Altmetrics: complexities, challenges and new forms of measuring and comprehending scientific communication in the social[i]

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R E V I E W

Abstract

Objective. It aims to discuss some aspects of altmetria, an area commonly associated with metrics such as bibliometrics, scientometrics and webometrics, but with important differences in order to contribute to its own understanding, institutionalization and consolidation.

Method. The article is a theoretical approach on the subject altmetria, being elaborated from a set of texts selected in international databases. The selected bibliography subsidized critical and reflexive analyzes on the subject.

Results. The text brought reflections on the altmetria and its theoretical foundation, seeking to discuss the definition of the area, its relation with other metric studies of information and the complexities and challenges related to the production and use of altmetric indicators.

Conclusions. The area has great potential, but it needs more reflection, in-depth analysis and discussion about its theoretical foundations. There are uncertainties related to the institutionalization of the area and controversies about the possibilities of the indicators to measure the "impact" of academic production.

Keywords
Altmetrics; Bibliometrics; Scientific Communication; Scientific Indicators; Scientometrics; Social Web

Altmetria: complejidades, desafíos y nuevas formas de medición y comprensión de la comunicación científica en la web social

Resumen

Objectivo. Tiene como objetivo debatir algunos aspectos de la altmetria, área comumente asociada a las métricas como la bibliometria, cientometria y webometria, pero con importantes diferencias, con el propósito de contribuir a su comprensión, institucionalização y consolidación.

Método. El artículo tiene un abordaje teórico sobre la temática de altmetria, siendo elaborado a partir de un conjunto de textos seleccionados en bases de datos internacionales. La bibliografía seleccionada contribuyó a análisis críticos y reflexivos sobre el tema.

Resultados. El texto trajo reflexiones sobre la altmetria y su fundamentación teórica, buscándose discutir la definición del área, su relación con otros estudios métricos de la información y las complejidades y desafíos inherentes a la producción y uso de indicadores altmétricos.

Conclusiones. El área posee gran potencial, pero carece de más reflexión, análisis profundizados y discusión sobre sus fundamentos. Existen incertidumbres relacionadas a la institucionalización del área y controversias sobre las posibilidades de los indicadores para medir el "impacto" de la producción académica.

Palabras clave
Altmetria; Bibliometria; Cientometria; Comunicación científica; Indicadores científicos; Web social

1 Introduction

The interest in mediating, monitoring and assessing scientific and technological activities by means of indicators generated from products, especially publications, arises in the 20th century, with the prominence of researchers such as Lotka, Zifp, Bradford, Nalimov, Solla, Price, and Eugene Garfield, who brought the first contributions for the construction of the areas of Bibliometrics and Scientometrics. In the 1960s, the development of these areas grew and got strongly institutionalized, largely due to the interest in using their methods, theories and principles to manage academic and scientific activity, in a setting lacking resources, in addition to needing to measure the efficacy and efficiency of the investments made among different projects, institutions and research groups.

A relevant historical mark in the development of bibliometric and scientometric indicators was the use of the analysis of citations to assess and monitor scientific research. The analysis of citations is closely related to the concept of Impact Factor (IF), a methodology proposed by Eugene Garfield in 1955, aiming to qualify scientific journals, using an index calculated from the average number of citations from papers published during the previous two years. The rise of informatics, the popularization of the Internet, the digitalizing of scientific production and the implementation of databases made it possible to generate and analyze more comprehensive and complex indicators, involving different dimensions, in an ever-growing speed. In this context, the *Web of Science* database (WOS) and *Science Citation Index* (SCI) arose, which were, for decades, practically the only tools available to produce scientific indicators.

Throughout time, other agents arrived to the ambient, broadening the alternatives for generating and analyzing science and technology indicators. Some examples are the creation of the Scopus database and SciELO, which also start offering indices and indicators based on citation, with a methodology similar to the one proposed by Eugene Garfield. Since the beginning of the use of citation analysis to monitor and assess scientific production, many criticisms were made to aspects such as methodology, tools, and differences among the areas, the quality of the data, the very concept of citation, as well as limitations to comprehend and measure the phenomenon and biases concerning the assessment of science developed in peripheral countries. It is important to mention the social and political sense of this type of measuring never reached a consensus in the academic community, bringing about distortions and inequalities that, to this day, become problems when analyzing policies of resource distributions, ranking of researchers, among others.

Traditionally, academic research and its "impact" have been measured and assessed by means of a gamma of different metrics based on citation, applied to researchers, journals, universities, countries, and so on. One of the most recently developed metrics, based in a mixture of citation and productivity of a researcher, is *h-index*. Notably, there are limitations to any type of indicator used to represent a reality and those based on citation are among the most criticized.

Bibliometrics and Scientometrics suffer constant changes due to the nonstop evolutions of information and communication technologies. New indicators, tools, methodologies, theories, and concepts arise, to the point that, currently, there is a great deal of difficulty in outlining metrics based on information with precision. There are attempts to categorize and group them, with limited success, using umbrella terms, such as Informetrics and metric information studies. With the developments achieved in the area, associated with the emergence of new information technologies such as the World Wide Web (WWW), new areas such as Cybermetrics, Webometrics, and countless variants with different levels of proximity appear. The development of these metrics and methodologies have been justified, in great part, by limitations inherent to bibliometric and scientometric methods, especially those based on citations. Furthermore, new social relations mediated by information appear in this networking context, allowing new digital objects to become available with potential relevance indicators, such as links among webpages, retrieving the idea of citation, yet now in a different sociotechnical context.

Certain arguments may give the impression there is an attempt to minimize the developments achieved by "traditional" or consolidated metrics[ii]. There seems to be an unthinking defense and a discourse of superiority of the new indicators becoming viable with the developments in information and communication technologies. Although one must acknowledge the qualities (and limitations) of the indicators used until then, one must also admit those based on citation, by themselves, do not capture the complete specter of the "impact" of a scientific research and complementing methodologies should be considered. Facing this assumption, a new emerging area is Altmetrics.

Even if Altmetrics are commonly associated to metrics such as Bibliometrics, Scientometrics, and Webometrics, this new metric features important differences when compared to the previous ones. It appears in a context in

which the WWW starts to be called *web 2.0* or *social web*. With the development of technologies for information and communication and for the web, new ways to produce, modify, adapt, collaborate, and disseminate knowledge started to take place. New sources of information appeared, as well as formats that did not exist until then. The possibilities of actions and reactions for social actors are wide, broadening the potential for sociability in a network so far unexplored to this level; nevertheless, they should be considered carefully and with scientific rigor when inaugurating new metrics and modes of information analysis. Thus, one can see a wide range of completely new indicators when compared to dominant information metrics based on citation.

These new metrics based on social networks and media, commonly denominated Altmetrics, or social web metrics, were introduced in 2010 by Priem and his colleagues as an alternative means to measure the impacts on social web investigation more widely, using different tools (Priem, Piwowar, & Hemminger, 2012). **However, Altmetrics comprehend the socialization of various results from scientific researches, registered in different sources, by diverse social actors, in the most varied social networks and media, means of communication, and tools for managing references.** Facing the complexity of this context, we agree with Zahedi, Costas and Wouters (2014) when they state the study of Altmetrics is just beginning, as there are more doubts than certainties about this new area as it starts to appear. It is important to highlight in this initial definition that the socialization covered by the experiences of Altmetrics does not widen only in terms of information sources, but also in terms of types of production of social connections, such as the rise of new forms of socialization around digital objects such as "likes", sharing with peers and voting.

The objects and phenomena we intend to measure in this new area denominated Altmetrics are still little known and explored. The complexity of measuring and interpreting the publics and their actions and interactions, tools, data sources and, hence, the altmetric indicators produced, are still a challenge and lack theoretic, conceptual and methodological developments. A search with the term altmetric run in the *Web of Science* (WOS) database on January 21st 2016 brought the total of only 63 scientific papers published, demonstrating the immaturity of the area and, consequently, the reflections on this theme in a global ambit.

