Performance Measurement and Metrics

Bibliometrics and altmetrics literature review: Performance indicators and comparison analysis

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Abstract

Purpose – The purpose of this paper is to present the evolution in notions from bibliometrics to altmetrics and confront them taking into consideration specific criteria. The objective of this paper is to present the evolution of research, regarding the above fields, the study of metrics and indicators used, and the strength and weaknesses resulting from the current literature. Furthermore, the authors present the manipulation techniques for both fields as their main weakness, as well as further key points, analyzing the alternative options of bibliometrics and altmetrics.

Design/methodology/approach – First, the authors present the evolution of the literature, concerning the specific field and metrics used, following with a brief description of basic indicators related to the field of bibliometrics (journal impact factor (JIF), eigenfactor, article influence score and h-index) discussing their advantages and disadvantages. In the second part, the authors describe altmetrics and present the differences with bibliometrics.

Findings – Both bibliometrics and altmetrics remain weak indicators as fraught with disadvantages with manipulation being the greatest of all. Nevertheless, the combination of the two is proposed in order to export safer conclusions on assessing the impact. Regarding the manipulation there is yet not a clean technique to eliminate manipulation. In specific, regarding bibliometrics, the manipulation of indicators refers only to the human factor intervention. The theoretical implication of this study constitutes of collecting the relevant literature regarding scientific indicators.

Research limitations/implications – We must consider the study of new indicators, which combine metrics and methodologies used in both bibliometrics and altmetrics. The theoretical implication of this study constitutes of collecting the relevant literature regarding scientific indicators. Therefore, researchers are encouraged to test the proposed propositions further.

Practical implications – The practical contribution, on the other side, provides scholars with the knowledge of how making their work more accessible, increasing their impact.

Originality/value – The authors add to the originality by providing a framework of the relevant literature for bibliometrics and altmetrics for future researchers. The authors describe altmetrics and present the differences with bibliometrics. The authors conclude the research with the implications of the conducted analysis and the potential directions for future research. Regarding manipulation, the authors provide with the techniques so researchers are aware of the methods in order to protect their academic profile.

Keywords Bibliometrics, Altmetrics, Review, Manipulation, Comparison analysis, Performance indicator

Paper type Literature review

Introduction

Bibliometrics represent the statistical analysis regarding books, journals, scientific articles and authors. The word frequency analysis, the citation analysis or the number of the articles of authors, were the basic, initial metrics for such statistical analysis. After the 90's, bibliometrics transformed from a simple statistical bibliography study to a separate and unique field of study according to the Institute for Scientific Information (ISI), Science Citation Index (SCI).

Scientometrics is the study of science and technology including the interaction between scientometric theories and scientific communication (Mingers and Leydesdorff, 2015; Hood and Wilson, 2001). Furthermore, it is the study of the related bibliography, the evaluation of the scientific research and the information systems (Van Raan, 1997). Moreover, scientometrics are often confused with bibliometrics, since both are related with the bibliography. Scientometrics, however, interpret differently the bibliography, instead of just measuring it, as it occurs with

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bibliometrics (Hood and Wilson, 2001). In our study, we confirm Mingers and Leydesdorff (2015) who state that with the technology growing, the electronic databases and the plethora of the available citations online, scientometrics will overgrow bibliometrics.

Tague-Sutcliffe (1992) defines informetrics as the study of the quantitative aspects of information in any form, not just records or bibliographies, and in any social group, not just scientists. The term informetrics was first introduced in 1979, but it became separate and parental definition of bibliometrics and scientometrics only in 1984, covering the basic definitions for both metrics and characteristics of retrieval performance measures (Hood and Wilson, 2001; Tague-Sutcliffe, 1992; Brookes, 1990).

