



Universiteit
Leiden
The Netherlands

Understanding the value of social media metrics for research evaluation

Zahedi, Z.

Citation

Zahedi, Z. (2018, December 12). *Understanding the value of social media metrics for research evaluation*. Retrieved from <https://hdl.handle.net/1887/67131>

Version: Not Applicable (or Unknown)

License: [Licence agreement concerning inclusion of doctoral thesis in the Institutional Repository of the University of Leiden](#)

Downloaded from: <https://hdl.handle.net/1887/67131>

Note: To cite this publication please use the final published version (if applicable).

Cover Page



Universiteit Leiden



The following handle holds various files of this Leiden University dissertation:

<http://hdl.handle.net/1887/67131>

Author: Zahedi, Z.

Title: Understanding the value of social media metrics for research evaluation

Issue Date: 2018-12-12

CHAPTER 1

General Introduction

Introduction

Developing robust indicators for assessing the impact and value of research has been highlighted as a crucial step to support the process of decision making in the context of research evaluation (Wilsdon et al., 2015; Wilsdon & Al., 2017). Limitations of current citation-based indicators in reflecting the broad value of research (beyond scientific impact) and its contributions to society are seen as critical challenges in research evaluation (MacRoberts & MacRoberts, 2017; Haustein & Larivière, 2015; Moed, 2005; MacRoberts & MacRoberts, 1989; Martin & Irvin, 1983). These limitations of citation-based indicators have led to the development of alternative indicators in research evaluation that could represent broader impacts of research. For instance, some national assessment exercises such as the Research Excellence Framework(REF)¹ in the UK or the Standard Evaluation Protocol (SEP)² in the Netherlands have incorporated criteria for evaluating the scientific, social, economic, and cultural impact of research in their respective assessments. The availability of indicators based on social media has opened the possibility to track and measure different aspects of online interactions in social media platforms (including aspects such as how often, by whom, and when scholarly publications are mentioned and discussed on social media). These new indicators, popularly known as *altmetrics* and more technically referred as *social media metrics* (Haustein, Bowman, & Costas, 2016; Wouters, Zahedi, & Costas, 2018) are usually proposed as potential alternatives to citation-based indicators to inform research evaluation (Priem, Taraborelli, Groth, & Neylon, 2010a). However, it is not yet clear how these new indicators can be used for the evaluation of scientific activities, and their validity for such purpose is still a bone of contention in the literature (Sugimoto, Work, Larivière, & Haustein, 2017). The main ambition of this PhD thesis is to increase our knowledge and understanding of the limitations, challenges, and actual possibilities of social media metrics for research evaluation. This chapter presents an introduction to social media and scholarly communication in section 1.1. Section 1.2 discusses the origins, definitions, and data availability (through different altmetric data aggregators) of social media metrics. Section 1.3 reviews the challenges, limitations, and possibilities of social media metrics for research evaluation; section 1.4 describes different social media metrics data sources, particularly focusing on Mendeley as a specific relevant data source for research evaluation. Finally, sections 1.5 and 1.6 introduce the aim and research questions of this thesis.

1.1. Social media and scholarly communication

Social media emerged in recent years as a novel and innovative form of communication among organizations and individuals, including scholars (McCay-Peet & Quan-Haase, 2017; Gruz, Staves, & Wilk, 2012). Although there is no consensus about the definition of social media in the literature, different definitions share some elements such as *user-generated contents* that are *shared across web-based environments*. In general, the term *social media* refers to “web-

¹ <http://www.ref.ac.uk>

² <https://www.knaw.nl/nl/actueel/publicaties/standard-evaluation-protocol-2015-2021>

based Internet applications that allow the creation, access, and exchange of user generated content that is ubiquitously accessible” (Batrinca & Treleaven, 2015). Another definition considers them as “web-based services that allow individuals, communities, and organizations to collaborate, connect, interact, and build community by enabling them to create, co-create, modify, share, and engage with user-generated content that is easy accessible” (McCay-Peet & Quan-Haase, 2017, page 16).

The rise of social media is changing how individuals are communicating and exchanging information in modern societies. Uptake of social media by American adults has grown from 5% in 2005 to 69% in 2011 (Pew research³, 2017). It is estimated that global social media users will be around 3 billion by the year 2021 (Statista⁴, 2018). The use of social media is also gaining momentum among academics (van Noorden, 2014) who use these platforms both for personal and professional purposes (Bowman, 2015). In addition to formal scholarly communication channels (i.e., journal publications, books, etc.), academics are also using social media platforms to communicate, collaborate, and disseminate research among various audiences (Gruzd, Staves, & Wilk, 2012). General social media platforms like Facebook, Twitter, Wikipedia, blogs, social bookmarking tools (e.g., Mendeley, Zotero, CiteULike, BibSonomy) (Gruzd & Goertzen, 2013) and particularly, academic social networking sites such as ResearchGate (with 14 million members⁵) and Academia.edu (with 59 million academics sharing over 20 million publications⁶) are becoming popular among researchers and academics (Thelwall & Kousha, 2014, 2015a; Wouters, Zahedi, & Costas, 2018; Wouters et al., 2018). Sharing of knowledge and publications, keeping up-to-date with other researchers, connecting with peers, receiving help to answer questions, following research topics, and being aware of job opportunities are among the motivations for the use of academic social networking sites such as ResearchGate (Chakraborty, 2012).

However, the popularity of social media varies across groups of researchers, and the extent to which these platforms are used for scholarly or personal purposes has been subject of several studies (Sugimoto, et al., 2017). In a survey published in Nature (Van Noorden, 2014) it was shown that Twitter is mostly used for academic purposes (e.g., to comment or to follow discussions about research). Mendeley is used for discovering papers and organizing references while Academia.edu or ResearchGate are mostly used by researchers for maintaining online presence (van Noorden, 2014). The existence of biases in the adoption and use of social media across genders, generations, or countries is also discussed in the literature (Alperin, 2013; Bolton, et al., 2013; Nicholas, et al., 2015; Thelwall & Kousha, 2015a). There are important differences in the perceptions among scholars about the value of social media for scholarly purposes and not all scholars consider social media as trustworthy or creditable channels for formal scholarly communication (Jamali, et al., 2014). For instance, Hank, Sugimoto, Tsou, & Pomerantz (2014) found that faculty members didn’t consider Facebook as

³ <http://www.pewinternet.org/fact-sheet/social-media/>

⁴ <https://www.statista.com/statistics/278414/number-of-worldwide-social-network-users/>

⁵ <https://www.researchgate.net/about>

⁶ <https://www.academia.edu/about>

a professional channel to interact with their students. European scholars considered disseminating research via social media platforms as less important than disseminating results via journals/books and conference publications (Jamali, Nicholas, & Herman, 2016). Also, a majority of research policy makers and researchers in higher education in Finland still expressed doubts about how indicators based on social media platforms could be used for research funding applications (Fraumann, 2017).

In spite of these biases and unclear value of social media for research evaluation, social media platforms are increasingly integrated in different phases of the research workflow, from identifying research opportunities to disseminating research across different communities of researchers from all disciplines (Rowlands, Nicholas, Russell, Canty, & Watkinson, 2011). Academic papers are saved in some social reference manager tools such as Mendeley, or mentioned or discussed on Twitter or blogging platforms (Thelwall, Haustein, Larivière, & Sugimoto, 2013). Also, a majority of users of social media platforms such as tweeters (Andrew Tsou, Bowman, Sugimoto, Larivière, & Sugimoto, 2016), bloggers (Shema, Bar-Ilan, & Thelwall, 2012), or Mendeley users (Haustein & Larivière, 2014) are academics or employed in academia (Puschmann & Mahrt, 2012). The study of the activities of scholars on social media has led to the development of tools to identify scientists on social media platforms like Twitter (Costas, van Honk, & Franssen, 2017; Hadgu & Jäschke, 2014; Ke, Ahn, & Sugimoto, 2016). Moreover, it seems that social media strategies⁷ are becoming part of the communication policies of academic organizations. Social media channels are increasingly embedded in academic organizations' web pages (libraries, universities, etc.) as well as in publishers and journals websites⁸ (Sugimoto et al., 2017). This increasing presence of social media in scholarly activities has resulted in the proliferation of social media data and indicators that could be used to track and measure these activities.