Altmetric indicators possess a great potential and lack further reflection and deeper analyses. Various studies based on Altmetrics are being developed from an empiric perspective, with a low level of reflection on its fundaments. A great number of published papers until now study, mainly, correlations between citations of scientific papers and altmetric indicators, but little theoretic knowledge is retrieved from their results. One can understand the research is still in its exploratory stage, seeking to define relations of relevance to provide conditions to induce theoretical perspectives and more comprehensive generalizations. Thus, there are still a number of issues that should be resolved before indicators are used to assess scientific research and make decisions. As there is no interest in replacing "traditional" Bibliometrics by Altmetrics, researches should not focus on the connection, but on specific differences between those two metrics. To what rate can Altmetrics, opposing "traditional" metrics, assess the broader "impact" of research? (Bornmann, 2014) What "impact" is being measured? What socialization phenomena should be prioritized when considering the assessment of scientific impact? What digital objects can and should be measured? These are only a few of the questions to be answered.

As it is an emerging area, inserted in the dynamicity and speed of the WWW and its technologies, uncertainties and difficulties can be identified and deserve to be investigated and debated. Some of these complexities are the mixture of actors and publics (scientists, academics, professionals and people not connected to academia); a very wide range of possibilities of actions and interactions from these actors and publics; volume and volatility of information; variety of information sources; peculiarities of each one of the tools to produce indicators; credibility and reliability of the generation processes; among others. The main current Altmetric tools are known.[iii] Despite being known, there is no clarity regarding what each of them factually measures, their differences and similarities. Facing the quantity of tools, their applications and particularities, comparisons, information sources used, index construction methodologies, advantages and disadvantages deserve a separate research, not being the central objective of this paper.

More subjective questions should not be forgotten. As Taylor (2013a) reminds us, little is the knowledge on users' intentions, motives and experiences. These aspects should be studied to exhaustion before the resulting indicators are used as subsidy for decisions and assessments of scientific productions and the agents involved in the researches. If one really wishes these indicators to surpass mere experimentations and academic studies, and to be employed to assess academic activity, it is necessary to resolve theoretical issues (of meaning and

conceptualization), as well as methodological (validity of the sources) and technical (normalization) ones (Torres-Salinas, Cabezas-Clavijo, & Jiménezes-Contreras, 2013).

We note there is still little debate, among other aspects, concerning the meanings "citation" and "impact"[iv] in scientific and social ambits and, consequently, uncertainties regarding what one is measuring and the meaning of the produced indicators. Further adjustments are still in need when it comes to definitions and relations with Bibliometrics, Scientometrics, Webometrics, among other metrics. There are attempts of invalidation of the indicators based on citation, such as IF, with no reflection on the differences among the produced indicators and their different conceptualizations, which does not strengthen the debate. There are uncertainties regarding the institutionalization of the area, defended as a perfect solution, with no deepened discussion concerning limits, controversies and new possibilities of altmetric indicators and the tools in use to study the "impact" of scientific production. Thus, this research aims to discuss some of these aspects intending to contribute towards the comprehension, institutionalization and consolidation of Altmetrics.

2 Altmetrics: emergence and definitions

This reflection begins discussing certain historical aspects, definitions and terms often used to conceptualize this new area of studies: Altmetrics. With this, we seek to identify elements subsiding a more precise comprehension of what we propose to study, so as to understand central aspects and, as far as possible, reflect on the delimitation of the area. From this analysis, it will be possible to situate it, so as to, at a later moment, seek to insert it amidst the other more consolidated areas of information metric studies, such as Bibliometrics, Scientometrics, and Webometrics, spotting similarities and differences among them.

It is possible to identify historic marks of Altmetrics when defending the existence of relations with Bibliometrics, Scientometrics, and Webometrics, but, at this first moment, the interest is set on definitions and conceptualizations not clinging to these areas, in the attempt to identify particular aspects of the emerging area itself. Altmetrics are very recent and their history is under construction. Some important contemporary marks regarding its emergence can be observed from Fenner's (2014) considerations, spotting researches conducted before the proposition of the term Altmetrics, yet presenting clear proximity.

Some researchers stand out as marks for Altmetrics, even if the term had not yet been employed. Among them, Fenner (2014) mentions the one published in 2008 by Dario Taraborelli, defending the use of bookmarking social tools to review post-publishing from peers (Taraborelli, 2008). Neylon and Wu described PLOS Article-Level Metrics, a service released in 2009, in a paper published in the same year (Neylon & Wu, 2009). Priem and Hemminger published a paper in July 2010 in which they used the term Scientometrics 2.0 and stimulated the use of new metrics based on Web 2.0 tools (Priem & Hemminger, 2010). Another empiric study, with application one may consider altmetric today, was elaborated by Groth and Gurney, based on the analysis of comments on papers about Chemistry on blogs in the area, the results being presented in 2010 (Groth & Gurney, 2010).

The use of the term Altmetrics itself begins in September 2010 and could not have been coined in a more suggestive fashion. Its first public apparition took place in a post by Jason Priem on Twitter, on September 28th 2010: *"I like the term @articlelevelmetrics, but it fails to imply *diversity* of measures. Lately, I'm liking #altmetrics."* (Priem, 2010). This first apparition of the term, even if historically important, is rather empty of meaning so as to conceptualize the area.

One of the most divulged definitions of the term comes from the text called "Altmetrics: a manifesto", published in October 2010. This manifesto became available on the website *altmetric.org* under Priem, Taraborelli, Groth and Neylon's (2010) responsibility. **These authors define Altmetrics as "the creation and study of new metrics based on the Social Web for analyzing and informing scholarship."** It is understood these authors present at least four terms contextually, as they suggest elements to identify and constitute the area of Altmetrics. Thus, one can understand Altmetrics is related to: creation (indicating the practical activity), study (regarding an area of study, including a theoretical load), new metrics (referring to the production of indicators different from the existing ones), social web (where one can understand the existence of social media tools, actions and interactions of publics) and, finally, academic information (delimiting the analyses in the academic, scientific ambit, yet leaving it open to a multiplicity of sources).

The definition proposed by authors Shema, Bar-Ilan and Thelwall (2014) is that Altmetrics is a term used to describe metrics based on the Web to measure the "impact" of academic materials, emphasizing what is conveyed in social networks and media as data sources. With this definition, the term "academic materials"

stands out, which, despite being a very ample term, refers to information sources resulting from a large group of academic activities, not limiting only to traditional outputs, such as papers, event presentations, theses and dissertations. It can, hence, include other types of materials to emerge with the web, such as information disclosed on blogs, reference management systems, and other social media and networks.

The term Altmetrics seems to be associated with two key terms which, to some extent, possess an intimate interrelation and gave birth to the concept: "article level metrics", as well as "alternative metrics". "Article level metrics" is a term concerning the possibility of producing indicators at article level, opposing the currently adopted methodology assessing papers from the journal where they were published. In other words, based on logic: if the journal possesses quality, the article, by inference, also does.

On the other hand, the term "alternative metrics" refers to the idea of an alternative to "traditional" metrics developed in the ambit of Bibliometrics and Scientometrics, especially IF. The term Altmetrics does not seem to be one of the best. We understand these are not the only ones capable of measuring at article level and may not be considered alternative to other indicators. As time goes by, other "alternatives" will certainly emerge, this one being derogatively labeled a "traditional" metric. Yet, apparently, the term is consolidating in such a fashion it would be difficult to replace it now with a more adequate and less controversial one. Even if this criticism is a valid one, it is also important to point out the term performs its role, even if temporarily, of putting the matter in its own nomenclature, with the need to produce new metrics to broaden the ones most currently used, declaring from the beginning its systemic insufficiency.

Haustein, Bowman and Costas (2015) consider the use of the term Altmetrics as an alternative metric to the citation inappropriate, defining it as a new group of metrics based (largely) on social media events regarding scientific communication. This proposal of conceptualization highlights a very relevant term for the comprehension of the area of Altmetrics: scientific communication. Such term is fundamental for the insertion of Information Science as a field that should take part of the discussions on Altmetrics.

