



**Evaluating the impact of research using the altmetrics approach
(Case study: The field of Scientometrics)**

Journal:	<i>Global Knowledge, Memory and Communication</i>
Manuscript ID	GKMC-02-2019-0013
Manuscript Type:	Article
Keywords:	Research evaluation, Social media, Citation indicators, Altmetrics indicators, Information research, Scientometrics

SCHOLARONE™
Manuscripts

Evaluating the impact of research using the altmetrics approach

(Case study: The field of Scientometrics)

Abstract

Purpose – The main objective of this research is to assess the impact of research in the field of scientometrics using the altmetrics (social media metrics) approach.

Design/methodology/approach – This is an applied study using scientometric and altmetrics methods. The research population consists of the articles and their citations published in the two core journals (Scientometrics, Journal of Informetrics) in a period of five years (included 1738 papers and 11504 citations). Collecting and extracting the articles directly was carried from Springer and ScienceDirect databases. The altmetric bookmarklet, a service provided by Altmetric Institute was used for data collection. The research articles with the altmetric scores were identified (included 830 papers). The altmetric scores represent the quantity and quality of attention that an article has received on social media. The association between altmetric scores and citation indicators was investigated using correlation tests.

Findings – The findings indicated a significant, positive and weak statistical relation between the number of citations of the articles produced in the field of scientometrics and the altmetric scores of these articles, as well as the number of readers of these articles in the two social networks (Mendeley and Citeulike) with the number of their citations. In this study, there was no statistically significant relationship between the number of citations of the articles and the number of readers on Twitter. In sum, the above findings suggest that some social networks and their indices can be as representations of the impact of scientific papers, similar citations. However, due to the weakness of the correlation coefficients, the replacement of these two categories of indicators is not recommended, but it is possible to use the altmetrics indicators as complementary scientometrics indicators in evaluating the impact of research.

Originality/value – The study of the impact of research in social media by using appropriate measures reflects not only the social impact of publications on authors, but also helps libraries, universities, research organizations and politicians in planning, budgeting and allocating resources.

Keywords - Research evaluation, Social media, Citation indicators, Altmetrics indicators, Scientometrics

Paper type- Research paper

1. Introduction

For many years, citation analysis is used to investigate the scientific effectiveness of researchers. Although citation-based indices are among the most accepted and important indicators for assessing performance and scientific effectiveness, there have always been some deficiencies in these indices. The fact that citations take time to accumulate also has an impact on research evaluation, as a wait of a few years after publication is needed before the impact of papers can be measured (more in some disciplines). As a result, many have turned to Journal Impact Factors as a proxy for the potential citation value of articles within journals; however, due to the skewness of citation distributions, journal measures should not be used as article-level indicators (Neylon, 2009). Additionally, the relationship between citations and the Impact Factor is weakening, so alternative metrics have been developed to respond to these challenges (Thelwall, 2013). On the other hand, due to the widespread use of social media in the scientific fields,

new indicators called altmetrics indices along with the traditional scientometrics concepts (citation analysis) have been created to investigate the impact of research activities in social media.

Altmetric was founded by Euan Adie in 2011. Previously a researcher, Adie had already worked on Postgenomic.com, an open source scientific blog aggregator founded in 2006. In 2011 Adie entered an altmetrics app into Elsevier's Apps for Science competition and won. Altmetric.com (<http://www.altmetric.com/>) is a commercial London-based tool that tracks, analyses and collects the online activity around scholarly outputs from a selection of online sources such as blogs, Twitter, Facebook, Google+, mainstream news outlets, media and other sources (Adie & Roe, 2013). Altmetric.com compiles all the social media attention gathered by a scientific publication in the so-called 'altmetric donut' or altmetric score. The altmetric score reflects both the quantity (the higher attention, the higher score) and quality (weighting according to different sources) of attention received by each item applying some kind of normalization (both by all articles of similar age and in the same journal (Costas & et al. 2014). Altmetric employs an algorithm to assign each item an automatically calculated score. Based on the volume and source of attention an item has received, the score is intended to reflect the reach or popularity of the research output.