Social media metrics refer to the metrics (e.g., number of tweets, Facebook counts, Wikipedia mentions, blog posts, news mentions, readers in social reference management tools, etc.) for *scholarly objects* (including all kinds of *research products* – (Piwowar, 2013)) driven *from social media platforms* (originally these indicators have been popularly known as *altmetrics* (Priem, 2010; Haustein, Bowman, & Costas, 2016). More recently it was suggested that tracking all these online events opens the possibility of studying the interactions between social media and all sorts of scholarly entities (i.e., not only scholarly objects, but also scholarly actors like authors, universities or journals) (Haustein, et al., 2016; Wouters, Zahedi, & Costas, 2018). Studying the interactions between social media and scientific entities provides the opportunity for obtaining valuable insights into the communications between social media audiences and scholarly actors. For instance, nowadays it is possible to study how scientific documents are discussed online or how different users (academic or not) engage with scholarly content and share it with different audiences. The study of “*the relationships and interactions between science and social media*” as sources of information instead of just

⁷ <https://university-relations.umn.edu/resources/social-media-strategy-and-best-practices>;
<https://www.elsevier.com/authors-update/story/social-media/making-the-most-of-social-media>

⁸ <http://journals.plos.org/plosone/>

impact indicators has led to the proposal of the *social media studies of science* as a new approach to obtain a more comprehensive perspective of the study of scholarly communication in the age of social media (Costas, 2017; Wouters, et al., 2018).

1.2. Scholarly indicators based on social media: origins and developments

As explained in the previous section, social media metrics (popularly called *altmetrics*) refer to the metrics (number of tweets, Facebook counts, Wikipedia mentions, blog posts, news mentions, readers in social reference management tools) for scholarly objects that are obtained from social media platforms. In this section the origin of the concept of *altmetrics*, the development of *altmetric data aggregators*, and the main conceptual debates around altmetrics are presented and discussed.

The origin of altmetrics, its promises, and drivers

The concept of *altmetrics* (Priem, 2010) originated from the desire to improve and complement the traditional impact assessment tools of research evaluation. The '*Altmetrics manifesto*' based itself on the diverse users' engagements with scholarly contents in the social web and across different online platforms (Priem, Taraborelli, Groth, & Neylon, 2010). The expectation of the *Altmetrics manifesto* was to enable real-time monitors for impact assessment (Priem & Hemminger, 2010) and to enhance the traditional peer review by enabling "*soft peer review*" (Taraborelli, 2008). Two important elements are central in the Altmetrics manifesto. First, the idea of enlarging the set of research products credited for research evaluation, by including outputs such as blog posts, datasets, codes, etc. (Piwowar, 2013). Second, the possibility of measuring more diverse forms of real-time impact across diverse audiences (researchers, general public, clinicians, practitioners) able to complement traditional scholarly impact analyses (Priem, Piwowar, & Hemminger, 2012).

One of the driving forces in the development of altmetrics was the 'promise' of these new metrics to solve the inadequacies of the more traditional and established scholarly metrics (particularly citations and peer review) (Wouters & Costas, 2012). This was in line with the need for more multi-dimensional research performance evaluations that was emphasized in the literature (Rousseau & Ye, 2013; Cronin, 2014; Van Leeuwen, Visser, Moed, Nederhof, & Van Raan, 2003). This need for more multi-dimensional research evaluations is grounded in the 'gap' existing between the actual value or quality of the scientific work and the way it is assessed in research evaluation. Wouters (2014)⁹ introduced the notion of the *evaluation gap* as the "gap between [...] the dominant criteria in scientific quality control [...] and on the other hand the goals of the research under evaluation or the roles of research in society". In the same line Cronin (2014) also argued that "a scholar's work may well have a range of impacts over time in different contexts, with different audiences, and for different reasons and traditional bibliometric indicators may not fully reflect these multivariate contributions"

⁹ <https://citationculture.wordpress.com/2014/08/28/a-key-challenge-the-evaluation-gap/>

(Cronin, 2014, page. 14). Thus, the new altmetric indicators could be seen as potential alternatives that could fill this gap.

A more technical driving force for the growth of altmetrics has been the development of Information and Communication Technologies (ICT), particularly the development of advanced Application Programming Interfaces (APIs)¹⁰ which has increased the capacity of collecting and analyzing large sets of social media data by altmetric data aggregators and researchers. In addition, the open science movement contributed to the development of altmetrics (Moed, 2017) by demanding an increased transparency and availability of research to the general public (Friesike & Schildhauer, 2015). Open science has been defined as “*the idea that scientific knowledge of all kinds should be openly shared as early as is practical in the discovery process*” (Nielsen, 2011). Open science is also concerned with the idea that access to any research products should be open and freely available (Holmberg, 2017). Wide access to research products is supposed to increase their visibility and hence facilitate the dissemination, sharing, and publication of data and research in online environments.

Finally, in recent years altmetrics have also received a lot of attention from research funders and science policy makers, due to their potential to demonstrate the contribution that scientific research has had to society-at-large (Wilsdon, et al., 2015). However, there is not yet enough evidence in the literature to show how altmetrics can actually reveal the societal impact of research (Tsou, Bowman, Ghazinejad, & Sugimoto, 2015; Alperin & Reilly, 2017). Further studies are needed to explore the potential and importance of these new social media metrics for research impact assessments (Wouters & Costas, 2012). Exploring these potentials are the main focus of this PhD thesis.

The rise of altmetric data aggregators

A critical element in the development of altmetrics and altmetric indicators can be attributed to the increasing availability of altmetric data and indicators, particularly after the foundation of several *altmetric data aggregators* (see Table 1). One of the first altmetric data aggregators was the *Lagotto open source Article-Level Metrics application*- formerly called *PLOS Article-Level-metrics (ALM)*. It started in 2009 by providing the mentions in social media (Twitter, Facebook, etc.) of PloS articles, and later on for any article from any publisher (Fenner, 2013). *Impact Story* (formerly called ‘Total Impact’) began in 2011 as an open source tool that provided aggregated impact of diverse research products across several social media tools. Other altmetric data aggregators include *Altmetric.com* (Adie & Roe, 2013), *Plum Analytics* (Buschman & Michalek, 2013), and more recently *CrossRef Event Data* (Wass, 2017). All of them provide aggregated metrics for scholarly materials coming from different social media sources. Table 1 provides an overview of the social media sources covered and indicators provided by these aggregators. Moreover, there are other online platforms such as

¹⁰ Application Programming Interface (API) is “a set of subroutine definitions, protocols, and tools for building application software. In general terms, it is a set of clearly defined methods of communication between various software components”. https://en.wikipedia.org/wiki/Application_programming_interface

Academia.edu, ResearchGate.net, Microsoft Academic Scholar Universe.com, SemanticScholar.org, or Loop (<https://loop.frontiersin.org/>) that also provide indicators from social media sources or with a social media component for researchers and their outputs (Orduña-Malea, Martín-Martín, & López-Cózar, 2016; Thelwall & Kousha, 2017; Costas & Franssen, 2018).

The existence of these different altmetric data aggregators and the proliferation of indicators provided by them at different aggregation levels (outputs, individuals, institutes, countries, etc.) raise some important questions such as *from where*, *when*, and *how* social media metrics are collected, processed, and reported by these aggregators. Hence, it is critical to explore to what extent altmetric aggregators differ in the social media metrics provided and to understand the reasons for (dis)similarities across them, and how they can influence the conceptual and analytical possibilities of the metrics provided.