Historically, **Information Science has been one of the fields most involved with studies in scientific communication, possessing credentials to contribute with its develop and should, hence, be open and attentive to pertinent innovations**. It is also important to mention the term Altmetrics has its origin in the context of the field, especially so as to comprehend scientific communication and research activities, once Priem, when creating the term, was still a PhD candidate at the School of Information and Library Science, at the University of North Carolina at Chapel Hill, USA (Roemer & Borchardt, 2015).

Priem, Piwoar and Hemminger (2012) stated Altmetrics build information from the use of social media and networks, being able to capture the unintentional and informal "street scientific credit", i.e. they can capture information on the "impact" on various research products and publics. From this statement, one notices one of the central points for understanding, which should be in a solid conceptualization of Altmetrics: variety of publics. This is a peculiar and exclusive feature of Altmetrics. Differing from other indicators commonly used to assess scientific production, Altmetrics capture information from other publics and not only scientists and researchers. One can understand it is this variety of publics that contribute not only with a diversification phenomenon, but also in scale, expanding significantly the possibility for circulation and social appropriation of academic information.

Other indications relevant for the identification of a clearer concept for Altmetrics can be found from the analysis of authors such as Roemer and Borchardt (2015). They consider the area of Altmetrics does not possess a strict definition or a group of defined metrics, with a certain emphasis on tools. Opting to emphasize altmetric tools to assess social actions in the variety of sources they provide, one perceives the importance of information technologies for the area.

In other words, **Altmetrics depend greatly on information and communication technologies and, above all, tools developed to measure interactions of publics and contents.** Even if social relations and interactions have always existed, they only now leave digital tracks in large scale that can be collected, measured, studied, compared, and analyzed for the comprehension of social aspects of science communication. In an e-mail message disclosing the Altmetric.com tool, in March 2016, this becomes clear as they announce: *"Over 5 million outputs and nearly 50,000 mentions a day."* (Altmetric, 2016)

More recently, Priem (2014, p. 266) defined the area of Altmetrics in quite an inclusive manner, strongly highlighting the study, use and also the tools: "study and use of measuring academic 'impacts' based on online environments and tool activities." However, for Haustein (2015), there is no general consensus on what builds

this new group of metrics, especially due to the fact they are constantly changing and expanding, being influenced by new technical possibilities – particularly the availability of applet programming interfaces – and business models to add data and editors. The use of the term "impact", in Priem's (2014) definition, may bring about some confusion regarding its meaning, as this word is widely used in other contexts with diverse meanings. This issue will be discussed further ahead in this text.

3 Altmetrics as an alternative to "traditional" metrics

Despite the deliberate attempt of this research to isolate Altmetrics from other information metric studies, this exercise is not trivial. A great part of the definitions, conceptualizations and contextualization concerning Altmetrics is marked by the attempt of making parallels and approximations to Bibliometrics, Scientometrics, Webometrics, etc. Some of these approximation attempts are here explored in the intent to better understand the area and its relations to other metrics, as well as to question the assumption it is an alternative to "traditional" indicators.

An example of association of Altmetrics with a Scientometric area can be observed in Priem's works. Before proposing the term, Priem, in partnership with Hemminger (2010), suggested "Scientometrics 2.0", i.e. performing scientometric studies from social web tools, with arguments similar to those used to defend Altmetrics. Some of the justifications for creating the area are found in the manifesto proposed by Priem and his collaborators in 2010: a crisis experienced by "traditional" filters used to determine the quality of scientific information; a slowness in peers' reviewing system; limitation of IF and citation analyses; among others.

While exploring concepts regarding metric studies of information, such as Webometrics, Cybermetrics, Bibliometrics, and Scientometrics, Gouveia (2013) defines Altmetrics as a use of Webometric and Cybermetric data in Scientometric studies, determining, hence, the existence of a clear relation between the areas. However, despite this proximity, the author does not consider them synonyms, but rather Altmetrics as a new field of studies. To reinforce this positioning, he agrees with Björneborn and Ingwerser (2004), who consider Altmetrics situated within the intersection of Scientometrics with Cybermetrics and Webometrics, overlapping also with Bibliometrics.

For Torres-Salinas, Cabezas-Clavijo, and Jiménez-Contreras (2013), the origin of Altmetrics goes back to the 1990s with Webometrics, the quantitative studies of the Web, which originated from the application of bibliometric techniques to online pages, and encompasses various disciplines, among them: communication. Likewise, Bornmann (2014) envisages the use of Internet for alternative metrics starting with "Webometrics" (or "Cybermetrics") by means of counting the number of times a paper is mentioned in the Web, or "cited in the Web" (Shema, Bar-Ilan, & Thelwall, 2014). Notably the same understanding takes place now with Altmetrics, creating indicators by means of counting the mention of academic products (especially articles) in social media and networks or therein "cited."

From the "citations" in each of these contexts, some indices can be elaborated. Bibliometrics possesses the classic IF, measured from the "citations" in scientific papers. In Webometrics, Ingwersen (1998) proposed the "Web Impact Factor" (WIF) calculated from web "citations." Similarly, Altmetrics use "citations" in social media and networks to create indices that can, analogously, be called "Social Impact Factor" (SIF).

The term Altmetrics, or alternative metrics, automatically arouses the questioning: alternative to what? The answer is simple: the meaning of the term comes proposing an alternative to the so-called "traditional" metrics, such as Bibliometrics and Scientometrics, especially regarding their metrics based on citation, such as IF. Hence, by itself, the term Altmetrics is conceptually associated with "traditional" metric studies of information.

The argument that Altmetrics is an alternative to bibliometric and scientometric indicators brought about countless questionings. The criticisms have grown from the results of empiric studies that found most indicators based on social media (if not all) are complementing and not alternative to indicators based on citation. Thus, authors such as Rousseau and Ye (2013, p. 2) criticize the term, stating Altmetrics are a good idea, but a bad name. They prefer the use of the term *Influmetrics*, proposed initially by Elisabeth Davenport and discussed by Cronin and Weaver (Cronin & Weaver, 1995) for being a term able to suggest fuzzy imperceptible features of academic influence, which can be captured for measuring and assessing in new environments (Cronin, 2005). Elaborating a proposal for a name that can broadly embody the complexity of these new indicators is not easy. A fundamental term would be social web, as it can encompass other more specific terms such as social media and

social network. Thus, an alternative to the word Altmetrics could be *sw-scientometrics* (social web scientometrics).

Some bibliometricists have manifested skepticism concerning the use of altmetric patterns of "citation" to track and identify academic "impact." In the same line, the defenders of Altmetrics state they can be considered forms of denigrating Bibliometrics in general, not only IF, causing controversies in the academic community in general (Roemer & Borchardt, 2015).

With the criticisms to the defense of Altmetrics as an alternative, the initial concept is being replaced with en envisagement of complementarity, i.e. in the potentialities of Altmetrics to think new indicators measured from new insights on new forms of "impact." As time goes by, the creator of the term Altmetrics and the formulation of its initial conceptualizations himself starts realizing this new area is not an alternative, but a complement, acknowledging the importance of subordinating to consolidated areas. For this author, Altmetrics can be considered, in most cases, a subgroup of Scientometrics and Webometrics, closer to the latter. Both focus on measuring academic influence on which Altmetrics use online environments and tools, rather than the Web in general, as in Webometrics (Priem, Groth, & Taraborelli, 2012). In the future, Altmetrics and traditional Bibliometrics can be seen working together ad complementing tools, presenting a multidimensional vision differing in multiple research "impacts" in multiple time scales (Priem, Piwowar, & Hemminger, 2012), which may even lead to producing researches experimenting with multidimensional indices and their validity for measuring academic impact of scientific production. It seems this complementarity of strategies brings a complexity enriching the possibility of comprehending phenomena behind scientific communication.