Alternative measurements are currently one of the most popular research topics in scientometric investigation and the focus is moving from web citation analysis to social media usage analysis (Li, Thelwall, & Giustini, 2012). The thought behind the altmetrics is that the web is not just used by academicians and therefore data from the web about scholarly research may be useful as evidence of the wider impacts of the research. Altmetrics additionally holds potential value for financing plan assessments. Some alternative indicators have advantages to usefully complement scientometric data by reflecting a different type of impact or through being available before citation data that can be used by funding agencies as part of their funding scheme evaluations.

There are already a number of studies concerning altmetrics. An overview of these studies can be found in Bar-Ilan, Shema, and Thelwall (2014), Haustein (2014), and Priem (2014). Many of these studies have measured the correlation between citations and altmetrics. Since the correlations were often at a moderate level, the results are difficult to interpret: Both metrics seem to measure something similar but not identical. The studies published so far cannot yet provide a satisfactory answer to the question whether altmetrics is appropriate for the measurement of societal impact or not (Bornmann, 2014). That is the reason for this investigation of the question. Some of these studies are described below.

Works like Thelwall et al. (2013); Li and Thelwall (2012); Li et al. (2012); Bar-Ilan (2012) have investigated the correlation between altmetrics and traditional bibliometric indicators. In general, these studies have found moderate agreement (i.e. 0.6 with Spearman correlation coefficient) with specific sources of altmetrics, i.e. Mendeley and Twitter. According to Thelwall (2018), the number of Mendeley readers tends to correlate better with synchronous citation counts after a few years. These results have been confirmed also by the meta-analysis conducted by Bornmann (2015) that concluded that the correlation with traditional citations for micro-blogging is negligible, for blog counts it is small, and for bookmark counts from online reference managers, it is medium to large. Nevertheless, none of these studies analyses the correlation between altmetrics and traditional bibliometric indicators by also taking into account quality assessment procedures performed by peers. These procedures are typical of many academic evaluation systems in different countries across the world. Notably, works like Wouters et al. (2015); Ravenscroft et al. (2017); Bornmann and Haunschild (2018) perform this kind of analysis. More specifically, Wouters et al. (2015) correlate different metrics with the output of the Research Excellence Framework (REF) held in 2016 in the UK. The REF is the reference system for assessing the quality of research in UK higher education institutions. The analysis is performed with different traditional and

alternative metrics and the outcomes available for different research areas converge towards limited or none correlation. Finally, the aim of the analysis carried out by Bornmann and Haunschild (2018) is twofold. In fact, first the authors in Bornmann and Haunschild (2018) measure the correlation between citation counts and altmetrics by using Principal Component Analysis and Factor Analysis. Then, they test the relationship between the dimensions and quality of papers using regression analysis on post-publication peer-review system of F1000Prime assessments. The results of the first part show how the count of Mendeley readers and tweets are related to citation count, while the regression analysis shows that only Mendeley readers and citation count are significantly related to quality. None of the aforementioned works present a comprehensive analysis investigating not only the correlation between traditional indicators and altmetrics, but also the correlation among the altmetrics themselves. The latter perspective is relevant in order to understand how to eventually use altmetrics as well as traditional indicators to support peers in quality assessment procedures of research outcomes.

Costas et al. (2015) employed more than 1.5 million of publications from Altmeteric.com and Web of Science to analyze the relationship between altmetric and bibliometric indicators. They detected that social network metrics (Facebook, Twitter, Goggle+ mentions) were located in a different component from social media (blogs, news). Li and Fred (2015) analyzed 66 Library and Information Science journals, but they did not find differences among metrics. However, there is much less studies that had used different data providers, and most of them were articles focused on comparing the coverage of each tool (Jobmann et al., 2014; Zahedi et al., 2015).

The study of the impact of research in social media by using appropriate measures reflects not only the social impact of publications on authors, but also helps libraries, universities, research organizations and politicians in planning, budgeting and allocating resources. Considering the important role of evaluating the impact of research in the field of Scientometrics, and since this field of study has been less studied from the point of view of altmetrics, this research evaluates the impact of research in this field by Altmeterics method. The findings of this research can complement the results of the previous studies on the evaluation of international research in the field of Scientometrics.