Table 1. Overview of altmetric aggregators, data sources, and metrics.

Aggregators	Founded year	Founded by	Category of impact	Metrics, raw data and data sources
<i>Lagotto (PLOS ALM)</i>	2009	Public Library of Science	Views, saves, citations, recommendations , discussions	Views from PMC usage; saves in Mendeley and CiteULike; discussions in Twitter, Facebook, Nature blogs, ScienceSeeker, ResearchBlogging, Wordpress.com, Wikipedia, Reddit, and OpenEdition; citations from CrossRef, PubMed, PMC, and DataCite; recommendations from F1000.
<i>Impact Story</i>	2011	Jason Priem and Heather Piwowar	Buzz and engagement (volume and quality of discussion around artifacts), openness	Altmetric.com, Mendeley, Twitter, CrossRef, ORCID, Base.
<i>Altmetric.com</i>	2011	Digital Science company	Altmetric Attention Score, mentions and readers	Twitter, Facebook, policy documents, Wikipedia, news, blogs, Mendeley, Pub peer and Publons, Faculty of 1000 Prime Reddit, Stack overflow, Google Plus, YouTube, Open Syllabus Project, Scopus and Web of Science citations.
<i>Plum Analytics</i>	2012	Andrea Michalek, acquired by EBSCO in 2012 and by Elsevier in 2014	Usage, captures, mentions, social media, and citations	<u>Usage</u> category includes abstract and full text views, downloads, URLs clicks, Dryad, figshare, and Slideshare views, Github collaborators, WorldCat holdings, Vimeo, YouTube, SoundCloud plays, Link Outs; <u>Capture</u> category includes Delicious bookmarks, Mendeley, CiteULike, and Goodreads readers, Slideshare, SoundCloud, and YouTube favorites, Github followers, forks, and watchers, Vimeo and YouTube subscribers, exports and saves in EBSCO; <u>Mention</u> category includes (economic) blog mentions, Reddit, Slideshare, Vimeo, and YouTube comments, Forum topic counts in Vimeo, Gist count in Github, news mentions, Wikipedia and StackExchange links, Amazon, Goodreads, and SourceForge reviews; <u>Social media</u> category includes Vimeo and YouTube likes, Google Plus +1, Facebook shares, likes, and c comments, Amazon, Goodreads, and SourceForge ratings, Figshare and SourceForge recommendations, Reddit scores, Twitter; <u>Citation</u> category includes citations from CrossRef, PubMed, RePec, SciELO, SSRN, Scopus, USPTO, clinical and policy citations.

Aggregators	Founded year	Founded by	Category of impact	Metrics, raw data and data sources
CrossRef Event Data	2017	CrossRef	Discussed, mentions, annotations, references, links, citations	Discussed in blogs and media, Wordpress.com, Newsfeed, Reddit and links in subreddits, StackExchange sites; Mentions in tweets; Annotations in Hypothes.is; References on Wikipedia pages; Links to DataCite and CrossRef registered contents; Citations in Patents via Cambia Lens.

Altmetrics: terminology and definition

Priem originally defined altmetrics as “*the creation and study of new metrics based on the Social Web for tracking, analyzing, and informing scholarship or as a form of information filtering tool*” (Priem, et al., 2010). NISO defined altmetrics as “*online events derived from activity and engagement between diverse stakeholders and scholarly outputs in the research ecosystem*” (National Information Standards Organization, 2016). Altmetrics have been also defined as “*traces of computerization of the research process, and as a tool for the practical realization of the ethos of science and scholarship in a computerized or digital age*” by Moed (2015). Haustein, Bowman, & Costas (2016) defined altmetrics as “*events on social and mainstream media platforms related to scholarly content or scholars, which can be easily harvested (i.e., through APIs), and are not the same as the more ‘traditional’ concept of citations*” as *social media metrics*”. These authors also introduced a framework for social media metrics in which the various types of acts that occur between the ‘scholarly objects’ and ‘agents’ in online platforms are grouped into three categories: acts of access (viewing, downloading, and saving), appraise (mentioning, rating, discussing, commenting, or reviewing), and apply (using, adapting, or modifying), depending on the degree of engagement of the agent with the scholarly object. Although there is no consensus among altmetrics researchers¹¹, most definitions revolve around the *interactions* and *engagement* between actors (scholarly or not) with objects (usually scholarly-related) and/or with other actors (scholarly or not). Thus, the definition of *social media metrics* proposed by Haustein et al. (2016) seems to be more convenient (i.e., in terms of accuracy and inclusiveness of most indicators) over the more popular but more vague term of altmetrics. In this thesis the term *social media metrics* is thus preferred over altmetrics, aligning also with the suggestion by Wouters, et al. (2018)¹².

¹¹ Since its introduction, the term altmetrics has been criticized as a “good idea but a bad term” (Rousseau and Ye, 2013). An important source of criticism is related to the impossibility to come up with a homogenous definition of what altmetrics are. This is particularly important given the multiplicity of sources and metrics that are included under this umbrella term (Haustein, Bowman, & Costas, 2016). Often, are the altmetric data aggregators who determine what constitutes altmetrics. For example, Altmetric.com and Plum Analytics both cover citations from Policy documents as a form of altmetrics, however Policy document citations can be just seen as another form of citations (Wouters, et al., 2018). Hence, a more accurate terminology for altmetrics is demanded in the literature (Haustein, Bowman, & Costas, 2015).

¹² However, in the chapters of this thesis that refer to published work and where the term altmetrics was used, the terminology originally used in the original publication is respected.

1.3. Challenges, limitations, and possibilities of social media metrics for research evaluation

The proliferation of indicators on the various users' interactions with scholarly outputs on social media platforms introduces new conceptual and practical challenges on how to determine their meanings, values, and possibilities for informing research evaluation and research policy. In this section these limitations and challenges are discussed and some of the possibilities that these new indicators can offer are introduced once their limitations are understood and accommodated.

Limitations and challenges

Priem (2014) presented the “*lack of theory, ease of gaming, and possible biases*” as the three main limitations of altmetrics (Priem, 2014). More recently, *heterogeneity* (the diversity of sources and activities and lack of conceptual frameworks for altmetrics), *data quality* (lack of accuracy, consistency, and replicability of altmetric data), and *dependencies* (on object identifiers, like DOIS and the availability of APIs from social media sources) have been highlighted as the *grand challenges* of social media metrics (Haustein, 2016). Building on these previous discussions, in this thesis three major challenges regarding social media metrics are further elaborated: *conceptual challenges*, *technical and data related challenges*, and *use challenges*.

Conceptual challenges are directly related with the lack of theories or frameworks in which social media metrics can be understood and discussed. The main conceptual challenge of social media metrics is to understand what they are actually measuring. Due to their heterogeneity (Haustein, 2016) as they capture many different activities and acts (Haustein, Bowman, & Costas, 2016), it is impossible to develop a common definition for all altmetrics. Therefore, further research is necessary in order to gain a better understanding of the different platforms and related activities associated with altmetrics, and defining what exactly these indicators reflect.

Technical and data-related challenges have to do with the data quality of social media metrics provided by altmetric data aggregators and their dependency on the technical affordances of underlying platforms and on the availability of the document's identifiers. The development and application of social media metrics is dependent on the characteristics and quality of the underlying data. Different altmetric data providers collect, aggregate, or report the same social media metrics differently (Chamberlain, 2013; Jobmann et al., 2014; Zahedi, Fenner, & Costas, 2014). These technical and methodological differences introduce challenges for interpreting the metrics provided, since it is not clear how these technical and methodological choices may affect the meaning of the indicators. Moreover, social media metrics are limited by the technical availabilities of the platforms (for example the API limits imposed by platforms such as Twitter or Facebook) used to collect the data (Haustein, 2016). In comparison with citation indicators, social media metrics are more prone to gaming by users. Most social media

platforms have an open and unsupervised nature. The lack of control in the metrics recorded from the activities of their users increase the possibilities of manipulation and gaming by users (e.g., when the same paper is shared, liked, or tweeted several times by the same user, cf. Robinson-Garcia et al, 2017); or the activities created by bots or cyborgs –(Haustein, Bowman, Holmberg et al., 2016)). Furthermore, the reliance on the availability of document identifiers (such as DOIs, PMID, arXiv id's, etc.) and APIs bias social media metrics towards documents with DOIs or other identifiers (e.g., PMID, arXiv id's, etc.), excluding those without such identifiers.