In 1999 along with the penetration of Web 2.0 and use of internet in science as a huge scientific database, the webometrics were introduced, including link analysis, web citation analysis and search engine evaluation (Bar-Ilan, 2008; Thelwall, 2008). Online data are dynamic and can be considered as a huge bibliographic database of scientific journals where web citations can be extracted. Applying data mining techniques on user generated content on internet, researchers can extract conclusions regarding the influence of such data on scientists and researchers (Thelwall, 2008). Researches show that web citations are well related with the ISI citation count. Web citation collection is created from online conferences and science blogs and platforms (Thelwall and Kousha, 2015).

The rapid growth of Web 2.0 and the extensive use of social media, the available data of the online literature, and the online scholar tools, rendered the scholarly communication, online (Liu and Adie, 2013). As a result, alternative metrics and measurements are created, relative to scientometrics and webometrics, focused on the scientific influence, known as altmetrics (Priem, Groth and Taraborelli, 2012). They can serve as filters, which "reflect the broad, rapid impact of scholarship in this burgeoning ecosystem" (Priem *et al.*, 2010).

The aim of this study is to present the evolution in notions from bibliometrics to altmetrics and confront them taking into consideration specific criteria. The objective of this paper is to present the evolution of research, regarding the above fields, the study of metrics and indicators used, and the strength and weaknesses resulting from the current literature. Furthermore, we present the manipulation techniques for both fields as their main weakness, as well as further key points, analyzing the alternative options of bibliometrics and altmetrics.

This paper is organized as follows. First we present the evolution of the literature, concerning the specific field and metrics used, following with a brief description of basic indicators related to the field of bibliometrics (journal impact factor (JIF), eigenfactor, article influence score (AIS) and h-index) discussing their advantages and disadvantages. In the second part, we describe altmetrics and present the differences with bibliometrics. We conclude our research with the implications of the conducted analysis and the potential directions for future research.

Methodology

The first stage of our research involves a review of the extant literature focusing on scientific articles related to bibliometrics and altmetrics. Our research was conducted on the major online libraries, such as Emerald, Science Direct, Sage Journals, Wiley and Google Scholar. In order to limit our results we used Boolean methods based on the keywords: altmetrics, bibliometrics, social media, impact factor and h-index. The search was not limited to a certain time span. The reason for this decision is that, even though altmetrics represent a relative new field of study, bibliometrics go much back in time. We followed the approach developed by Creswell (1994), who states that the purpose of a review is to summarize the accumulated knowledge base regarding the topic of interest and highlight issues that research has yet to resolve. The data analysis was conducted as follows. Each article was read and summarized using our initial classification by the topics shown on Tables I and IV. These two tables were established based on the results of the literature review.

Table I. Classification of the literature based on their reference to bibliometrics, altmetrics or both

Field	Articles		
	JIF	h-index	Eigenfactor and AIS
Bibliometrics	Garfield (1999), Miller (2012), Malay (2013), Coats and Shewan (2015), Timothy (2015), Link (2015), Franceschet (2010b), Franceschet (2010a), Costas *et al.* (2015), Editors (2006), Falagas and Alexiou (2008), Garfield (2005), Hoeffel (1998)	Alonso *et al.* (2009), Ausloos (2015), Bornmann *et al.* (2008), Gisbert and Panés (2009), Hirsch (2005), Hirsch (2007), Kelly and Jennions (2006), Khan *et al.* (2013), Liu and Fang (2012), Purvis (2006), Saleem (2011), Delgado López-Cózar *et al.* (2014), Hagen (2013)	Bergstrom *et al.* (2008), Franceschet (2010c), Malay (2013), Coats and Shewan (2015), Franceschet (2010b), Franceschet (2010a), Bergstrom (2007)
Altmetrics	Eysenbach (2011), Galligan and Dyas-Correia (2013), Lin (2012), Lin and Fenner (2013), Liu and Adie (2013), Piwowar (2013), Priem, Groth and Taraborelli (2012), Priem *et al.* (2010), Ringelhan *et al.* (2015), Thelwall *et al.* (2013), Thelwall and Kousha (2015)		
Bibliometrics vs Altmetrics	Ortega (2015), Bornmann (2014), Priem, Piwowar and Hemminger (2012), Taylor (2013), Costas *et al.* (2015), Melero (2015), Rasmussen and Andersen (2013), Torres-Salinas *et al.* (2013), Haustein *et al.* (2014)		