2. Research questions

- RQ1. What is the presence rate of the articles published in the core journals of Scientometrics in social media?
- RQ2. What is the state of the altmetric scores of the articles published in the core journals of Scientometrics?
- RQ3. What are the most effective articles in the field of Scientometrics based on altmetric indicators?
- RQ4. Which media are the most important social media in the field of Scientometrics?
- RQ5. Is there a significant statistical relation between the presence of international articles in the field of Scientometrics in social media and the number of the paper citations?
- RQ6. Can altmteric indicators be used as a substitute or complementary of citation index for assessing the impact of research?

3. Methodology and data gathering

This is an applied research using the altmetrics (social media measures) method. The research population consists of the articles and their citations published in two core journals in the field of Scientometrics

(“Scientometrics” journal, Journal of Informetrics) in a period of five years (2012-2016). The articles, their citation, and their altmetric data were collected and extracted in two steps. In the first step, these articles directly were collected from Springer and ScienceDirect databases. Then, in the next step, in order to determine the presence rate of the retrieved articles in social media, each article was manually searched using the altmetric bookmarklet. This tool is a service provided by Altmetric Institute was used for data collection. The research articles with the highest altmetric scores were identified. In this step the collected data were stored in two excel files separately for each of the two studied journals. Finally the association between altmetric scores and citation indicators was investigated using correlation tests. The results of these analyses are presented in the following.

4. Data analysis

●In this section, in order to answer the research questions, the results of the analysis of the retrieved data is presented. To answer the RQ1, the survey revealed that of a total of 1342 papers retrieved from “Scientometrics” journal, 699 articles (52%) have not been mentioned in any of the social media, and 643 papers (48%) have been shared at least once in social media and have an altmetric score (table I). Also the gathered data from “Journal of Informetrics” shows that of a total of 396 papers retrieved, 209 articles (52.5%) were not mentioned in any of the social media. A total of 187 papers (47.4%) have been shared at least once in the social media and have an altmetric score (table I).

Table I- The presence rate of international articles in the field of scientometrics in the social media

Publication year	The number of articles		The number of citations		The number of articles with the altmetrics indicators		The percentage of articles with the altmetrics indicators		The number of articles without the altmetrics indicators	
	Sci.	Info.	Sci.	Info.	Sci.	Info.	Sci.	Info.	Sci.	Info.
2012	245	63	2335	1006	105	17	42.85	26.98	140	46
2013	250	93	2203	1101	105	39	42	41.93	145	54
2014	336	79	2213	619	130	28	38.69	35.44	206	51
2015	238	80	937	434	134	43	56.3	52.5	104	38
2016	273	81	461	195	169	61	61.9	75.3	104	20
total	1342	396	8149	3355	643	187	48	47.4	699	209

The presence rate of international articles in the field of Scientometrics in the social media by publication year is shown in Figure 1.