Use challenges are related with the practical uses that social media metrics can have in real life practices, particularly when using them without considering the context. Examples of contextual elements that are important to consider include aspects such as *who are the users?* (e.g., who are the tweeters, the Mendeley readers, etc.), *what are their motivations?* (e.g., do they tweet a paper to praise it, to criticize it, to mock it?), or *how do they engage with the research objects?* (e.g., is the publication retweeted, is there anything added to say something about the publication? etc.) (Haustein, Peters, Sugimoto, Thelwall, & Larivière, 2014; Robinson-Garcia, Costas, Isett, Melkers, & Hicks, 2017). For instance, tweets to academic papers may originate from automated accounts or bots (Haustein, Bowman, Holmberg et al., 2016). Also tweeters' motivations for tweeting about science may range from serious discussions, humorous interactions, or mere self-promoting mentions of publications (Haustein, Bowman, Holmberg et al., 2016). It has also been discussed that most tweets about research are actually very superficial or repetitive (Robinson-Garcia et al., 2017), or with a low engagement of the tweeters with the publications, with the majority of tweets just briefly summarizing the title of the papers (Thelwall, Tsou, Weingart, Holmberg, & Haustein, 2013; Haustein, 2018).

All of the challenges above call into question the value and validity of social media metrics for research evaluation purposes. Actually, most current social media metrics are not yet used in any formal research assessment (Moed, 2017; Wouters et al., 2015; Wouters et al., 2018; European Commission, 2017; Thelwall & Kousha, 2015b). Nevertheless, these limitations and challenges make it necessary to deeply understand them before considering the applications of social media metrics in any context. A proper understanding of the nature and characteristics of these social media metrics, particularly regarding their value for scientific communication, may still open the chance for their careful inclusion in specific new evaluation contexts, as argued in Wouters et al (2018).

1.4. Possibilities of social media metrics

Despite the challenges discussed above, social media play an important role in communication. Their value for communication and interaction with different communities of users should not be ignored.

The possibility of social media metrics for tracking interactions between social media users and scholarly entities opens four main venues of application of social media metrics with possibilities to inform research evaluation:

- *Social media metrics as indicators of presence and reception of research* (Costas, Van Honk, Calero-Medina, & Zahedi, 2017),
- *Social media metrics as indicators of thematic interest, and local or global reach* (Costas, Van Honk, Calero-Medina, & Zahedi, 2017; Haustein, Bowman, & Costas, 2015),
- *Social media metrics as a form of capturing societal impact* (Bornmann, 2012), and
- *Social media metrics as an early predictor of future citation impact* (Thelwall & Nevill, 2018).

These possibilities are discussed in depth in the following sections.

Social media metrics as indicators of presence and reception of research.

Identifying the coverage of publications mentioned on social media platforms and average number of social media mentions per publications are examples of basic indicators that inform the *presence* and reception of research across different social media sources (Costas et al., 2017). These descriptive indicators allow to compare the research produced by different units of analysis (universities, institutions, research groups, or countries). This type of information could inform research managers about the visibility of research of their units across different social media platforms.

Social media metrics as indicators of thematic interest, and local or global reach.

Social media metrics can help to unveil *communities of attention* around scholarly documents and scientific topics (Haustein et al., 2015), and to track the local or global reach of scholarly documents and topics across different audiences (Costas et al., 2017). The analysis of the thematic orientation and topics of interest of social media users can depict academic and public interests in science as well as their reception across different geographical locations (Wouters et al., 2018; Zahedi & Costas, 2017). These possibilities enable the characterization of social media users and their use of scholarly content, as well as the identification of typologies of users based on their social media behaviour (Haustein et al., 2015). These type of analyses can inform research managers of hot topics and trends discussed in social media platforms as well as specific groups of users that are interacting with their research (Costas, van Honk, Clara-Medina, & Zahedi, 2017; Wang, Fang, Li, & Guo, 2016).

Social media metrics as a form of capturing societal relevance or impact.

The demand for demonstrating the societal relevance of research or contribution of research to society is quite central in several national research evaluation frameworks (e.g., the UK Research Excellence Framework or the Dutch Standard Evaluation Protocol), as well as for

several funding bodies (Wilsdon et al., 2015). There is no consensus in the literature on the definition of societal relevance or societal impact of research (Bornmann, 2012). *Societal relevance* is defined by Meijer (2012) as the “*result of analyzing and measuring productive interactions of scientific research with the non-scientific stakeholder which are professionals, public, private, and scientists groups that could bring social, cultural, economic, and scientific returns based on (as a result of) their interactions with research groups*”. Based on this definition, a general framework for scientific and societal (socio-economic) relevance has been proposed (Meijer, 2012). This framework puts an emphasis on the knowledge exchange between research and its related professional, public, and economic contexts and how it connects research to societal issues with health and education sectors and lay public. In the context of REF (2014), societal impact of research is defined as “*where the effect or influence [of research] reaches beyond scholarly research, e.g., on education, society, culture or the economy. Research has a societal impact when auditable or recorded influence is achieved upon non-academic organization(s) or actor(s) in a sector outside the university sector itself – for instance, by being used by one or more business corporations, government bodies, civil society organizations, media or specialist/professional media organizations or in public debate*” (Wilsdon et al., 2015).

The relevance of social media metrics for the measurement of the societal impact or social reach of research lies in its promise to reflect broad impact of research beyond scientific impact (Priem, 2010). This is usually related to the idea that “*bibliometric indicators do not provide any insights on the social or economic impact of research and are, thus, limited to assessing the impact of research within the scientific community*” as emphasized by Haustein & Larivière (2015). Aligning with this idea, tracking the use of research by different academic or non-academic users (public, practitioners, professionals, etc.) on social media platforms could reflect the relevance of research for these users. For instance, it is suggested that tweets to papers (Bornmann, 2014) or citations of papers in policy documents¹³ as indicators of the value of research for society or for policy making could reflect ‘societal impact’ of research (Bornmann, Haunschild, & Marx, 2016). However, tweets to papers have not yet provided any evidence of societal reach of research as the papers were discussed mainly by scholars than users from the general public (Tsou, Bowman, Ghazinejad, & Sugimoto, 2015). Alternatively, it has been suggested that some other approaches such as using semantics and natural language analysis can track the spread of scientific ideas in society (Taylor, 2013). Also, mapping the context of social interactions and communication patterns of researchers in Twitter could better reflect the orientation of researchers towards academia or other stakeholders (Ràfols, van Leeuwen, & Robinson-García, 2017) than just considering mentions of papers on Twitter. Nevertheless, due to the lack of agreement of what is exactly considered as societal impact of research and how to exactly measure it, it has been argued that social media metrics have not yet shown any evidence of the societal impact of research (Alperin & Reilly, 2017).

¹³ Since policy mention are not obtained from social media platforms, these measures are actually no social media metrics (Haustein, et al., 2016; Wouters, Zahedi, & Costas, 2018)

Social media metrics as an early impact indicator or predictor of future citation impact.