Table I divides the literature based on each article's reference to bibliometrics or altmetrics. Nine articles refer to both so they form a separate classification. Moreover, the articles related to bibliometrics are further separated in subcategories based on the indicator that is examined on each. Some articles are presented in more than one category since they examine more than one indicator. The indicators with most articles are JIF and h-index with 13 articles for each. We could say that even there are indicators that are presented in more articles, the categories are almost equally divided with seven articles for eigenfactor and AIS and eleven to refer to altmetrics.

Bibliometrics review

We present the most widespread bibliometric indicators, specifically the JIF, the eigenfactor, the AIS and the h-index. Descriptions, advantages and disadvantages, common misunderstandings and a comparison between the JIF and the eigenfactor are provided.

JIF

In 1955, Garfield (2006) proposed an indicator which considers the mean of citations – a journal takes and reflects its influence on a specific scientific field. This indicator, named JIF, is calculated by the fraction:

$$\frac{\text{number of citations of the journal in the last two years}}{\text{number of citable articles}}. \quad (1)$$

The period of the two years can be increased or decreased so as to reflect short- or long-term influence (Garfield, 1999). JIF is easy to understand and simple to measure, therefore it is commonly used by the scientific community. Authors take in consideration the JIF before submitting their work on a journal. Editors use JIF as a marketing tool, as a status symbol and libraries all over the world use it in order to organize better their collection of journals (Garfield, 1999; Franceschet, 2010b; Malay, 2013). JIF represents a complete indicator for measuring the influence and the importance of a scientific journal. In fact, in journals with high JIF it is more difficult to publish because they address strict accepting rules, so the more important a journal is, the more difficult to publish (Hoeffel, 1998). Besides its simplicity, JIF is often dealt with misunderstandings. As Garfield (1999) claims, researchers often confuse

JIF with authors' impact. Furthermore it represents a common tactic to compare journals' impact factor from different disciplines. This strategy may cause problems due to the diversity of the scientific fields. The bigger a scientific community is, the more the published material, although the key for bigger JIF is not the density but the time of a citation cited (Garfield, 2005; Link, 2015). Regarding the disadvantages of the JIF indicator, scientists often challenge JIF's validity, since it complicates and influences young researchers on their first steps on academia (Timothy, 2015). Furthermore, JIF can be easily manipulated. For example, literature review papers tend to collect more downloads, therefore, editors choose these instead of primary research articles despite their original contribution in scientific fields (Link, 2015). Moreover, authors are often prompted to cite articles that are published on the specific journal they want to publish their article in order to increase its JIF (Malay, 2013). Manipulation and its methods will be further analyzed on a separate paragraph.

Eigenfactor and AIS

Eigenfactor was proposed as an alternative to JIF and until today is not disputed for its validity, indicating the importance and the prestige of a journal among the scientific community (Coats and Shewan, 2015; Bergstrom *et al.*, 2008). In order to calculate eigenfactor we take in consideration a journal and follow a random citation of that journal to another, then select another citation from the second journal and follow it to the next and so on. By this procedure, we also calculate the percentage of the time spent at each journal. One citation on a high impact journal may have more importance in contrast with many citations of less recognized journals (Bergstrom, 2007). Therefore, a journal acquires high influence when it takes citations from other high impact journals (Franceschet, 2010c). We notice that eigenfactor operates as Google's algorithm for searching results, since it takes into consideration the amount of the links (in our case citations) as well as the source (Bergstrom *et al.*, 2008). Furthermore, eigenfactor is relying on the amount of the published articles on a journal, therefore, journals with high amount of published articles tend to obtain higher eigenfactor value respect to the relative JIF (Franceschet, 2010c; Malay, 2013). The algorithm behind the eigenfactor indicator is reliable and is established as a prestige indicator since it has a strong mathematical background ignoring self-citations and the results of its research are open and published on the web (Franceschet, 2010c). Finally, with eigenfactor we can compare journals' scores from different scientific fields (Bergstrom, 2007).