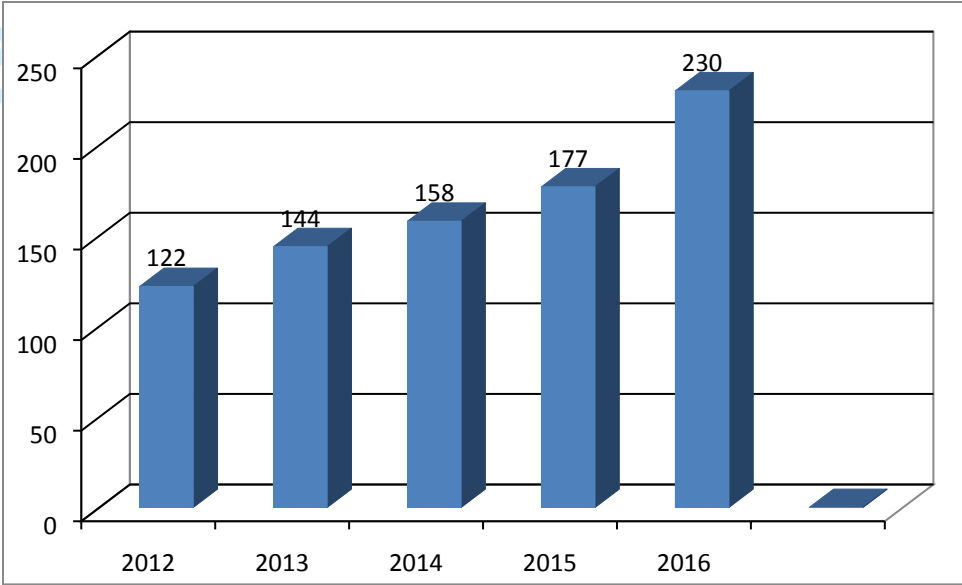


Figure 1. The presence rate of international articles in the field of Scientometrics in the social media by the publication year

• The Altmetric database which is one of the most important altmetrics service providers, examines the presence rate of an article in various social media. The basis of the work is that any discussion on blogs, news and Q & A sites has different points for an article. Of all these points, a general altmetric score is given that indicates the rate of sharing and use of the article in social media. In other words, the altmetric score indicates the quantity and quality of attention an article received in various social media. To answer RQ2 the analysis of the retrieved data from "Scientometrics" journal show that the maximum and minimum altmetric scores of articles are 208 and 1, respectively. The highest average altmetric scores are for the articles published in this journal in 2016. The maximum and minimum altmetric scores for "Journal of Informetrics"'s articles are 200 and 1, respectively. The highest average altmetric scores are for the articles published in this journal in 2012 and 2013. Table II shows the status of the altmetric scores of the articles by the publication year using altmetric database¹.

Table II. The status of the altmetric scores of the articles by the publication year (using altmetric database)

The Publication year	Maximum of the altmetric score		Minimum of the altmetric score		Average of the altmetric score	
	Sci.	Info.	Sci.	Info.	Sci.	Info.
2012	208	200	1	1	5.98	16.17
2013	38	69	1	1	4.11	10.69
2014	43	19	1	1	5.04	4.03
2015	118	45	1	1	5.08	6.38
2016	83	87	1	1	7.18	6.83

¹ <https://www.altmetric.com/>

To answer RQ3, table III presents the most effective articles in the field of Scientometrics based on the altmetric indicators.

Table III. The most effective articles in the field of Scientometrics based on the altmetric indicators

Rank	The article title	Authors	The publication year	The altmetrics score	The papers citations	The journal title
1	Negative results are disappearing from most disciplines and countries	Daniele Fanelli	2012	208	185	Scientometrics
2	Exploring scientists' working timetable: Do scientists often work overtime?	Xianwen Wang ,Shenmeng Xu, Lian Peng, Zhi Wang, Chuanli Wang, Chunbo Zhang ,Xianbing Wang	2012	200	19	Journal of Informetrics
3	Methods for estimating the size of Google Scholar	Enrique Orduna-Malea, Juan M. Ayllón, Alberto Martín-Martín, Emilio Delgado López-Cózar	2015	118	13	Scientometrics
4	Hybrid open access—A longitudinal study	Mikael Laakso, Bo-Christer Björk	2016	87	1	Journal of Informetrics
5	Tracking the digital footprints to scholarly articles from social media	Xianwen Wang, Zhichao Fang, Xinhui Guo	2016	83	2	Scientometrics
6	A bibliometric analysis of academic publication and NIH funding	Jiansheng Yang ,Michael W. Vannier, Fang Wang ,Yan Deng , Fengrong Ou ,James Bennett ,Yang Liu, Ge Wang	2013	69	12	Journal of Informetrics
7	Validating online reference managers for scholarly impact measurement	Xuemei Li, Mike Thelwall, Dean Giustini	2012	66	0	Scientometrics
8	The advantage of simple paper abstracts	Adrian Letchford, Tobias Preis, Helen Susannah Moat	2016	61	5	Journal of Informetrics
9	Universality of scholarly impact metrics	Jasleen Kaur, Filippo Radicchi, Filippo Menczer	2013	60	31	Journal of Informetrics
10	Grand challenges in altmetrics: heterogeneity, data quality and dependencies	Stefanie Haustein	2016	57	10	Scientometrics