The relation, intersection, and limits among the areas of Bibliometrics, Scientometrics, Informetrics, Webometrics, and Altmetrics, among others, remains controversial. These seem to be much more transversal rather than hierarchical. From the analysis of the concepts of various metrics of information, we observe there are substantial differences among them. The techniques and tools used to collect and analyze data, the methodologies, the theories, the objects of analysis, the social actors, and the concepts differ significantly. However, many principles or logics are similar. In practically all these areas, the expanded concept of "citation" and "impact" can be found, even if with different meanings among them.

Nevertheless, the central point strongly uniting these metrics is science, its communication and social aspects involved in its processes and the search for ways to better comprehend the phenomenon, especially using indicators. Roemer and Borchardt (2015) start from a similar view, considering that, despite the differences between Bibliometrics and Altmetrics, the central interest of this nascent area remains greatly congruent with that of Bibliometrics, as both are essentially interested in what can be learned from the quantitative analysis of information concerning academic production and publication.

The "alternative" positioning of Altmetrics, specifically regarding Bibliometrics and Scientometrics based on citation, created a group of obstacles to their development. Altmetrics now has to rethink such obstacles in order to advance (Roemer, Borchardt, 2015). **Considering Altmetrics as an alternative to "traditional" metrics can be a mistaken strategy, as the concept of alternative is strongly related to superiority, which is not necessarily true**. Although the term leads to this mistake, researches embrace it and are unlikely to replace it with a different name. However, the concept has been improving, as it is necessary for the area to look at itself rather than try to stand out using the strategy of minimizing its sister areas, denying important previous developments.

From the considerations presented, one understands Altmetrics can be conceptualized as an emerging area in the field of Information Science, dwelling on the study, production, and use of technological and scientific indicators, based on tools that capture information from multiple sources, as they socialize in social networks and media, generate actions and interactions of a large variety of social actors and new forms of relation with digital objects and among people. This area relates transversally to the areas of Bibliometrics, Scientometrics, and Webometrics, with scientific communication as an integrating core, but with new types of indicators measuring another complementary type of citation, engagement and impacts from academic outputs.

With these considerations so far, one can see the ever-growing difficulty to delimit with precision the areas of metric studies of information (Altmetrics, Bibliometrics, Scientometrics, Webometrics, Informetrics, among others). We understand a graphic representation of the relations among the metrics, consolidated or altmetric, can be thought from an approximation with a brain cell (Figure 1). The group of metrics can be compared, analogously, to a brain cell, a basic unit, i.e. an area within the central nervous system that would be Information Science; the cytoplasm could be associated with a region where metrics mix, interacting transversally and often

fused; the cell nucleus could be considered scientific communication, surrounded by the cytoplasm, indicating high interaction, with a central position in relation to information metrics; dendrites, on the other hand, would be the extensions in charge of receiving stimuli from the environment, such as the areas related to metric studies of information; finally, the axon would be the conducting extension that makes it possible to link this area to other areas or fields of knowledge.

Figure 1 aims to present a systemic perspective of how one can understand the relation among these different, albeit very proximate, research areas. The general idea we attempt to explore is that metric studies unfold in various branches that end up specializing in tools, methods, and even some concepts that end up being specific to them. However, we understand the core of all this is scientific communication, i.e. what allows these results to unfold is the fact that there is a social action of producing communication concerning scientific production. As this communication ends up taking place by various means and forms, the unfolding areas of metric studies emerge as these means become more diverse, complex and develop throughout time. It is, in fact, the transversality of knowledge that unite these areas, while other areas of knowledge end up connecting as well. For instance, it is with the advent of the Internet and the technical possibility of producing websites and other means of communication that Webometrics and Cybermetrics arise. Now, with the advent and popularization of social media, Altmetrics emerge with new possibilities of metric studies. What is represented here is a living organism developing dynamically and establishing new connections from new perspectives of scientific communication. In this organism, the relations with information metrics become more and more complex when it comes to classify them in a more simplistic and strict manner.

Figure 1 – Analogy among different areas of Metric Studies of Information, Scientific Communication, and a brain cell
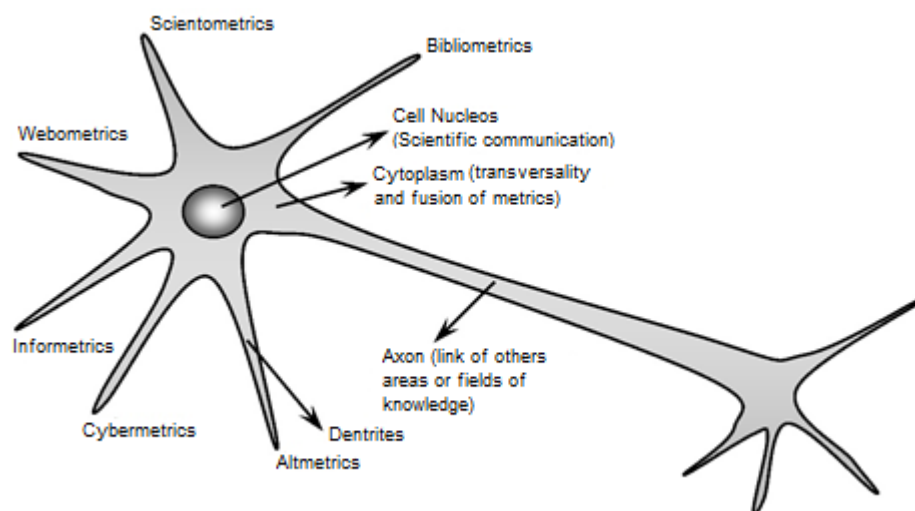
Source: Elaborated for this paper by its author.

4 Altmetrics, "citation," and criticisms to the Impact Factor

There are various types, functions, and aims of bibliometric and scientometric indicators. They can be divided, for instance, in productivity, collaboration, co-occurrence, and citation indicators. Within these categorizations, numerous variations of indicators can be built and analyzed, prominently those based on citations. Many are the indices calculated from citations, as well as the criticisms made to them. The defenders of Altmetrics criticize IF, a well-known citation index, very strongly. Nevertheless, little is debated on the concept of citations and its conceptualizations in different contexts. We seek now to elucidate certain aspects concerning these critiques and to problematize concepts of "citations" and "impact" in the contexts of "traditional" and altmetric indicators, so as to contribute toward a better comprehension of the measured phenomena and their particularities.

One of the main citation indices developed and with latent importance, even currently, was created in 1955 by Eugene Garfield, named IF. It consists in an index calculated from the average number of citations of published/indexed papers in databases developed by the Institute for Scientific Information (ISI)[v], during the past

two years. The influence and repercussion of this index are such it is now used as a synonym for citation index. However, this use is mistaken, as it is the registered trademark of an index created by the institute.

There are many other databases and tools to create citation indices with the same or a similar methodology as proposed by Eugene Garfield. Official IFs are calculated by Thomson Reuters by means of journals indexed by the Web of Knowledge database and published on the Journal Citation Report (JCR). Although they are an "impact" measurement of the journals, they are commonly used as a metric to represent the quality of a paper and the prestige of its authors. The logic is simple: it is inferred an article is automatically good as it is published on a journal with a high citation index, generating prestige to the journal, the paper, and the researcher. This form of assessment of scientific productions has been criticized historically; nevertheless, it is an outspread low-cost practice to assess science. System Qualis[vi] for journals itself, used to assess postgraduate programs in Brazil, is based on the same principle. Thus, it is common to hear a proud researcher say: "I have published a paper on a journal with IF *'x'*, or a journal classified *Qualis 'y'*."

Facing the controversies and criticisms to citation indices (an old concern of the areas of Bibliometrics and Scientometrics), hybrid proposals emerge. One of the most recent metrics in this sense is the *h-index*, calculated considering aspects of productivity and citation of a researcher. It is an assessment of the researcher's "impact" and productivity derived from the counting of his/her articles and citations. Researchers have a given h-index is their published papers were cited "h" or more times. This form of aggregation of citation counts indicates the researchers must produce a certain quantity of highly cited papers so as to reach a higher score, as a large quantity of articles with few or no citations is insufficient (Ball & Duke, 2015).