By dividing the eigenfactor with the amount of the articles published on a journal, researchers created the AIS. We notice that since AIS calculates the mean of the influence per article, it can be compared with the JIF (Bergstrom, 2007; Bergstrom *et al.*, 2008).

Combining the number of citations from diverse journals and their prestige, a journal can achieve better placement on the academic recognition. As a result, many researchers confuse JIF and eigenfactor. In this paper we fully define JIF and eigenfactor in order to overcome any misunderstanding. Eigenfactor is an indicator of prestige and reliability and JIF an indicator of popularity. Furthermore, eigenfactor presents lower uncertainty respect to JIF and AIS, and seems to have bigger variety for different scientific fields, while AIS is more stable (Franceschet, 2010a). JIF gathers more criticism than every other indicator, because it creates a constant pressure to academics to publish on journals with high scores (Coats and Shewan, 2015; Miller, 2012). Not considering letters and editorials, represents another criticism for JIF, since it is not clear which type of publication is citable and as Garfield (1999) claims, many rules are up to authors discretion.

H-index

Evaluating scientists is necessary on a competitive academic environment. A positive evaluation may provide access to bigger finance, accepting more proposals or influence the overall career of a researcher (Gisbert and Panés, 2009; Alonso *et al.*, 2009). H-index is the metric

that dominates for such purpose (Kelly and Jennions, 2006; Hirsch, 2005). As Hirsch (2005) defines, a scientist has an h-index when h publications of his/her N_p publications in total, have h citations each, and the rest ($N_p - h$) have less than h citations each. H-index considers the productivity of a researcher as well as the quality and the recognition from the scientific community (Hirsch, 2005; Alonso *et al.*, 2009; Gisbert and Panés, 2009) (Figure 1).

H-index is an acceptable, objective and understandable indicator by the academic community. It calculates both productivity and quality of a researcher's work and it is associated with peer reviews (Costas and Bordons, 2007; Hirsch, 2005, 2007; Gisbert and Panés, 2009). On the contrary, h-index depends on the scientific field. When scientists are associated with mainstream scientific fields, they tend to present higher values of h-index. We explain this fact due to the eventually more possible citations, an article can get. Moreover, h-index considers and calculates also the self-citations. Scientists can increase their h-index, simply, by continuously self-citing (Hirsch, 2005; Alonso *et al.*, 2009). In order to calculate the h-index, we calculate the quantity instead of the quality of an article. Therefore publications with elevate number of citations, are counted by the algorithm only once, without re-considering them, even if the citations they will get after the initial calculation, will increase significantly (Khan *et al.*, 2013). H-index depends also on the years of experience of the researcher. A mature researcher will have higher h-index rather a young one. So, it is difficult to compare two scientists just by their h-index, without first consider their age and level of experience (Kelly and Jennions, 2006). Finally, h-index depends on the database it is extracted from and there are significant differences between Scopus, ISI Web of Science and Google Scholar (Khan *et al.*, 2013; Alonso *et al.*, 2009). In case of multiple authors, which is the most common case, it is difficult to calculate the h-index for every author if the effort of writing an article is not equally shared (Hagen, 2013) which means that h-index will be calculated equally for all co-authors, even if their percentage of contribution is different (Liu and Fang, 2012; Ausloos, 2015). To overcome the disadvantages, researchers created h_{mcr}-index, which calculates the level of the participation for each co-author (Liu and Fang, 2012). More flexible variants of h-index have been proposed which focus either on productivity or influence, and in practice, it is shown that they can complement very well each other (Bornmann *et al.*, 2008).