To answer RQ4, the most important social media published the articles in the field of Scientometrics, was studied. The results show out of 1642 articles retrieved by the "Scientometrics" journal, 640 papers (47.6%) were shared by Mendeley, one of the social tools for managing references. Other important social media used by Scientometrics scholars are: Twitter with 592 articles (44.1%) and "CiteULike" with 104 articles (7.7%). Also, out of 396 articles retrieved by the "Journal of Informetrics", 188 articles (47.4%) were shared by Twitter, 175 articles (44.1%) by Mendeley and 35 articles (8.8%) by CiteULike. Table IV shows the most important social media published the Scientometrics articles based on the publication year. Figure 2 shows the presence rate of the Scientometrics articles in other social media using altmetric database.

Table IV. The most important social media published the Scientometrics articles based on the publication year

The publication year	The number of readers in Mendeley		The number of readers in Twitter		The number of readers in CiteULike	
	Scientometrics	Journal of Informetrics	Scientometrics	Journal of Informetrics	Scientometrics	Journal of Informetrics
2012	245	16	97	17	37	7
2013	250	37	91	39	19	7
2014	336	24	116	28	19	7
2015	238	39	124	43	13	10
2016	273	59	164	61	16	4
total	640	175	592	188	104	35

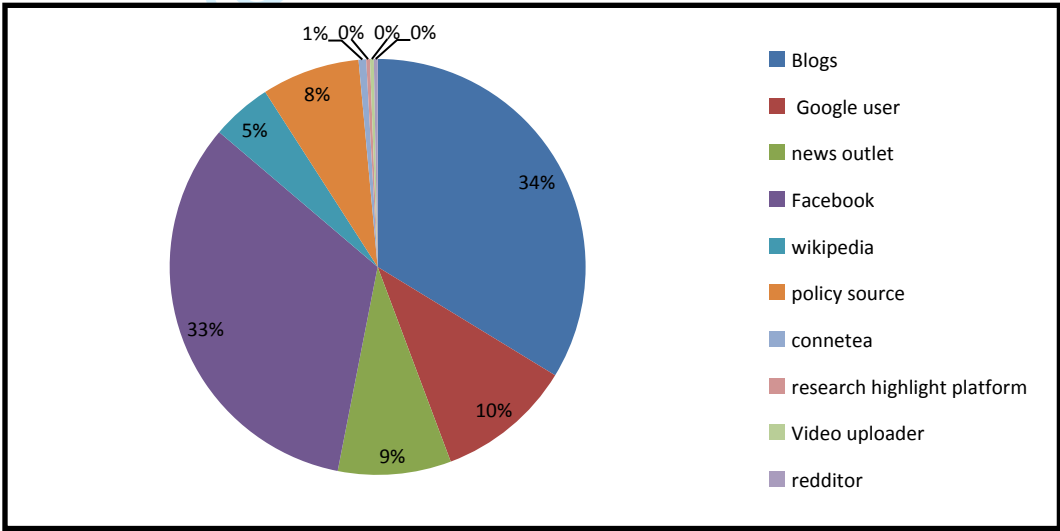


Figure 2. The presence rate of Scientometrics articles in other social media using altmetric database

To answer RQ5, due to the non-normality of the distribution of data, Spearman correlation test was used to investigate the relationship between the presence of international articles in the field of Scientometrics in social media and the number of paper citations, as well as to test the research hypothesis. To this end, data related to the mean altmetric score of the studied articles and the number of the papers citations were entered into SPSS software and then the Spearman rank correlation test was performed. The results of these analyses are presented in table V. As can be seen, the results of the correlation test show a statistically significant positive and weak correlation between the studied variables. The relationship between the number of articles citations and the altmetric score of the articles ($p = .000$ and $r = 0.145$) indicate that with increasing the number of citations, the altmetric score of the articles also increased. Also, the results of the correlation test indicated a significant, positive and mean statistical relationship between the number of readers of articles in Mendeley and the number of the received citations ($p = 0.000$ and $r=0.572$), as well as the number of readers of articles in the CiteULike and the number of the received citations ($p= 0.000$ and $r= 0.314$). These findings suggest that with the increase in the number of the article citations, the number of readers of these articles has also increased in some scientific networks

such as Mendeley and CiteULike. However, there was not a significant relationship between the number of the readers of the articles on Twitter and the number of the received citations ($p=0.302$ and $r = 0.37$).