Identifying early or predicting future impacts is an important element that could support research evaluation decisions. The delay between publication dates and citations undermines the use of citations for the analysis of recent publications. Exploring whether social media indicators could reflect early or future citation impacts of publications has been subject of some studies (Eysenbach, 2011; Shuai, Pepe, & Bollen, 2012; Thelwall & Nevill, 2018; Thelwall, 2018). The correlations between citations and social media metrics differ by type of metrics. For instance, the recommendations received by publications from the F1000 post-publication peer-review platform have a weak correlation with citations received by these publications (Bornmann & Leydesdorff, 2013). The low coverage of Web of Science publications in F1000 (Waltman & Costas, 2014) made the F1000 recommendations less relevant for prediction of citations. Tweets to papers in online medical journals (Eysenbach, 2011) and arXiv preprint downloads in physics (Brady, Harnad, and Carr, 2006) correlate moderately with later citations. Blogged articles published in PloS journals tend to receive more citations than non-blogged articles (Shema, Bar-Ilan, & Thelwall, 2014). Finally, the number of Mendeley readers has the strongest correlation with citations of all social media metrics (Costas, Zahedi, & Wouters, 2015). Mendeley has been suggested to provide evidence of early impact of publications. Scopus publications in the field of Library and Information Science received more Mendeley readers than citations in the first months of their online publications (Maflahi & Thelwall, 2016). Mendeley has also been discussed as a useful tool to indicate early evidence of scholarly impact (Thelwall, 2017b).

1.5. Social media metrics data sources

Social media metrics data sources vary based on their scholarly orientation (Mendeley readership, F1000 recommendations, or Wikipedia citations), social media orientation (tweets or Facebook counts), or combination of both (RG score from ResearchGate or counts of publications, citations, downloads, views from Academia.edu) (Wouters et al., 2018). Some of these tools provide open APIs (e.g., Mendeley, Facebook, Twitter) to retrieve the metrics, while others (e.g., Research Gate, Academia.edu) do not.

Of these data sources, *Mendeley* (<http://www.mendeley.com>) deserves special attention. It is a free online reference manager and academic social network tool founded in 2007 and acquired by Elsevier in 2013. Over 6 million users worldwide use this platform¹⁴. *Readership counts* provided by Mendeley include the total number of users who have saved (added) a document to their private libraries. Besides, Mendeley offers some statistics on the academic status (students, professors, researchers, librarians, professionals, etc.), discipline and country of the users, as well as tags assigned to the saved publications by them¹⁵. Readership data in Mendeley can be obtained via an open API¹⁶ and hence large scale data collection from this platform is feasible. The existence of both social and scholarly related features (e.g., saving

¹⁴ <https://www.mendeley.com/research-network/community>

¹⁵ <https://www.mendeley.com/reference-management/stats>

¹⁶ <http://dev.mendeley.com/methods/>

papers, highlighting text, writing notes, sharing or recommending papers, joining relevant groups for scholarly discussions and communications, discovering what others are reading, etc.) (Gunn, 2013) makes Mendeley an important source of both scholarly and social media data. Moreover, its higher coverage of publications than any other social media platforms (Haustein et al., 2013; Thelwall, 2017), its popularity among academic and non-academic users (Haustein & Larivière, 2014; Mohammadi, Thelwall, Haustein, & Larivière, 2015; Zahedi, Costas, & Wouters, 2013), and the moderate correlation of Mendeley readership with citations (Sugimoto et al., 2017) present Mendeley as the most relevant and promising source of social media metrics that is worth to further explore. For these reasons, Mendeley readership is specifically studied in several chapters of this thesis.

1.6. Aim of this PhD thesis

The main aim of this PhD thesis is to explore the possibilities of social media metrics to inform research evaluation. As mentioned in the introductory section, this work aims to contribute to the state of the art in social media metrics research by providing novel insights into how scholarly objects are covered across multiple social media platforms, the characteristics of the covered publications, and how social media metrics are related to traditional metrics. How different scientific disciplines are over or underrepresented in social media platforms is also analyzed. Moreover, critical challenges regarding data quality issues of social media data are thoroughly described and discussed. The final purpose of this PhD thesis is to depict the actual possibilities of social media metrics (particularly Mendeley readership metrics as explained in section 1.5) in order to establish their potential uses for informing research evaluation.

1.7. Main research questions and structure of the thesis

The main question that this thesis addresses is *what is the potential usefulness and added value of social media metrics to inform research evaluation?*.

This thesis describes the presence and distribution of different social media metrics across scientific publications and their relationship with traditional impact indicators. It compares main altmetric data aggregators in terms of data quality of the social media metrics data provided by them. This thesis further studies the main characteristics of publications mentioned in Mendeley as one of the main social media metrics platforms. Finally, some possibilities and applications of social media metrics (readership metric) are studied. All the specific research questions presented together provide answers for the main research question of this thesis.

Q1: What aspect of research impact do social media metrics reflect? In particular, how do social media metrics relate to the more traditional bibliometric indicators?

The answer to this first question is crucial for understanding what social media metrics are and whether and how these metrics relate to citation impact indicators. Chapter 2 provides a general overview of the presence and coverage of publications presented in social media

platforms and the distribution of social media metrics across fields, publication years, and document types. This chapter gives some important insights into the extent to which scientific publications are presented across social media platforms, the amount of social media attention received by them, and disciplinary differences in their reception of social media metrics. This chapter also describes the relationship between social media metrics and citation indicators. Correlation and factor analysis are used in this chapter in order to study the underlying dimensions of these indicators and their relationship with citation indicators.

Q2: What are the most important challenges regarding data quality in the social media metrics offered by different altmetric data aggregators?

The second question of this PhD thesis deals with exploring the data quality of social media metrics provided by different altmetrics aggregators. Understanding the underlying reasons of the existing differences in the metrics across altmetrics aggregators is central for the proper development of applications of social media metrics based on these data. Chapter 3 provides a thorough analysis of the most important data quality challenges and issues regarding social media data provided by the major altmetric data aggregators. This chapter presents how the data collection and reporting approaches of these altmetric data aggregators both technically and conceptually influence the metrics provided. The results of this chapter help in gaining an understanding of how the methodological choices in the tracking, collecting, and reporting of altmetric data influence the reported metrics and their analytical possibilities. Important recommendations for the users of social media metrics and data aggregators are proposed and discussed.

Q3: What are the main characteristics of publications saved and read on Mendeley?

This third question (discussed in Chapter 4) expects to understand the relationship of different document characteristics that relationship Mendeley readership (as one of the most prominent social media metric) and how the relationship between these different bibliographic characteristics and readership is (di)similar to that observed for citations. Chapter 4 describes the disciplinary differences in the relationship between Mendeley readership and citation counts with particular documents' bibliographic characteristics across a dataset of 1.3 million publications from the Web of Science. The association between Mendeley readership, citation counts, and document characteristics (i.e., document types, number of pages, length of titles, length of reference lists, number of authors, institutes and countries) has been investigated using Ordinary Least Square (OLS) regression analysis. As the OLS model takes into account very high values which are typical for skewed distributions, it is considered as the most suitable regression strategy for altmetrics data (Thelwall & Wilson, 2014; Thelwall, 2016). The chapter contributes to the identification of document-related differences between Mendeley readership and citations. This information is useful for the future construction of appropriate and meaningful indicators based on Mendeley readership.

Q4: What are the practical analytical possibilities of Mendeley readership metrics?

The fourth research question of this thesis deals with understanding analytical possibilities of readership metrics for evaluation perspective. This is particularly crucial for any practical application of this type of indicator. Chapters 5 and 6 discuss analytical possibilities of Mendeley readership metrics by focusing on two main sub-questions:

Q4.1: Do Mendeley readership metrics offer any advantage over journal-based indicators in identifying highly cited publications?

Chapter 5 presents the results of a large-scale analysis of the distribution and presence of Mendeley readership scores over time and across disciplines across 9.1 million publications from Web of Science from the years 2004-2013. Using precision-recall analysis the chapter studies whether Mendeley readership scores can identify highly cited publications more effectively than journal citation scores.

Q4.2: What are the topics of interest of different Mendeley users and how do their use of scholarly documents reflect different types of impact of research?