According to the aforementioned literature, h-index is not used as a stand-alone indicator. In specific, h-index combined with JIF we can reveal great scientists on

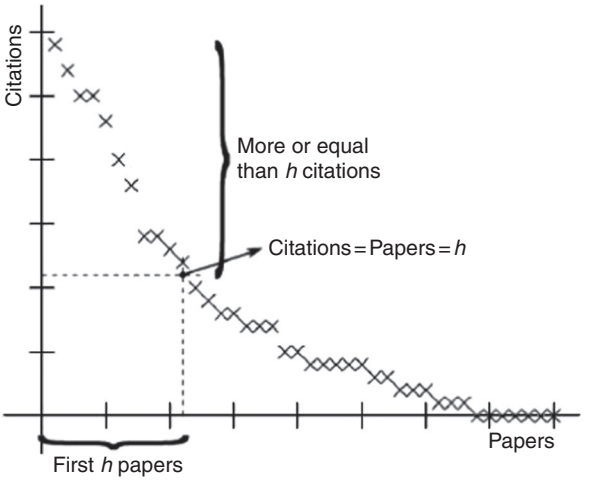

Figure 1.
Calculating h-index

Source: Alonso *et al.* (2009)

every scientific field. Although it is not a golden standard on evaluating a scientist, h-index it is established as a realistic indicator of academic recognition (Costas and Bordons, 2007; Saleem, 2011).

Altmetrics review

Web 2.0 and social media create massive amounts of available data online, including online literature and tools for academic purposes (Liu and Adie, 2013). Scientists create alternative metrics and indicators, relative to webometrics and scientometrics, called altmetrics (Priem, Groth and Taraborelli, 2012). The main idea behind altmetrics is that, with such a huge amount of available information, tools are needed for filtering and decreasing the outcomes to study (Priem *et al.*, 2010).

We call altmetric events the specific actions on articles, such as Twitter mentions, Facebook shares, likes and comments, Mendeley saves, blog posts, F1000 ratings, views and downloads (Priem, Piwowar and Hemminger, 2012). The need of taxonomy of these metrics in order to better understand them, led to the following categorization/classification by the PLoS database (Lin and Fenner, 2013):

(1) viewed: online actions regarding the access of an article;

(2) saved: online actions regarding the storage of an article on online reference managers, providing sharing among researchers and better organizing;

(3) discussed: online discussions of an article content (tweets, forum discussions or comments regarding an article);

(4) recommended: online actions that formally endorse an article; and

(5) cited: citations of an article on scientific journals.

Table II presents the basic classification of the aforementioned metrics. We notice, as we read from left to the right, the engagement is increasing.

Together with Tables II and III presents the use of the scientific articles by academics and public for each metric.

Table II. Classification of altmetrics

Scientific article				
Viewed	Saved	Discussed	Recommended	Cited
PLOS HTML	CiteULike	NatureBlogs	F1000 Prime	CrossRef
PLOS PDF	Mendeley	ScienceSeeker		PMC
PLOS XML		ResearchBlogging		Web Of Science
PMC HTML		PLOS Comments		Scopus
PMC PDF		Wikipedia		
		Twitter		
		Facebook		
		→ Increasing engagement →		

Table III. Use of scientific articles by academics and public

	Academics	Public
Recommended	Citations by editorials, f1000	Press article
Cited	Citations, full-text mentions	Wikipedia mentions
Saved	CiteULike, Mendeley	Delicious
Discussed	Science blogs, journal comments	Blogs, Twitter, Facebook, etc.
Viewed	PDF downloads	HTML downloads

Open source, open data, timeliness and speed are some of the advantages the altmetrics have (Galligan and Dyas-Correia, 2013; Priem *et al.*, 2010; Piwowar, 2013; Taylor, 2013). Furthermore, altmetrics represent a more societal interaction respect to the strict scientific citations. Moreover, altmetrics draw their data mostly from social media and as a result, academics who do not publish on journals but use social media to share their work, and everything they consider useful and interesting, produce altmetrics events (Thelwall *et al.*, 2013). Ringelhan *et al.* (2015) studied the capability of Facebook on predicting the probable number of citations of an article, counting the number of likes, while Eysenbach (2011) focused on Twitter and the fact that the tweet analysis can predict the number of citations in a period of three days. Finally, altmetrics can be used as a marketing tool, not only for a scientific article but also for any online activity that needs monitoring and evaluation (Galligan and Dyas-Correia, 2013; Thelwall *et al.*, 2013).