Table V. The results of the correlation test between the total number of the papers citations and their altmetric scores

The number of the paper citations	The altmetric score of the articles	The number of the readers in Mendeley	The number of the readers in CiteULike	The number of the readers in Twitter
P value	0.000	0.000	0.000	0.302
Spearman correlation	0.145	0.572	0.314	0.37

To answer RQ6, it is assumed that those scientific social media, in which there is a significant correlation between the articles citations and their bookmarkings, are likely to have the potential to be used as an alternative or complementary tool in the evaluation of research. Hence, some scientific social networks such as Mendeley and CiteULike can be used as complementary and not a substitute for evaluating the impact of research. But for the networks such as Twitter, this assumption was not met.

5. Results

The summary of results obtained from data analysis in this study is described below:

- The presence rate of the studied articles in social media is about 48% of the total number of the retrieved articles (Table I). A review of the results of the previous studies suggests that the altmetric coverage of research outputs has been different based on the type and nature of the studied subject area, the type of social media and the database used to collect altmetric data (Holmberg, 2015). Comparing the results of this study with some previous studies in other subject areas (Zahedi, Costas, & Wouters, 2014; Mohammadi, Thelwall, 2014; Haustein, Costas, Larivière, 2015), it can be said that the research outputs in the field of Scientometrics have a relatively good altmetric coverage.
- The frequency of the articles with altmetric indicators based on the publication year, indicates the prevalence of the use of social media by researchers in recent years. This finding seems logical, because the use of social media has been steadily expanding, especially in recent years, and also the focus of the Altmetric Institute's data is on the documents published since 2011. The increase in the presence of scientific productions in social media in recent years has also been reported in the study of Costas and others (2014).
- The most important social media published the articles in the field of Scientometrics are Mendeley (46.88%), Twitter (44.87%), and CiteULike (7.99%) (Table IV). Thus, Mendeley has a good coverage of the articles in the field of Scientometrics and can be used in the future research. Previous researches (Zahedi, Costas & Wouters 2014; Priem et al. 2012; Li et al. 2012) also referred to Mendeley and Twitter as one of the most important tools for providing article-level data and altmetric information. The other social media published the articles in the field of Scientometrics are respectively Blog, Facebook, Google Plus, News outlet, Policy source, Wikipedia, Connetea and Reddit (Figure 2).
- The research findings indicate that there is a significant, positive and weak statistical relation between the number of the paper citations and the altmetric scores of these articles, as well as the number of the

readers of the Scientometrics articles in Mendeley and CiteULike with the number of the paper citations (Table V). This finding is in accordance with the findings of Prime, Piwowar and Hemminger (2011), which reported a statistically significant relationship between the number of the received citations in the Web of Science and the number of downloads of documents in the “PLOS” scientific social network. Mohammadi and Thelwall (2014) also have a statistically significant relationship between the number of the received citations in the WOS and the number of bookmarkings in the Mendeley social network. Also, Haustein and others (2013) found a moderate correlation between these two variables in Mendeley. These findings may indicate that the strength of the relationships and, consequently, the validity of altmetrics are different depending on the studied social network. In this study, there was no statistically significant relationship between the number of paper citations and the number of readers of articles on Twitter (Table V).

6. Conclusions

In sum, the findings of this research suggest that some social networks and their indices can be as representations of the impact of scientific papers, similar citations. However, due to the weakness of the correlation coefficients, the replacement of these two categories of indicators is not recommended, but it is possible to use the altmetrics indicators as complementary scientometrics indicators in evaluating the research and calculating the scientific effect. As Bornmann (2011) and Rousseau (2013) have pointed out, if alternative metrics are used to evaluate research, these measures should be the same as scientometric indicators based on a specialized judgment process. Therefore, the results based on this type of evaluation should not only directly lead to decision making on research budgets, but also need to be used to assist experts in deciding on a specialized arbitration process.