Chapter 6 focuses on the different user groups in Mendeley and their thematic orientations. A dataset of 1.1 million Web of Science publications from the year 2012 are analyzed. The disciplinary differences in the reading (saving) patterns of different Mendeley user groups are depicted using VOSviewer maps. Topics of interest of different user groups in Mendeley are analyzed in order to identify the topics focused by different communities of users. The results provide important evidence on the use of scientific publications by user groups (particularly non-publishing ones, such as students or librarians). The results of this chapter support the possibility of using users-based readership to inform different types of impact (scientific, educational, and professional) of scientific publications.

Finally, chapter 7 includes the **discussion and conclusions** of the main results of this PhD thesis. It presents the summary of findings and the implications of the results for using them in research evaluation, together with perspectives for further research.

1.8. References

- Adie, E., & Roe, W. (2013). Altmetric: enriching scholarly content with article-level discussion and metrics. *Learned Publishing*, 26(1), 11–17.
- Alperin, J. P. (2013). Ask not what altmetrics can do for you, but what altmetrics can do for developing countries. *Bulletin of the American Society for Information Science and Technology*, 39(4), 18–21. <http://doi.org/10.1002/bult.2013.1720390407>
- Alperin, J. P., & Reilly, K. (2017). From opportune indicators to narratives: conceptualizing altmetrics for social impact. In *4: AM conference*, 24-26 Septemeber 2017, Toronto, Canada.
- Batrinca, B., & Treleaven, P. C. (2015). Social media analytics: a survey of techniques, tools and platforms. *AI & SOCIETY*, 30(1), 89–116. <http://doi.org/10.1007/s00146-014-0549-4>
- Bolton, R. N., Parasuraman, A., Hoefnagels, A., Migchels, N., Kabadayi, S., Gruber, T., ... Solnet, D. (2013). Understanding Generation Y and their use of social media: a review and research agenda. *Journal of Service Management*, 24(3), 245–267. <http://doi.org/10.1108/09564231311326987>
- Bornmann, L. (2012). Measuring the societal impact of research. *EMBO Reports*, 13(8), 673–676. <http://doi.org/10.1038/embor.2012.99>
- 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. <http://doi.org/10.1016/j.joi.2014.09.007>
- Bornmann, L., Haunschild, R., & Marx, W. (2016). Policy documents as sources for measuring societal impact: how often is climate change research mentioned in policy-related documents? *Scientometrics*, 109(3), 1477–1495. <http://doi.org/10.1007/s11192-016-2115-y>
- Bornmann, L., & Leydesdorff, L. (2013). The validation of (advanced) bibliometric indicators through peer assessments: A comparative study using data from InCites and F1000. *Journal of Informetrics*, 7(2), 286–291. <http://doi.org/10.1016/j.joi.2012.12.003>
- Bowman, T. D. (2015). Investigating the Use of Affordances and Framing Techniques By Scholars To Manage Personal and Professional Impressions on Twitter, (July), 256. Dissertation, Indiana University, Bloomington, IN, USA.
- Buschman, M., & Michalek, A. (2013). Are alternative metrics still alternative? *Bulletin of the American Society for Information Science and Technology*, 39(4), 35–39. <http://doi.org/10.1002/bult.2013.1720390411>
- Chakraborty, N. (2012). Activities and reasons for using social networking sites by research scholars in NEHU: A study on Facebook and ResearchGate. *Planner-2012*, 19–27.
- Chamberlain, S. (2013). Consuming Article-Level Metrics: Observations and Lessons, 2(2).
- Costas, R. (2017). Towards the social media studies of science: social media metrics, present and future. *Bibliotecas. Anales de Investigación*, 13(1), 1–5.
- Costas, R., & Franssen, T. (2018). On the cautionary use of the h-index and the proliferation of individual-level bibliometric sources: response to Teixeira da Silva & Dobróński. *Scientometrics*, 115(2):1125-1130. <http://doi.org/10.1007/s11192-018-268>

- Costas, R., Van Honk, J., Calero-Medina, C., & Zahedi, Z. (2017). Discussing practical applications for altmetrics: development of “social media profiles” for African, European and North American publications. In *22nd International Conference in Science & Technology Indicators (STI)*, 6-8 September, 2017, Paris, France.
- Costas, R., van Honk, J., & Franssen, T. (2017). Identifying scholars on Twitter: opening the path to the social media studies of science. In *4 AM Conference*, Toronto, Canada.
- Costas, R., Zahedi, Z., & Wouters, P. (2015). 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*, 66(10), 2003–2019. <http://doi.org/10.1002/asi.23309>
- Cronin, B. (2014). Scholars and Scripts, Spoors and Scores. In B. Cronin & C. R. Sugimoto (Eds.), *Beyond bibliometrics: harnessing multidimensional indicators of performance* (pp. 3–21). Cambridge, MA: MIT Press.
- Eysenbach, G. (2011). Can Tweets Predict Citations? Metrics of Social Impact Based on Twitter and Correlation with Traditional Metrics of Scientific Impact. *Journal of Medical Internet Research*, 13(4), e123. <http://doi.org/10.2196/jmir.2012>
- Fenner, M. (2013). What Can Article-Level Metrics Do for You? *PLoS Biology*, 11(10), e1001687. <http://doi.org/10.1371/journal.pbio.1001687>
- Fraumann, G. (2017). *Valuation of altmetrics in research funding*. University of Tampere. Retrieved from <http://tampub.uta.fi/handle/10024/101653>
- Friesike, S., & Schildhauer, T. (2015). Open science: many good resolutions, very few incentives, yet. In I. M. Welp, J. Wollersheim, S. Ringelhan, & M. Osterloh (Eds.), *Incentives and Performance. Givernance of Research Organizations*. Springer.
- Gruzd, A., & Goertzen, M. (2013). Wired academia: Why social science scholars are using social media. *Proceedings of the Annual Hawaii International Conference on System Sciences*, 3332–3341. <http://doi.org/10.1109/HICSS.2013.614>
- Gruzd, A., Staves, K., & Wilk, A. (2012). Connected scholars: Examining the role of social media in research practices of faculty using the UTAUT model. *Computers in Human Behavior*, 28(6), 2340–2350. <http://doi.org/10.1016/j.chb.2012.07.004>
- Gunn, W. (2013). Social Signals Reflect Academic Impact: What it Means When a Scholar Adds a Paper to Mendeley. *Information Standards Quarterly*, 25(2), 33. <http://doi.org/10.3789/isqv25no2.2013.06>
- Hadgu, A. T., & Jäschke, R. (2014). Identifying and analyzing researchers on twitter. *CEUR Workshop Proceedings*, 1226, 164–165. <http://doi.org/10.1145/2615569.2615676>
- Hank, C., Sugimoto, C. R., Tsou, A., & Pomerantz, J. (2014). Faculty and student interactions via Facebook: Policies, preferences, and practices, 56(5), 216–223. <http://doi.org/10.1515/itit-2014-1061>
- Haustein, S. (2016). Grand challenges in altmetrics: heterogeneity, data quality and dependencies. *Scientometrics*, 108(1), 413–423. <http://doi.org/10.1007/s11192-016-1910-9>