The study of altmetrics revealed also some disadvantages regarding the lack of theoretical background (Priem, Piwowar and Hemminger, 2012). Moreover, Bornmann (2014) states that the quality of the data and the commercialization on social media can manipulate altmetrics scores. Sugimoto (2016) presents a conceptual framework applied in acts underlying these metrics in the context of scholarly communication.

Bibliometrics vs altmetrics

Results of reviewing articles reveal differences between bibliometrics and altmetrics with some of them focusing on the strengths of bibliometrics or weaknesses and vice-versa. There are specific advantages and disadvantages for each field listed in Table IV.

Analytically, comparing bibliometrics and altmetrics, we notice that altmetrics interact more with scientific blogs, grey literature, books and conferences compared with bibliometrics that are unable to cover such sources. Therefore, altmetrics affirm the unrevealed and societal impact that bibliometrics are unable to do (Ortega, 2015; Taylor, 2013; Priem *et al.*, 2010; Rasmussen and Andersen, 2013; Haustein *et al.*, 2014). Furthermore, altmetrics are considered more transparent since it is the entire scientific community who evaluates them (Galligan and Dyas-Correia, 2013; Lin, 2012; Rasmussen and Andersen, 2013; Taylor, 2013). Findings obtained from altmetrics, and in general from academic social media, are difficult to generalize due to the diversity between sources and measurable actions (Sugimoto *et al.*, 2016). Moreover, altmetrics are influenced from the providing services, such as Research Gate and Google Scholar, while bibliometrics, even though they can be influenced from the scientific database (e.g. h-index), tend to be more stable (Ortega, 2015; Delgado López-Cózar *et al.*, 2014; Torres-Salinas *et al.*, 2013). Altmetrics depend always on each service and platform, for measurable acts extraction. Most of these

Table IV.
Advantages and disadvantages for bibliometrics and altmetrics

Bibliometrics	Advantages	Actual impact
		Strong theoretical background
	Disadvantages	Influenced by the database
		Manipulation
		Cannot compare across scientific fields
Altmetrics	Advantages	Unrevealed/societal impact
		Transparency (open data)
		Timeliness
	Disadvantages	Lack of theoretical background
		Influenced by the service
		Manipulation
		Differences across scientific fields

metrics only exist inside the specific platform in consideration and they cannot be calculated outside the tool. This fact renders altmetrics less stable and more dependent on specific tools, respect to bibliometrics (Sugimoto *et al.*, 2016). Furthermore, altmetrics allow assessing the social impact of scholarly outputs almost in real time, providing them with the advantage of timeliness (Melero, 2015; Priem *et al.*, 2010). Finally, we conclude with two affirmations. Altmetrics, in contrary to bibliometrics, lack of a strong theoretical background (Priem *et al.*, 2010; Ortega, 2015; Torres-Salinas *et al.*, 2013) and that bibliometrics correlate positively but only moderate with altmetrics (Costas *et al.*, 2015; Priem, Piwowar and Hemminger, 2012; Haustein *et al.*, 2014).

Scientists should consider altmetrics as a complementary factor to bibliometrics and combine them for a more informed peer-review judgment, decreasing the dependence on less reliable indicators, such as JIF (Bornmann, 2014, 2015; Galligan and Dyas-Correia, 2013; Thelwall *et al.*, 2013; Priem, Piwowar and Hemminger, 2012; Costas and Bordons, 2007; Priem, Groth and Taraborelli, 2012; Ortega, 2015; Melero, 2015; Rasmussen and Andersen, 2013; Torres-Salinas *et al.*, 2013).