It should be noted that in this research only the altmetrics performance of the studied articles was examined only on the basis of the data of one of the altmetrics data service providers (altmetrics database). In order to resolve the current study limitations, future research can perform the altmetric activity of other scholarly journals or other subject areas at different times and using data obtained from other altmetric data service providers and compare the results.

References

- Adie E, Roe W. (2013). Altmetric: Enriching scholarly content with article-level discussion and metrics. *Learned Publishing*. 26(1): 11–17.
- Bar-Ilan, J., Shema, H., & Thelwall, M. (2014). Bibliographic References in Web 2.0. In B. Cronin & C. R. Sugimoto (Eds.), *Beyond bibliometrics: harnessing multi-dimensional indicators of performance*. Cambridge, MA, USA: MIT Press. PP. 307-325.
- Bornmann, L. (2011). Scientific peer review. *Annual Review of Information Science and Technology*, 45, 199-245.
- Bornmann, L. (2014). Validity of altmetrics data for measuring societal impact: A study using data from Altmetric and F1000Prime. *Journal of Informetrics*, 8(4): 935-950.
- Bornmann, L. (2015) Usefulness of altmetrics for measuring the broader impact of research: A case study using data from PLOS and F1000Prime. *Aslib Journal of Information Management* 67: 305–319.
- Bornmann, L., Haunschild, R. (2018). Do altmetrics correlate with the quality of papers? A large-scale empirical study based on F1000Prime data. *PLoS One*. 13(5): e0197133.
- Bong, Y. B., Ale Ebrahim, N. (3 April 2017). The Rise of Alternative Metrics (Altmetrics) for Research Impact Measurement, *Asia Research News* 2017, DOI: <https://doi.org/10.6084/m9.figshare.4814215.v1>.
- Costas, R., Z. Zahedi, and P. Wouters. (2014). Do altmetrics correlate with citations? Extensive comparison of altmetric indicators with citations from a multidisciplinary perspective. *Journal of the Association for Information Science and Technology*. DOI:10.1002/asi.23309. Available from: <http://arxiv.org/abs/1401.4321>.
- Erfanmanesh, M., Rohani, V. A., & Abrizah, A. (2012). Co-authorship network of scientometrics research collaboration. *Malaysian Journal of Library & Information Science*, 17(3): 73-93.
- Eysenbach, G. (2011). Can tweets predict citations? Metrics of social impact based on Twitter and correlation with traditional metrics of scientific impact. *J Med Internet Res*, 13(4): e123.
- Harnad, S. (2008). "Validating research performance metrics against peer rankings", *Ethics in Science and Environmental Politics*, 8(11):103-107.
- Haustein, S., Peters, I., Bar-Ilan, J., Priem, J., Shema, H., & Terliesner, J. (2014a). Coverage and adoption of altmetrics sources in the bibliometric community. *Scientometrics*, 101(2): 1145-1163.
- Haustein, S., Peters, I., Sugimoto, C. R., Thelwall, M., & Larivière, V. (2014b). Tweeting biomedicine: An analysis of tweets and citations in the biomedical literature. *Journal of the Association for Information Science & Technology*, 65(4): 656-669.
- Haustein, S. (2014). Readership metrics. In B. Cronin & C. R. Sugimoto (Eds.), *Beyond bibliometrics: harnessing multi-dimensional indicators of performance*. Cambridge, MA, USA: MIT Press. PP 327-344.
- Haustein, S., Costas, R. & Larivière, V. (2015). Characterizing social media metrics of scholarly papers: the effect of document properties and collaboration patterns. *PLoS ONE*, 10(3). Retrieved from <http://journals.plos.org/plosone/article/file?id=10.1371/journal.pone.0120495&type=printable> (Accessed May 10, 2017).
- Holmberg, K.J. (2015). *Altmetrics for information professionals: Past, present and future*. Chandos Publishing.