As for definitions, defenses, and justifications of the use of altmetric indictors as an alternative to IF, we observe a large group of mistakes. The first of them is not to consider IF as a synonym of citation analysis. There is not clarity, hence, if the criticism made refers to the Science Citation Index (SCI) or the indicators based on citation in a general manner. There is a certain consensus on the limitations of the indicators produced by the base, but there is not such consensus regarding indices based on citations. In fact, there is some agreeing on these indicators being relevant, and on the development of new tools for citation analysis, such as SciELO, Scopus and Google Citations, contributing greatly to diminish limitations imposed by SCI. So there does not seem to be much clarity on the concept of "citation" in the discourses and rather an unreflective criticism to IF, as if they were villains causing the evils of science assessment.

Some metrics in research level such as *h-index, g-index,* or *i-10 index* were developed in the past decade. Metrics in article level can be elaborated by different approaches. Despite being commonly associated with Altmetrics, they are not synonymous. The quantity of citations an article receives may be considered an article-level metric, just as one can create an altmetric index for a scientific journal in its group (making the indicator a "journal-level" one).

"Impact" is a word that can refer to countless possibilities of interpretation depending on the context in which it is used: forcedly placed, pressed, impelled, cast, affected, influenced, collided, altered from one state into the other, modified, etc. **It is not possible to assess the "impact" if there is no clarity about its meaning.** Ball and Duke (2015) consider "impact" figuratively as "the effect or influence an agent, event, or resource has on another." It is distinct, but related to concepts, such as attention (how many people know about the entity) and disclosure (how broadly a resource has been distributed). When proposing metrics, it is important to understand what exactly is being measured and the strength of the evidence that foresees the "impact" of the entity one means to assess; furthermore, one needs to make it conceptually explicit, concerning informational phenomena, what social aspects and relational dynamics this assessment represents. The citation counts, for example, are commonly used to measure the influence a paper has over subsequent literature in a discipline. Despite its limitations, they work as a useful measurement, representing "impact" for other entities (authors, funding agencies, among others).

An emblematic moment of criticisms to IF was the publication, in 2012, of the San Francisco Declaration on Research Assessment (DORA), a worldwide initiative aiming to improve how the outputs of scientific activities are used by funding agencies, academic institutions, and other actors. Some recommendations of the declaration, aligning with the logic of Altmetrics, are: avoid the use of metrics of journals to judge articles or individuals in order to subsidy decisions on hiring, promoting, and funding; consider other types of research results, such as the groups of data, software, patent, as well as political and practical influence of the researchers; use IF with other metrics based on article level, more specific than those based on journals; use open data to calculate metrics; etc. **In theory, the recommendations seek to broaden the view of assessment toward other social**

manifestations that can indicate the relevance of a given researcher and/or research, which may even highlight the suggestion to analyze their political influence and practical acting.

The criticisms to IF, found abundantly in literature, show a certain dependency on the use of this tool to produce scientific indicators. Naturally, IF and, consequently, citation indices, are not exempt from criticisms, and altmetric indicators can help fill some gaps currently found beyond the reach and competence of citation indices. Yet, it makes no sense to replace citation-based indicators with others such as altmetric ones (Donato, 2014).

Automated indices have made new dimensions possible for citation analyses, such as large scale analysis. The first example of an automated indexer was *CiteSeer*, followed by *Google Scholar*. Tools are now available to calculate various "impact" assessments and to create citation indices (Dutta, 2014). One must not forget that, throughout the past few years, a large number of indicators and assessments have been produced from counting publications and citations. New metrics start being offered from other databases, information sources, and other materials, such as dissertations, theses, and books. Some examples are indicators generated by Scopus, Google Scholar Citations, SciELO, and ISI itself, which have also been perfecting their products. These important developments cannot be minimized.

Metrics based on "citation" and peer review have a long tradition and are widely applied to assess scientific research. Analyzing citations is a popular assessment method, useful in the context of science and research management policies. Citations are generally considered a proxy for "scientific impact." (Moed, 2005). However, they are not without limitations, as they measure a limited aspect of quality. Peer assessment is also an important tool, often considered a superior standard in investigation quality assessment, but also has its limitations. So both citations and peer review are considered partial indicators of "scientific impact," as they are unable to reveal sufficiently the total "impact" of the research. Given these limitations, the combination of peer review with "multi-metric approach" is a necessary proposal to assess research (Rousseau & Ye, 2013).

When seeking the insertion of Altmetrics in the group of Information Science metrics, one focuses excessively on questionings on IF, leaving aside debates on the central term: "citation." One understands that, in order for the area of Altmetrics to advance, one should discuss the meaning of "citation" in different contexts. Citation, from a "traditional" point of view", may be briefly defined as the formal mention of a scientific work in another. This type of "citation" has features that can interfere in the quality and reliability of citation indices. Some common criticisms are political citation, self-citation, negative citations, etc. Despite attempts from databases to minimize these issues, little advance has been achieved. Even in self-citations, technically easier to disregard, there are diverging positions concerning this practice.

When one attempts to make a counterpoint or associate altmetric indicators with citation-based indicators, conceptual mistakes can take place. Traditional "citation" already has fuzzy surroundings, little consolidated, with theoretical gaps regarding its meanings. Haustein, Bowman and Costas (2015) consider the need for a citation theory. Gilbert (1977) stated "we do not yet have a clear idea of what exactly we are assessing when we analyze citation data." So associating Altmetrics with "citation" and "impact" seems rather dangerous and precipitated, as little is known about this phenomenon, making it still necessary to define the meaning of the various indicators grouped in the term Altmetrics (Haustein, Bowman, & Costas, 2015).

The conceptualization and meaning of Altmetrics cannot be associated with citation and citation indexes. There is need to create a theoretical-conceptual framework for metrics built from social media. Traditional "citation" and "citation" in social media and networks differ considerably, as Altmetrics capture events on ever-changing platforms, whose use and user communities are new, diverse, and not as well understood as the traditional act of "citing", known since the early days of modern science. The rules for "citation" already established in scientific context (how, what, and when to cite) are not yet established in the context of social media, an ecosystem in a flowing state (Haustein, Bowman, & Costas, 2015).

Facing the aforementioned, what is defended is a smaller approximation, an attempt to replace or refute IF and citation analysis by Altmetrics. Altmetrics assess a group of different phenomena and unreflective analogies with "citation", which can hinder the development of their methods, techniques, and theories. Different "impacts" can be seen in the "citation" indicators generated in Bibliometrics and Altmetrics. The first refers to the "impact" within scientific community, while the latter refers to social "impact". Hence, the theories used for each of these phenomena should be different. While in studies based on "traditional citation" one must use "traditional citation" theories, in Altmetrics one should seek knowledge in social theories, above all, understanding it is based in new processes of information circulation, preferentially in a networking environment. Altmetrics will advance more quickly if one focuses efforts into defining the meaning and understanding of what "impact" it can measure.

The meaning of "impact" from the logic of Bibliometrics and Scientometrics differs from the "impact" in the perspective of Altmetrics. For Altmetrics, it seems wider, closer to how Neylon, Wilmers and King (2014) view it, considering "impact" able to signify the effects of the investigation toward beyond scientific community, and to include political influence, improvements in health and life standards, cultural enrichment or a better environment. Different forms of "impact" – and the framework by which "impact" is assessed and used as a reward – in general depend on the institution's aims and mission.

