1.

**In GS** the median of citations of OA articles is always higher than that for NonOA articles.

**Table 4:** Medians of citations by journals, databases and quartiles

No.	Journal abr. title	OA			NonOA			JCR quartile
		WOS	Scopus	GS	WOS	Scopus	GS	
1	JHydrol	12	14	17	9	10	12	I
2	JHydroEng	5	5	10	4	6	5	I
3	EarthEng&StrDyn	7	10	18	4	6	7	I
4	StrSaf	20	34	34	4	5.5	11.5	I
5	Comp&Str	8	11	13	5	7	8.5	I
6	Build&Env	9	11.5	17	6	8	10	I
7	JStrEng	5	6.5	9	4	6	6	II
8	JCompCivEng	3	6	6	4	5	5	II
9	JConStRes	4.5	5.5	8.5	4	6	7	II
10	AutCon	4	9	14	4	8	10	II
11	ThWalStr	3	5	6	3,5	5	5,5	II
12	StrEng&Mech	3	3	3	2	2	1	III
13	Comp&Concr	1,5	2	2,5	2	2	1	III
14	Steel&ComStr	0	0	0	2	2	1	IV

When comparing the medians for the citations of OA and NonOA articles, it can be observed that in Scopus the highest ratio between the median number of citations of OA and NonOA articles is 6. In WOS the OA article obtained as many as 5 times more citations than a NonOA article.

### Statistical analysis

A statistical test of the null hypothesis presuming that the expected number of citations is the same for OA and NonOA articles, was performed by a t-test. The statistical analysis by quartiles showed that for articles published in the journals ranked into the first quartile the null hypothesis can be rejected with the significance level  $\alpha=0.05$  or less in all but-one journal. For articles published in journals in the second quartile the hypothesis that OA articles received more citations than NonOA articles was confirmed by computed significance level of  $\alpha=0.05$  or less in the GS for only two of the journals (JStrEng in ThWalStr). For the journal ThWalStr we can confirm it also in Scopus. In WOS it could not be confirmed for any journal.

If the significance level was increased to 10 % for the analyzed journals (JStrEng and ThWalStr) then it could be confirmed also for Scopus and WOS that OA articles receive significantly more citations than NonOA articles. For the journals from the third quartile in WOS and Scopus the null hypothesis can not be rejected.

**Table 5:** Results of t-test

No.	Journal abr. title	Statistics	Critical value	Risk	Statistics	Critical value	Risk	Statistics	Critical value	Risk	JCR quartile
		WOS			SCOPUS			GS			
1	JHydrol	3.32	1.65	0.0005	3.33	1.65	0.0005	3.31	1.65	0,0005	I
2	JHydroEng	1.38	1.73	0.0921	1.29	1.73	0.1063	1.58	1.73	0.0655	I
3	EarthEng&StrDyn	1.91	1.68	0.0314	1.90	1.68	0.0319	2.95	1.67	0.0022	I
4	StrSaf	2.79	1.83	0.0106	2.75	1.80	0.0095	2.31	1.83	0.0231	I
5	Comp&Str	2.24	1.67	0.0140	1.61	1.66	0.0554	2.21	1.66	0.0149	I
6	Build&Env	1.96	1.67	0.0271	2.29	1.67	0.0126	2.82	1.67	0.0031	I
7	JSE-ASCE	1.66	1.67	0.0510	1.57	1.67	0.0603	1.98	1.67	0.0262	II
8	JCCE-ASCE	0.90	1.77	0.1928	1.18	1.77	0.1292	1.63	1.80	0.0656	II
9	JConStRes	0.98	1.75	0.1746	0.98	1.75	0.1702	0.97	1.75	0.1746	II
10	AutCon	0.75	1.68	0.2272	0.75	1.68	0.2287	1.35	1.68	0.0911	II
11	ThWalStr	-1.64	1.68	0.0540	-1.80	1.68	0.0392	-1.81	1.68	0.0384	II
12	StrEng&Mec	-0.03	1.70	0.4894	1.17	1.71	0.1259	1.77	1.71	0.0444	III
13	Com&Concr	-1.21	1.76	0.1232	-0.68	1.83	0.2561	0.74	2.02	0.2469	III

### The maximum number of citations

The most cited article is an OA article published in the JHydrol (1<sup>st</sup> quartile). It was the most cited article in all three data bases. The most citations were in GS (131 citations), in Scopus it obtained 89 and in WOS 80 citations. Among NonOA articles the most cited article is an article published in the journal in the first quartile (Com&Struct). It obtained the most citations in GS (105), then in Scopus (95) and WOS (72). The data are presented in Table 6.

**Table 6:** Maximum numbers of citations

Maximum values of citations	OA	Journal	NonOA	Journal
WOS	80	JHydrol	72	Comp&Str
Scopus	89	JHydrol	95	Comp&Str
GS	131	JHydrol	105	Comp&Str

The highest value of the ratio between the number of citations for OA and NonOA articles was reached in the JHydroEng (1<sup>st</sup> quartile). The values are comparable in WOS and SCOPUS (2.4 and 2.6).

## Discussion and conclusion

The main contribution of our paper is the conclusion that OA articles in the field of civil engineering reach more citation than NonOA articles. The analysis was made for all articles published in 14 journals, with impact factors in the year 2007, ranked into the JCR subject group Civil engineering. None of these journals are openly accessible. Therefore, we could compare the citations of similar papers from the same journal based on the condition if the paper is archived in the open access repository or on author's web sites or not. Our results confirmed that OA has a positive impact on the citations of articles. This can be seen on the general level, as 2 026 studied articles achieved 65 240 citations. Among them 29 % were obtained from OA articles. On the average each article was cited 32 times. OA articles received 43 citations whereas NonOA articles were cited much less, 29 times. The influence of journals' impact factor on the number of received citations was analysed separating journals in four quartiles according to the rank in the WOS subject categories, which showed that in highly ranked journals OA articles received more citations than NonOA articles published in the same journals. This means that OA does not automatically result in more citations since the maximum number of citations of an individual paper in lower impact journals hasn't been influenced by OA status.. Our results confirms that access is not a sufficient condition for citation, but it is a necessary one (Harnad and Brody, 2004) ..

Turk and Björk (2008) stated that in the field of civil engineering and in construction informatics the benefits of open access as a new form of scientific communication were not sufficiently widespread yet. The benefits of open access publishing for authors, i.e. higher visibility, discoverability and global publicity of their work, retention of copyright of article through publishing agreements and authorship conservation on intellectual idea might not be sufficient. Journal publishers benefit from OA business models as their reputation and journals impact increase. Institutional prestige and status is today ranked through different world university rankings i.e. Academic Ranking of World Universities which attracts high attentions worldwide. Some of their criteria are based on the scientometric measures of bibliometric data of mainly research performance, i.e. number of citations (Aguillo et al. 2010). Our results give guidance to institutions and their funders how to present their research results and where and when OA is an important factor.

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