- Haustein, Peters, I., Bar-Ilan, J., Priem, J., Shema, H., & Terliesner, J. (2013). Coverage and adoption of altmetrics sources in the bibliometric community. In *Proceedings of the 14th International Society of Scientometrics and Informatics Conference*, 15-19 July 2013, Vienna, Austria.
- Haustein, S., Bowman, T. D., & Costas, R. (2015). Communities of attention around journal papers: who is tweeting about scientific publications? In *Social Media & Society 2015 International Conference* (pp. 4–5), Toronto, Canada.
- Haustein, S., Bowman, T. D., & Costas, R. (2016). Interpreting Altmetrics: Viewing Acts on Social Media through the Lens of Citation and Social Theories. In C. R. Sugimoto (Ed.), *Theories of Informetrics and Scholarly Communication* (pp. 372–406). Berlin, Boston: De Gruyter. <http://doi.org/10.1515/9783110308464-022>
- Haustein, S., Bowman, T. D., Holmberg, K., Tsou, A., Sugimoto, C. R., & Larivière, V. (2016). Tweets as impact indicators: Examining the implications of automated “bot” accounts on Twitter. *Journal of the Association for Information Science and Technology*, 67(1), 232–238. <http://doi.org/10.1002/asi.23456>
- Haustein, S., & Larivière, V. (2014). Mendeley as a source of global readership by students and postdocs? Evaluating article usage by academic status. In *In 35th International Association of Technological University Libraries (IATUL), 2-5 June 2014, Aalto University, Helsinki, Finland. Helsinki* (pp. 1–10). Helsinki, Finland.
- Haustein, S., & Larivière, V. (2015). The Use of Bibliometrics for Assessing Research: Possibilities, Limitations and Adverse Effects. In *Incentives and Performance* (pp. 121–139). Cham: Springer International Publishing. http://doi.org/10.1007/978-3-319-09785-5_8
- Haustein, S., Peters, I., Sugimoto, C. R., Thelwall, M., & Larivière, V. (2014). Tweeting biomedicine: An analysis of tweets and citations in the biomedical literature. *Journal of the Association for Information Science and Technology*, 65(4), 656–669. <http://doi.org/10.1002/asi.23101>
- Holmberg, K. (2017). *Different types of Altmetrics. Policy Support Facility (PSF), Mutual Learning Exercise (MLE) on Open Science: Altmetrics and Rewards, European Commission.*
- Jamali, H. R., Nicholas, D., & Herman, E. (2016). Scholarly reputation in the digital age and the role of emerging platforms and mechanisms. *Research Evaluation*, 25(1), 37–49. <http://doi.org/10.1093/reseval/rvv032>
- Jamali, H. R., Nicholas, D., Watkinson, A., Herman, E., Tenopir, C., Levine, K., ... Nichols, F. (2014). How scholars implement trust in their reading, citing and publishing activities: Geographical differences. *Library and Information Science Research*, 36(3–4), 192–202. <http://doi.org/10.1016/j.lisr.2014.08.002>
- 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(1), 1–19.
- Ke, Q., Ahn, Y., & Sugimoto, C. R. (2016). A Systematic Identification and Analysis of Scientists on Twitter. *PLOS ONE*, 12(4), 1–28. <http://doi.org/10.1371/journal.pone.0175368>
- Maflahi, N., & Thelwall, M. (2016). When are readership counts as useful as citation counts?

- Scopus versus Mendeley for LIS journals. *Journal of the Association for Information Science and Technology*, 67(1), 191–199. <http://doi.org/10.1002/asi.23369>
- McCay-Peet, L., & Quan-Haase, A. (2017). What is social media and what questions can social media research help us answer? In L. Sloan & A. Quan-Haase (Eds.), *The SAGE handbook of social media research methods* (pp. 13–26). Sage Publications Inc.
- Meijer, I. (2012). Societal returns of scientific research How can we measure it ? Societal returns of scientific research. “*New Perspectives on Enduring Research Questions in University-Society Interaction?*”, *INTERACT-UNI EU-SPRI Conference*, (i), 1–13.
- Moed, H. F. (2015). Altmetrics as traces of the computerization of the research process, 8(93), 4–17. Retrieved from <http://arxiv.org/abs/1510.05131>
- Moed, H. F. (2017). *Applied evaluative informetrics*. Springer.
- Mohammadi, E., Thelwall, M., Haustein, S., & Larivière, V. (2015). Who reads research articles? An altmetrics analysis of Mendeley user categories. *Journal of the Association for Information Science and Technology*, 66(9), 1832–1846. <http://doi.org/10.1002/asi.23286>
- National Information Standards Organization. (2016). *Outputs of the NISO Alternative Assessment Metrics Project*. Retrieved from: [http://www.niso.org/apps/group_public/download.php/17091/NISO RP-25-2016 Outputs of the NISO Alternative Assessment Project.pdf](http://www.niso.org/apps/group_public/download.php/17091/NISO%20RP-25-2016%20Outputs%20of%20the%20NISO%20Alternative%20Assessment%20Metrics%20Project.pdf)
- Nicholas, D., Jamali, H. R., Watkinson, A., Herman, E., Tenopir, C., Volentine, R., ... Levine, K. (2015). Do Younger Researchers Assess Trustworthiness Differently when Deciding what to Read and Cite and where to Publish? *International Journal of Knowledge Content Development & Technology*, 5(2), 45–63. <http://doi.org/10.5865/IJKCT.2015.5.2.045>
- Nielsen, M. (2011). Definitions of Open Science? Open Knowledge. Retrieved April 12, 2018, from <http://openscience.org/an-informal-definition-of-openscience/>
- Orduña-Malea, E., Martín-Martín, A., & López-Cózar, E. D. (2016). ResearchGate como fuente de evaluación científica: desvelando sus aplicaciones bibliométricas. *El Profesional de La Información (EPI)*, 25(2), 303–310.
- Piwowar, H. (2013). Altmetrics: Value all research products. *Nature*, 493(7431), 159. <http://doi.org/10.1038/493159a>
- Priem, J. (2010). I like the term #articlelevelmetrics, but it fails to imply *diversity* of measures. Lately, I’m liking #altmetrics. Retrieved from: <https://twitter.com/jasonpriem/status/25844968813>
- Priem, J. (2014). Altmetrics. In B. Cronin & C. R. Sugimoto (Eds.), *Beyond bibliometrics: harnessing multidimensional indicators of performance* (pp. 263–287). Cambridge, MA: MIT Press.
- Priem, J., & Hemminger, B. H. (2010). Scientometrics 2.0: New metrics of scholarly impact on the social Web. *First Monday*, 15(7).
- Priem, J., Piwowar, H. A., & Hemminger, B. M. (2012). Altmetrics in the wild: Using social media to explore scholarly impact. Retrieved from <http://arxiv.org/abs/1203.4745>

- Priem, J., Taraborelli, D., Groth, P., & Neylon, C. (2010). altmetrics : a manifesto. Retrieved from <http://altmetrics.org/manifesto/>
- Puschmann, C., & Mahrt, M. (2012). Scholarly blogging: A new form of publishing or science journalism 2.0? In M. Tokar, S. Beurskens, M. Keuneke, I. Mahrt, C. Peters, C. Puschmann, & T. van Treeck (Eds.), *Science and the Internet* (pp. 171–182). Düsseldorf: Düsseldorf University Press.
- Ràfols, I., van Leeuwen, T. N., & Robinson-García, N. (2017). How to make altmetrics useful in societal impact assessments: shifting from citation to interaction approaches. Retrieved from: <http://blogs.lse.ac.uk/impactofsocialsciences/2017/03/23/how-to-make-altmetrics-useful-in-societal-impact-assessments-shifting-from-citation-to-interaction-approaches/>
- Robinson-Garcia, N., Costas, R., Isett, K., Melkers, J., & Hicks, D. (2017). The unbearable emptiness of tweeting—About journal articles. *PLOS ONE*, 12(8), e0183551. <http://doi.org/10.1371/journal.pone.0183551>
- Rousseau, R., & Ye, F. (2013). A multi-metric approach for research evaluations. *Chinese Science Bulletin*, 58(26), 3288–3290.
- Rowlands, I., Nicholas, D., Russell, B., Canty, N., & Watkinson, A. (2011). Social media use in the research workflow. *Learned Publishing*, 24(3), 183–195. <http://doi.org/10.1087/20110306>
- Shema, H., Bar-Ilan, J., & Thelwall, M. (2012). Research Blogs and the Discussion of Scholarly Information. *PLoS ONE*, 7(5), e35869. <http://doi.org/10.1371/journal.pone.0035869>
- Shema, H., Bar-Ilan, J., & Thelwall, M. (2014). Do blog citations correlate with a higher number of future citations? Research blogs as a potential source for alternative metrics. *Journal of the Association for Information Science and Technology*, 65(5), 1018–1027. <http://doi.org/10.1002/asi.23037>
- Shuai, X., Pepe, A., & Bollen, J. (2012). How the Scientific Community Reacts to Newly Submitted Preprints: Article Downloads, Twitter Mentions, and Citations. *PLoS ONE*, 7(11), e47523. <http://doi.org/10.1371/journal.pone.0047523>
- Sugimoto, C. R., Work, S., Larivière, V., & Haustein, S. (2017). Scholarly use of social media and altmetrics: A review of the literature. *Journal of the Association for Information Science and Technology*, 68(9), 2037–2062. <http://doi.org/10.1002/asi.23833>
- Taraborelli, D. (2008). Soft peer review: Social software and distributed scientific evaluation. In *Proceedings of the 2008 International Conference on the Design of Cooperative Systems*, (pp. 99–110).
- Taylor, M. (2013). The Challenges of Measuring Social Impact Using Altmetrics - Research Trends. *Research Trends*, (33), 1–6. Retrieved from <http://www.researchtrends.com/issue-33-june-2013/the-challenges-of-measuring-social-impact-using-altmetrics/>
- Thelwall, M. (2017). Are Mendeley reader counts useful impact indicators in all fields? *Scientometrics*, 113(3), 1721–1731. <http://doi.org/10.1007/s11192-017-2557-x>