Manipulating bibliometrics and altmetrics

Bibliometrics are prone to manipulation either regarding journals, either authors. Regarding journals, some try to increase their JIF with illicit methods that not conform with the true scope of the indicator (Coats and Shewan, 2015; Editors, 2006). Based on JIF's definition, in fraction (1) the indicator increases by increasing the numerator or by decreasing the denominator. Self-citing is a common practice for that purpose. Furthermore, authors try to include as many citations as they can from the specific journal they want to publish (Malay, 2013). Regarding the denominator of the fraction (1), editorials or letters are not calculated as citable so the value decreases, leading in higher JIF (Falagas and Alexiou, 2008). In order to manipulate bibliometrics, many researchers include co-authors or prefer literature reviews (Editors, 2006; Falagas and Alexiou, 2008). Another manipulation technique is the no-publication technique. Even it seems oxymoron, some journals increase their JIF by not publishing anything for two years (Coats and Shewan, 2015). H-index can be easily manipulated by self-citing a lot (Purvis, 2006). Ethic, however, is what a scientist has in mind in order not to manipulate the indicators (Falagas and Alexiou, 2008; Editors, 2006; Delgado López-Cózar *et al.*, 2014).

As Thelwall *et al.* (2013) claim, altmetrics are easier to manipulate respect to bibliometrics, even their nature is more open and transparent, as a result of the control of the online community (Lin, 2012). On social media such control does not fully exist, since fake profiles are created, and therefore fake mentions, while there is no way to identify online user (Bornmann, 2014). Delgado López-Cózar *et al.* (2014) conducted an experiment, creating false papers connected to a young researcher named Marco Alberto Pantani-Contador. They tried to study how and if such malpractices can be detected from Google Scholar. The false papers, except the useless and irrelevant content, contained citations to published articles of the laboratory López-Cózar, and Robinson-García work. The results of the experiment were astonishing. H-index and i10-index increased significantly, showing the ease GS citations can be manipulated.

Some methods permit altmetrics to evolve in order to be manipulated, taking in consideration the big data and the cross-calibration from different sources (Priem and Hemminger, 2010). Furthermore, we use tools that minimize the manipulation (i.e. DataTrust), that send alerts when strange action is pointed, such as many views or downloads from the same IP (Lin, 2012) or BotorNot (http://botornot.co/) that detects fake Twitter accounts. This article has no scope of listing the manipulation techniques. Even there will always be ways to manipulate the indicators, real scientist is and will be altruist, ethical and dedicated to science.

Further research and conclusions

Our study contributes to the literature and the analysis of the metrics and indicators related to books, journals and scientific work of scholars/authors by reviewing the literature and providing with the relevant frameworks and tables for better understanding of the field. Both bibliometrics and altmetrics remain weak performance indicators as fraught with disadvantages with manipulation being the greatest of all. Nevertheless, the combination of the two is proposed in order to export safer conclusions on assessing the academics', universities' and journals' impact. Regarding the manipulation of indicators the focus was on reporting techniques used to manipulate the scores, and highlight that there is yet not a clean technique to eliminate manipulation. In specific, regarding bibliometrics, the manipulation of indicators refers only to the human factor intervention. As a result, fair play and strong ethical values by the researchers are required. We need to conduct further research exploring the development of policies and software, which would make the manipulation of altmetrics impossible. We also must consider the study of new indicators, which combine metrics and methodologies used in both bibliometrics and altmetrics. It is time to surpass the current mentality of confronting bibliometrics and altmetrics as oppositional techniques and consider them as parallel facilities in the field of scholarly communication. The theoretical implication of this study constitutes of collecting the relevant literature regarding scientific indicators. The practical contribution, on the other side, provides scholars with the knowledge of how making their work more accessible, increasing their impact.

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