The attempt to employ a wide concept as "citation" can bring conceptual confusion and mistaken approximations with the analysis of citations used in Bibliometrics and Scientometrics. Haustein, Bowman and Costas (2015) say these metrics are events on social media platforms related to academic content or that of academics, easily captured (using APIs) and, hence, do not possess the same concept as more "traditional" citation. Some new nomenclatures, perhaps more adequate, have been proposed in literature. Taylor (2013b), facing the complexity in measuring, assessing and understanding academic "impact" in society, emphasizes the existence of formal citation of papers in papers, formal citation of papers on academic platforms, and formal citation of papers on non-academic platforms. Piwowar (2013) uses the term "(public) engagement" as an alternative to citation (Bornmann, 2014). Even so, there still is not a theory on the meaning of "engagement" in Altmetrics and the term "citation" is still widely employed. Perhaps a possible path for this question is to turn to theories of engagement in the field of social networks and assess the meaning of many of their metrics in relation to the sense they can lend to the analysis of academic production.

5 Challenges of measuring and comprehending altmetric indicators

From the discussions and debates so far, it is possible to perceive there are various challenges to be transposed to a proper comprehension and development of the area of Altmetrics. Certain challenges and complexities of measuring this new object are here explored, highlighting core questions: new social actors and types of production; new data sources and tools; and meanings of actions in social media and networks.

5.1 New social actors and types of production

Altmetrics presents other challenges with the insertion of new and uncertain actors (scientists, professionals, students, curious ones, and any other sort of person) and types of production (scientific, cultural, artistic, literary, etc.) for being distributed in traditional media (books, articles, theses and dissertations, events, computer software, patents, cultural productions, etc.) or in those that emerged with the Web (blogs, social media, social networks, slideshows, reference management environments, post-publishing evaluation environments, etc.). The very concept of scientific communication will then need to be discussed over again, as Altmetrics bring a mix of that with the concept of science popularization, creating, hence, a very strong interface with the area of communication.

Brigham (2014) elucidates Altmetrics can reveal how a greater diversity of individuals is affected by scientific contents, such as professionals, physicians, educators, and the public in general, as well as actions and reactions can be performed with these scientific products, such as reading, discussion, storing, recommending, etc. The variation of these publics and uses led to the concept of "impact flavors", a form of "understanding distinct patters in diverse impacts of individual products." The "impact" flavor of an academic product or research in media will differ greatly from one stored in a reference manager or a work cited in a scientific research.

Currently, there is no clear knowledge of the publics affected by scientific contents socialized in the Web, nor of the meaning of the various actions these social actors can perform. The crossing points between publics and information sources are practically infinite, and increase even more the complexity of the analysis of objects and phenomena. When Altmetrics are placed next to Bibliometrics and Scientometrics (with their already known complexities), these seem simple before the new and dynamic challenges. Sud and Thelwall (2014) point out even citations, produced in a controlled quality environment and researched throughout decades, are controversial. Therefore, Altmetrics, with even fuzzier objects when compared to "traditional" indicators, is not sufficiently mature, resulting fragile and questionable statements.

The existence and interaction of scientists and society, in a given environment, at uncertain levels, brings much difficulty to understand the phenomenon and indicators produced from it. Altmetric indicators can comprise a group of wider indicators, measuring aspects previously hard or practically impossible to gauge so far. The multiplicity of indicators, which can be generated and combined differently from previous paradigms, is

substantially unknown. We currently do not know if the "impact" is social (from society in general) or among scientists themselves. Altmetrics cannot be simplistically regarded as an evolution of bibliometric, scientometric, or webometric indicators, since what actually emerged was a new form to measure the "impact" of science. For Torres-Alinas, Cabezas-Clavijo and Jiménez-Contreras (2013), these measurements are quantitative approximations to the measuring of interest, arousing amongst the scientific community and also in a generalist public, transcending or complementing the "impact" of "traditional" citation indices.

Facing this new perspective, authors such as Bornmann (2014) point out it is unclear how the investigation "impact" in other areas of society should be measured – conversely to research "impact" in itself. While peer review and Bibliometrics became standardized methods to assess the "impact" of a given research on other ones, there is not yet a structured framework accepted to assess social "impact." Furthermore, the roles and audience in scientific communication change depending on the scenery, where scientists can also be considered part of the general population in matters that go beyond their specialization. **The issue of forms to measure social relevance, now in a wider sense, is placed as a central challenge for the evolution of research on ways to use Altmetrics.**

The forms to calculate indices and indicators from these data will present a given "impact," but it is actually unknown what "impact" it will be. Will current altmetric assessment tools reproduce the measurements made in Bibliometrics, assessing the relations among scientists themselves, now migrating to social networks? Future studies in correlating indices originated from these areas of knowledge could help assess this issue. For Thelwall (2013), it seems Altmetrics captured widely, or at least differently, the aspect of visibility and the "impact" of investigation comparing to citation counts. For instance, "non-publishing" or "pure" readers are estimated to constitute one third of the scientific community, and they can twit or post articles on blogs without ever citing other articles. Yet, doubts still remain in a certain measure and many studies will be necessary to diminish them.

Altmetric indicators create and strengthen various interdisciplinary relations. Among them, one of the clearest is the relation between the area of Information Science and that of Social Communication. Hence, as we dwell on the comprehension of Altmetrics, it becomes necessary to appropriate concepts, theories and methods for analyzing these two areas of knowledge. There is an important conceptual difference between scientific communication and scientific disclosure. The first is strongly linked to Information Science and the latter to the field of social communication. The scientist him/herself is being called to come closer to society. When the first is strongly interested in the communication taking place within science, the latter is inserted in its disclosure to society. This approximation of science toward society was noted by Barros (2015), who points out the fact that funding agencies, such as CNPq[vii], ceased to assess scientific production exclusively, and now assess the "disclosure" of the results as well, by means of personal blogs on science and on the media, with the need to raise the researchers' awareness on the importance of disclosing their research products.

It is important to conceptually review the social models used for "impact" researches in academic production, understanding Altmetrics have widened their space in sociability, including new actors, new forms of sociability, new objects of relation, and new tools as a connectivity interface. These new elements not only make the area more complex; they also demand new epistemologies for a better analytical interpretation and appropriation.

5.2 New data sources and tools

Currently, little is known about social interactions and features assessed by altmetric tools and their ability to measure different objects, actions, and publics. Even if the discourses defend Altmetrics are a great alternative to consolidated indicators for being able to measure a wider scientific "impact" specter in society (scientists and society in general), this actually cannot be categorically stated, as there are not sufficient scientific proofs to support it. One thing is the theoretical and hypothetical concept of the meaning of Altmetrics; another is the empiric, scientific meaning, which is still an object under construction.

The choice for each altmetric tool used in empiric studies will determine social (and academic) participation levels in scientific communication, inherent to the adopted tool, not making it possible to make conclusive generalizations for the area of Altmetrics as a whole. Each one has peculiarities and different methodologies for measuring objects, phenomena, and different interactions and publics. Although it is possible to identify the sender in socialized messages, actions, and interactions, currently altmetric tools do not segment publics, bringing limitations for the comprehension of what the "impact" is.

With the advent of the Internet and its constant evolutions, scientists from all over the world have been increasingly appropriating tools and environments available online. As they interact in these environments (especially those related to social media and networks), various tracks (data and information) are left, so activities can be measured and generate indicators. The old invisible schools are losing a bit of their invisibility with these previously unimaginable new possibilities of mediating actions and interactions. In this sense, Souza (2015) points out scientists currently create blogs to narrate their everyday research, use social networks websites to interact with other scientists and the public in general, organize and share their bibliographies and notes in online reference management tools, etc. With this, processes previously restricted to the backstage of science gain visibility and become capable of being registered and measured, opening a new front for the realization of studies on scientific communication (Souza, 2015).

Naturally, different data sources can assess different types of "impact." For example, to measure the "impact" on politics, it will be necessary to analyze governmental documents. To cast a look on professionals and the influence at work, it will be necessary to monitor the online communities in which they gather. In order to understand how aware the public has become, it may be necessary to check Twitter and Facebook (Lie & Aide, 2013). But can this classification also apply to Altmetrics? It does not seem to be a simple activity, or even the fact that these sources can be present simultaneously in the same environment or social medium.