- Thelwall, M. (2018). Does Microsoft Academic find early citations? *Scientometrics*, 114(1), 325–334. <http://doi.org/10.1007/s11192-017-2558-9>
- Thelwall, M., Haustein, S., Larivière, V., & Sugimoto, C. R. (2013). Do Altmetrics Work? Twitter and Ten Other Social Web Services. *PLoS ONE*, 8(5), e64841. <http://doi.org/10.1371/journal.pone.0064841>
- Thelwall, M., & Kousha, K. (2014). Academia.edu: Social network or Academic Network? *Journal of the Association for Information Science and Technology*, 65(4), 721–731. <http://doi.org/10.1002/asi.23038>
- Thelwall, M., & Kousha, K. (2015a). ResearchGate: Disseminating, communicating, and measuring Scholarship? *Journal of the Association for Information Science and Technology*, 66(5), 876–889. <http://doi.org/10.1002/asi.23236>
- Thelwall, M., & Kousha, K. (2015b). Web indicators for research evaluation. Part 2: Social media metrics. *El Profesional de La Información*, 24(5), 607. <http://doi.org/10.3145/epi.2015.sep.09>
- Thelwall, M., & Kousha, K. (2017). ResearchGate versus Google Scholar: Which finds more early citations? *Scientometrics*. <http://doi.org/10.1007/s11192-017-2400-4>
- Thelwall, M., & Nevill, T. (2018). Could scientists use Altmetric.com scores to predict longer term citation counts? *Journal of Informetrics*, 12(1), 237–248. <http://doi.org/10.1016/j.joi.2018.01.008>
- Thelwall, M., Tsou, A., Weingart, S., Holmberg, K., & Haustein, S. (2013). Tweeting Links to Academic Articles. *Cybermetrics: International Journal of Scientometrics, Informetrics and Bibliometrics*, 1-8.
- Tsou, A., Bowman, T. D., Ghazinejad, A., & Sugimoto, C. R. (2015). Who tweets about science? In *Proceedings of the 2015 International Society for Scientometrics and Informetrics* (pp. 95–100). Istanbul, Turkey.
- Tsou, A., Bowman, T. D., Sugimoto, T., Larivière, V., & Sugimoto, C. R. (2016). Self-presentation in scholarly profiles: Characteristics of images and perceptions of professionalism and attractiveness on academic social networking site.... *First Monday*, 21(4), 1–30.
- Van Leeuwen, T. N., Visser, M. S., Moed, H. F., Nederhof, T. J., & Van Raan, A. F. J. (2003). The Holy Grail of science policy: exploring and combining bibliometrics in search of scientific excellence. *Scientometrics*, 57(2), 257–280. <http://doi.org/10.1023/A:1024141819302>
- Van Noorden, R. (2014). Online collaboration: Scientists and the social network. *Nature*, 512(7513), 126–129. <http://doi.org/10.1038/512126a>
- Waltman, L., & Costas, R. (2014). F1000 Recommendations as a Potential New Data Source for Research Evaluation: A Comparison With Citations. *Journal of the Association for Information Science and Technology*, 65(3), 433–445. <http://doi.org/10.1002/asi>
- Wang, X., Fang, Z., Li, Q., & Guo, X. (2016). The Poor Altmetric Performance of Publications Authored by Researchers in Mainland China. *Frontiers in Research Metrics and Analytics*, 1(October), 1–8. <http://doi.org/10.3389/frma.2016.00008>
- Wass, J. (2017). Crossref Event Data: A new, open, underlying data set for altmetrics. In *The 2017 Altmetrics Workshop: the Dependencies of Altmetrics*, 26 September 2017, Toronto,

Canada.

- Wilsdon, J., Allen, L., Belfiore, E., Campbell, P., Curry, S., Hill, S., ... Hill, J. (2015). *The Metric Tide: Report of the Independent Review of the Role of Metrics in Research Assessment and Management*. <http://doi.org/10.13140/RG.2.1.4929.1363>
- Wilsdon, J. R., & Al., E. (2017). *Next-generation metrics : Responsible metrics and evaluation for open*. Brussels. Retrieved from <http://doi.org/10.2777/337729>
- Wouters, P. (2014). A key challenge: the evaluation gap. *The Citation Culture, 2012–2014*. Retrieved from <https://citationculture.wordpress.com/2014/08/28/a-key-challenge-the-evaluation-gap/>
- Wouters, P., & Costas, R. (2012). Users , narcissism and control – tracking the impact of scholarly publications in the 21 st century. Utrecht: SURFfoundation. Retrieved from [http://www.surf.nl/nl/publicaties/Documents/Users narcissism and control.pdf](http://www.surf.nl/nl/publicaties/Documents/Users%20narcissism%20and%20control.pdf)
- Wouters, P., Thelwall, M., Kousha, K., Waltman, L., De Rijcke, S., Rushforth, A., & Franssen, T. (2015). The Metric Tide: Literature Review (Supplementary Report I to the Independent Review of the Role of Metrics in Research Assessment and Management). *Hefce*, 188. <http://doi.org/10.13140/RG.2.1.5066.3520>
- Wouters, P., Zahedi, Z., & Costas, R. (2018). Social media metrics for new research evaluation. In W. Glänzel, H. F. Moed, U. Schmoch, & M. Thelwall (Eds.), *Handbook of Quantitative Science and Technology Research*. Springer.
- Zahedi, Z., & Costas, R. (2017). How visible are the research of different countries on WoS and twitter? An analysis of global vs. local reach of WoS publications on Twitter. In *Proceedings of the 16th of International Conference on Scientometrics and Informetrics*, Wuhan, China.
- Zahedi, Z., Costas, R., & Wouters, P. (2013). What is the impact of the publications read by the different Mendeley users? Could they help to identify alternative types of impact? . In *PLOS ALM Workshop, 7-9 October, 2013, San Francisco, US*. Retrieved from <https://openaccess.leidenuniv.nl/handle/1887/23579>
- Zahedi, Z., Fenner, M., & Costas, R. (2014). How consistent are altmetrics providers ? Study of 1000 PLOS ONE publications using the PLOS ALM , Mendeley and Altmetric . com APIs. In *altmetrics14: expanding impacts and metrics An ACM Web Science Conference 2014 Altmetrics Workshop, 23-26 June, Indiana University, Indiana, USA*. (pp. 5–6). Indiana: Figshare. Retrieved from <http://dx.doi.org/10.6084/m9.figshare.1041821>