- Jobmann, A., Hoffmann, C.P., Künne, S., Peters, I., Schmitz, J. & Wollnik-Korn, G. (2014). Altmetrics for large, multidisciplinary research groups: Comparison of current tools. *Bibliometrie - Praxis und Forschung*, 3, <http://www.bibliometrie-pf.de/article/viewFile/205/258> [Accessed on January 1 2018].
- Lahikainen, Johanna (2016) Altmetrics in Social Sciences and Humanities: Possibilities, Challenges, and Experiences. Paper presented at: IFLA WLIC 2016 – Columbus, OH – Connections. Collaboration. Community in Session 136 - Social Science Libraries with Asia and Oceania.
- Li, X., & Thelwall, M. (2012). F1000, Mendeley and traditional bibliometric indicators. In *Proceedings of the 17th International Conference on Science & Technology Indicators*, 451-551.
- Li, X., Thelwall, M.; Giustini, D. (2012). Validating Online Reference Managers for Scholarly Impact Measurement. *Scientometrics*, 91 (2): 461-471.
- Li, S., Fred, Y. (2015). Evaluating journals' yearly impact with altmetric indicators. *CJLIS*. 8(2): 25-38.
- Mohammadi, E., & Thelwall, M. (2014). Mendeley readership altmetrics for the social sciences and humanities: Research evaluation and knowledge flows. *Journal of the Association for Information Science & Technology*, 65(8):1627-1638.
- Mohammadi E, Thelwall M, Haustein S, Lariviere V. (2015). Who reads research articles? An altmetrics analysis of Mendeley user categories. *Journal of the Association for Information Science & Technology*. 66(9): 1932-46.
- Neylon C Wu S (2009) Article-level metrics and the evolution of scientific impact. *PLoS Biology* 7: e1000242.
- Priem, J.; Piwowar, H. A.; Hemminger, B. M. (2012). Altmetrics in the Wild: Using Social Media to Explore Scholarly Impact. Retrieved May 20, 2016 from <http://arxiv.org/html/1203.4745v1>.
- Priem, J., Taraborelli, D., Groth, P., & Neylon, C. (2010). Altmetrics: A manifesto. Retrieved from <http://altmetrics.org/manifesto/> (Accessed May 25, 2017).
- Ravenscroft J, Liakata M, Clare A, Duma D. (2017). Measuring scientific impact beyond academia: An assessment of existing impact metrics and proposed improvements. *PLOS ONE* 12: e0173152 doi: 10.1371/journal.pone.0173152 [PMC free article] [PubMed]
- Robinson-García, N., Torres-Salinas, D., Zahedi, Z., & Costas, R. (2014). New data, new possibilities: exploring the insides of Altmetric.com. *El profesional de la información*, 23(4):359-366.
- Rousseau, R., & Ye, F. Y. (2013). A multi-metric approach for research evaluation. *Chinese Science Bulletin*, 58. doi: 10.1007/s11434-013-5939-3.
- Thelwall, M. (2018). Early Mendeley readers correlate with later citation counts. *Scientometrics* 115(3): 1231-1240. <https://doi.org/10.1007/s11192-018-2715-9>.
- Thelwall, M.; Haustein, S.; Lariviere, V.; Sugimoto, C. R. (2013). Do Altmetrics Work? Twitter and Ten other Candidates. *PLoS ONE*, 8 (5). e64841: 1-8. Retrieved June 1, 2016 from www.plosone.org/article/fetchObject.action?uri=info%3Adoi%2F10.1371%2Fjournal.pone.0064841&representation=PDF.
- Thelwall, M. & Kousha, K. (2013). ResearchGate Disseminating, Communicating and Measuring Scholarship? Available at: <http://cba.scit.wlv.ac.uk/~cm1993/papers/ResearchGate.pdf> (Retrieved 20 June 2017).

- Wouters P, Thelwall M, Kousha K, Waltman L, de Rijcke S, Rushforth A et al. (2015). The Metric Tide: Literature Review (Supplementary Report I to the Independent Review of the Role of Metrics in Research Assessment and Management) London, UK: Higher Education Funding Council for England (HEFCE).

-Zahedi, Z., Costas, R., & Wouters, P. (2014). How well developed are altmetrics? A cross-disciplinary analysis of the presence of 'alternative metrics' in scientific publications. *Scientometrics*, 101(2):1491-1513.