The area of Altmetrics can generate indicators from a large variety of online tools, including social media websites, information sharing websites, online academic networks, and other tools used to create, obtain, share, organize, and manage multiple types of information. Some tools are created specifically for altmetric finalities, but also data generated by other existing data sources, with or without academic purposes, are used (Roemer & Borchardt, 2015).

Brigham (2014) points out Altmetrics cover more varieties of academic information, once they do not only measure at article level, also able to capture metrics in other researches and "products." These other research products, such as groups of data and software, normally are not captured in "traditional' citation metrics. Similarly, Zahedi, Costas and Wouters (2014) defend more "traditional" metrics are unable to measure the online "impact" of scientific literature (for example, via Facebook, Twitter, reference managers, blogs, or wikis) and other outputs, such as data groups, software, slides, posts, etc. At a first moment, one can consider this possibility interesting, but the pulverization of these information sources renders categorizations and certain types of analyses more difficult.

There is a certain consensus that one of the advantages of Altmetrics is the possibility to measure other types of information sources neglected by consolidated bibliometric indicators, including non-conventional ones that emerged with the Web and information technologies. However, on the contrary of "traditional" indicators, the meaning of these indicators is not known for certain. What does it mean to "cite" software? What are the reasons that lead people to "cite" a blog? It is not a criticism toward Altmetrics, but an alert about the complexity and challenges to assess these new sources that previously were not part of the concerns, as such analyses were not viable.

The coexisting dynamics of different types of sources, tools, actions and interactions make it more difficult to build and analyze indicators. Very little is known about the context of unconventional materials "citations," as well as the workings and peculiarities of each existing tool and the meaning of the indicators produced. **The variety of sources and tools makes Altmetrics a complex, delicate activity, loaded with questions that need to be investigated.**

5.3 Meanings of actions and reactions in social media and networks

Another complexity inherent to altmetric indicators is the fact that there still is no clarity of the meaning of the actions, intentions, and interactions in social media and networks, as well as no concepts of engagement and citation. Some of these issues are presented by Rasmussen and Andersen (2013). For them, an aspect of this complexity regards tweets and likes: what do they mean? If a paper is shared or commented on Facebook or Twitter, does it mean it has high quality? Does it mean the research is relevant for a group of people? While this is clearly an issue concerning the content in what is shared and discussed, it is also a matter of who the sender and the recipients are. If, for instance, tweets on a scientific paper are used as a social "impact" measurement, it will be a poor measurement, as tweets can only reach solely or mainly other researchers in the same area. We see here the need for research regarding Altmetrics to carry on a dialogue with studies that seek to comprehend

sociability phenomena in the network, now, nevertheless, focusing specifically on matters inherent to scientific production. This connection becomes fundamental and allows the elaboration of new research plans that can interpret the meaning of these actions on social media and networks.

Kumar and Mishra (2015) present some definitions of actions that can be thought in the context of the altmetrias. Even that the classification cannot be perfect and have limitations, it's capable to help in percept the complexity of study the scientific communication in social media and networks, because is little the known about what each of these actions and interactions mean. For the author, terms emerge from web and their definitions are unclear, meaning different things for different people.

Kumar and Mishra (2015) propose some terms and their concepts applicable to Altmetrics: (1) "reach" would be the number of people alerted to the existence of a webpage who had the opportunity to see it. In this case, "reach" reflects the number of people who could potentially see a social media (Facebook, Twitter, LinkedIn, Google+, an academic blog, etc.). A closer step toward "impact" would be (2) "engagement," defined as the number of people who visualize a webpage and, then, some action takes place in response to what is seen. For instance: someone can "like", tweet, re-tweet, share what they saw with their friends. Another (3) would be "virality", which seeks to capture a stronger level of engagement and propensity for the message to "viralize" or quickly spread. One more concept proposed is (4) "dissemination," meaning the number of people who visualize or download the online paper. (5) The "impact" of the research is understood as the number of people who change their way of thinking or practice because of it. Finally, (6) "citation" would concern the literature based in peer review.

An attempt to classify the various actions that can be assessed by altmetric indicators is proposed by Lin and Fenner (2013). Some of the definitions they give are: (1) *Visualize*: activity in which users access online papers; (2) *save*: activity of saving papers in online bibliographic managers, which help researchers organize papers for themselves and share with others; (3) *discuss*: discussion of the research described in the papers (varying from a small comment shared on Twitter to deeper comments posted on a blog); (4) *recommend*: activity in which a user formally endorses the scientific paper (via online platform such as a recommendation channel); (5) *cite*: formal citation of a paper in another paper on a scientific journal.

When one consults an author specialized in social media and networks analysis, but not directly involved with Altmetrics, one can see the complexity of assessing scientific communication in the social web can be even greater than it seems. Khan (2015) brings various categories for the analysis of actions and interactions in social media and networks, being one of the authors reviewed for this work the one who presents wideness in the perspective of the possible happenings in social media and their relations with scientific community: Like, Dislike, Share, Check-In, Check Back In, See, Click, Tag, Mention, Hovering, Pin, Embed, Endorse, Download and Upload. For the author, these actions are the way to express symbolic reactions to the contents of social media and networks. They carry emotions and behaviors that help assess popularity and influence. It is understood that, not only Altmetrics, but every area interested in analyzing social media and networks is still unprepared to assess these actions and interactions, as there is, nevertheless, a community of researchers developing works in this area, be it in communication, computing, and the interdisciplinarity among these areas. The collaboration with this academic community becomes fundamental at this moment of immaturity of research in Altmetrics. Understanding the meaning of these actions and interactions is certainly one of the most complex and challenging aspects for the area.

The context presented in this research points to the complexity in which the area of Altmetrics is inserted. We observe an environment that counts on multiple concepts and variables with countless possibilities of combinations, bringing difficulties to measure and comprehend the phenomena under assessment. One may attempt to graphically illustrate this context and the multiplicity of elements, factors and possibilities of combination from the 100% connected networks (Figure 2).

Figure 2 features especially aspects highlighted in this section: Social Actors (green) and types of production (grey); data sources and tools (red); and meanings of actions and reactions in social media and networks (blue). However, we point out such a picture is merely illustrative, portraying generically and superficially the complexity of what is intended to present. The number of clusters is certainly greater than the 30 presented and their 702 connections; furthermore, what is presented can be subdivided, increasing even more the quantity of combinations possible among the clusters. Figure 2 presents data from a square root that does not confer any weight to the clusters, hence there are huge possibilities for pondering among the clusters and conformities of the web and, consequently, the meanings of the data. Despite this, we believe it can serve as a good representation

of the complexity in which the area of Altmetrics is inserted and the challenges inherent to the produced indicators, their meanings, and the consolidation of the area.

The main idea in Figure 2 is that, in order to deal with the theme of Altmetrics, be it from the point of view of academic research or even the development of new products or services for the scientific area, it is necessary to deal with all these aliments present therein and, furthermore, deal with them and their relations among themselves. Figure 2 exalts the complexity of the theme and draws attention to the fact that one must take into account the relation among social actors, types of production, data sources and tools, and the meaning of the actions and reactions in social media. When placing these elements all interconnected, what is sought here is to defend a research position: the systemic view of the issue, drawing attention to the fact that casting a look at only one cluster related to the issue of Altmetrics means to leave aside important relations that must be considered and analyzed critically for the assessment and development of the area. For instance, if only the technical tools and possible actions to be developed in social media were to be considered, not taking into account who the social actors are, a research in the area would risk imagining the actors would behave similarly and react to this scientific communicational phenomena likewise, which we know does not happen. So it is fundamental to have a critical systemic position for the advancement of research in this form of metric studies, especially taking into account that it radicalizes the perspective of socialization of previous forms, widening considerably the reach of visibility of scientific communication through social media and their multiple forms of social appropriation. The perspective of Altmetrics is one which seeks to make this greater complexity of social interaction in the area of scientific communication visible, and presenting this from a systemic view as in Figure 2 is to highlight this complexity and draw the attention that is due to it.

Figure 2 – Social actors, types of production, data sources, tools, actions and reactions in social media and networks illustrating the complexity of the area of Altmetrics.
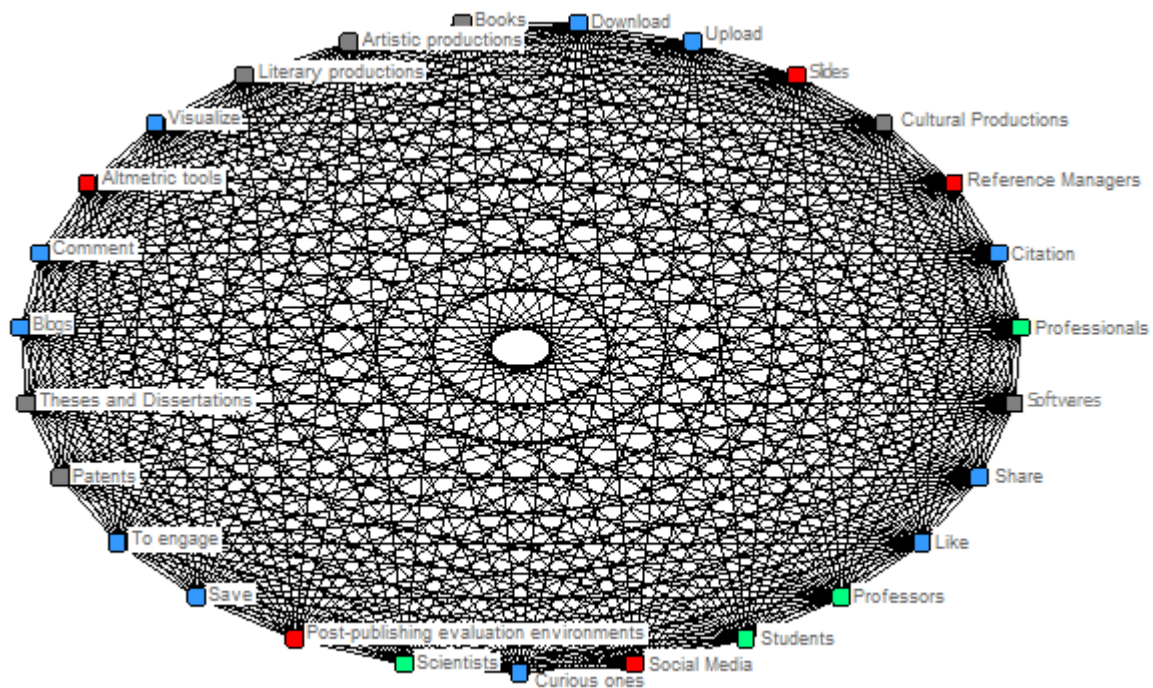
Source: Elaborated for this paper by its author.

6 Conclusions

The development of Altmetrics is involved within an extremely new context with countless challenges to be more deeply investigated. Its conceptualization is still fragile and unstable. Criticisms regarding Bibliometrics and Scientometrics are of little use, not bringing benefits to their institutionalization and strengthening. Criticisms focused on IF and, consequently, in the analysis of citations are sterile, not enabling them to bring them higher, nor helping to understand the phenomenon whose assessment is intended.

New complex forms of assessment and comprehension of another little known type of "citation" and "impact" are identified. Altmetrics bring an extremely new context, so far little explored by consolidated metrics, such as Bibliometrics, Scientometrics, Informetrics, Cybermetrics, and even Webometrics. The simple association (positive or negative) of Altmetrics with their predecessors is not enough to understand or define them. New knowledge, until recently distant from consolidated metrics, and which are a challenge even to other areas, will need to be unveiled. An interdisciplinary look is in demand for a better clarification of the objects, actions, and interactions involved.

Altmetrics have other tools, using other data sources and counting on a large heterogeneity of social actors. The consolidated metrics, historically, measure scientific production in relation to scientists themselves. Altmetrics measure the social "impact" of scientific productions, offering a new complementary, therefore more complex, form of assessing scientific "impact." It goes beyond measuring the "impact" among peers and non-peers, as it assesses scientific "impact" in society as a whole.

There are various specific challenges and complexities in Altmetrics. In addition to the complexity of assessing publics (research or society in general and their variations), the different tools and sources related to Altmetrics present an even greater difficulty: the different manners to measure these actions and interactions in social media and networks (save, discuss, recommend, cite, etc.).

Even if this research leaves more questions than answers, certain aspects could be comprehended from the results and reflect on the current view we expose here on the field of Altmetrics, especially from the view of research and systemic perspective, defending and seeking to present proofs throughout this work. Some of them, useful to understand the area of Altmetrics, can be, provisionally, summarized as follows:

- They can be considered a new area of knowledge and study, and not an alternative area to "traditional" (or rather: consolidated) indicators;

- They dwell on metrics strongly based on actions and interactions in Social Web or Web 2.0, highlighting social media and networks;

- They count on a large variety of little studied data and academic information sources (traditional and emerging with the WWW), bringing about difficulties in the interpretations of the assessments;

- Actions and interactions are likely to take place, "citation" and engagement in social media and networks are vast and little is known about their meanings, being one of the greatest challenges for Altmetrics;

- The area is inserted in the field of Information Science, with central relation to the subfield of scientific communication, but possessing interdisciplinary relations, especially with the area of Social Communication;

- Altmetrics are not the only indicators at article level and at researcher level. The quantity of citations in an article and the h-index oppose this statement;

- Altmetric indicators cannot be considered alternative, but rather complementary to bibliometric, scientometric, and webometric indicators, among others, as each one of these measures different phenomena. Using them as a group seems to be the best alternative;

- They capture actions and interactions from various – and uncertain – sources from many social actors, not only scientists and academics, bringing additional complexities and challenges to the comprehension of the phenomenon;

- They depend greatly on tools developed to assess interactions of publics and socialized academic contents. Little is known about the features and workings of these tools and about what each one measures;

- The attempts to define, defend and justify the use of altmetric indicators as an alternative to the Impact Factor and citation studies have not been helping to understand them; further reflection about themselves is still in need.

We did not intend, in this reflection, to exhaust the topic, but rather to bring further elements to the debate in an area that is only beginning to develop. Hence, many other equally important aspects were not object for analysis here. The thorough discussion on the advantages and disadvantages, limits and possibilities of Altmetrics is huge and was only superficially analyzed. The types of indicators being produced, with their features and forms of calculation, deserve to be explored in other works. The tools and features of the main information sources were not dealt with in this research. Many other questions, both theoretical and empiric, need to be investigated and gaps should be filled. A huge research window is open with the emergence of this new area, which possesses great potential to contribute with the comprehension of scientific communication, of better forms to assess science and the "impacts" on society as a whole and to provide new approaches for planning scientific and technological policies.

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ii Since "traditional" may be used derogatively, representing the idea of old-fashioned or outdated, in some moments this term is used in quotation marks; in some cases, it is replaced by "consolidated". (Author's note.)

iii Some of the best known current Altmetric tools are: ImpactStory; Altmetric.com; Plum Analytics; Mendeley; Ademia.edu; and PLoS Article-Level Metrics. (Author's note.)

iv The terms "citation" and, consequently, "impact" are used in quotation marks when employed in the context of Altmetrics strictly, as it is understood they possess substantially different meanings when used in other contexts. The concepts of citation used traditionally in the areas of Bibliometrics and Scientometrics, for example, cannot be considered synonymous to those used in Altmetrics. (Author's note.)

v Now property of Thomson Reuters. (Author's note.)

vi *Qualis* is a group of procedures used by the University Level Personnel Coordinator for quality stratifications of intellectual production (highlighting scientific journals) for postgraduate programs (https://qualis.capes.gov.br).   (Author's note.)

vii The National Counsel for Research, one of the largest funding agencies in Brazil. (Translator's note.)