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Citation versus altmetrics of papers published in PLOS ONE: A comparative analysis of six countries

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ABSTRACT

With the development of open access, more scientific papers show the multi-dimensional academic impact, which makes researchers focus on the comparison between altmetrics and citations. By the use of statistical analysis, we compare the citation and altmetrics of open access papers published in PLoS in past 10 years by 6 countries which are selected in terms of regional distribution, scientific level, native language, etc., and find the following conclusions: Firstly, the level of scientific development and publication content in different countries have more effect on the 4 indicators of "citation", "save", "view" and "share" than the native language. Second, there is a significantly positive correlation between "citation" and "save" in the 6 countries, so as the "citation" and "view", while the altmetrics of "share" is just opposite. Therefore, to some extent, the altmetrics of "view" and "save" could be used to evaluate the scientific influence as a complement measurement of traditional citation metrics. Moreover, correlation coefficients between citations and part of altmetrics of the 6 countries are strong. Finally, the curve peaks of the 6 countries occurred in different years, papers published by developed countries have been active for slightly longer than that by developing countries. In detail, the "citation", "save"and "view" peaks occurred later in developing countries such as China and Brazil than in some developed countries. Besides, the "share" peak occurred after 6 or 7 years, which is similar for the 6 countries.

KEYWORDS

Open access; Citation metrics; Altmetrics; Scientific development; Publication content; Geographical area

Introduction

Traditional bibliometric analysis and peer review have formed the standard methods to assess the "scientific status of disciplines" (Chavda & Patel, 2016). The number of publications, citation frequency and h-index are traditional science measurement indicators. Since Garfield (1955) put forward citation analysis, it has received great popularity. The frequency of citation partly reflects the academic influence of research papers through the relationship of the references between them. Thus, citation analysis qualifies the quality of publications, and this makes it a good indicator to rank publications' values (Lehmann et al., 2006). It should be acknowledged that citation analysis has inherent deficiencies, such as the unclear motivation to cite, which leads to the incapability of evaluating scientific research achievements. The limita-

tion of citations on the influence evaluation of non-English journals unfairly benefits those in North America and Europe and shortchanges the scholars of the developing world (Alperin, 2013; Liang et al., 2013). However, it is still regarded as a good and common method to evaluate research impact. Citation indicators such as h-index (Hirsch, 2005), g-index (Egghe, 2006), p-index (Prathap, 2010) and other h-type indices, and journal impact factor (Garfield, 1972) have been used for research evaluation though controversial (Garfield, 1999; Leeuwen & Moed, 2005). Now, some scholars have suggested that citation is not capable to reflect broader impact (i.e., societal impact) of research (Holmberg et al., 2015), and cannot meet the requirements of scientific development in the era of Web 2.0.

In the era of Web 2.0, more scholars tend to share experiences, express ideas and disseminate research findings on different social media, such as Blogs, Twitter and Facebook. With the use of these new tools in scientific communication, traditional bibliometric analysis and peer review perform deficiently to evaluate the impact of scientific publications on social media. In this context, a new web-based metric called "altmetrics" (short for alternative metrics) was initially proposed by Priem and his collaborators in 2010, and they noted that altmetrics are the creation and research of a new kind of metrology based on the analysis and dissemination of research production in social networks (Priem et al., 2010). Altmetrics is a new metric to link research publications, which are viewed, liked, shared, downloaded, clicked, reviewed, tagged, posted, trackbacked, discussed, bookmarked, mentioned or tweeted on online platforms in almost real-time. It provides a new way of detecting the use of scientific publishing beyond formal citation (Donato, 2013). According to Work et al. (2015), altmetrics is usually based on activities on online communication platforms relating to scholars or scholarly contents. Typical examples of altmetrics include tweets, mentions in blog posts, readership counts on Mendeley or ResearchGate, likes and shares on social media such as Facebook and Google+, and recommendations and ratings on F1000. Altmetrics is usually considered as the subset of scientometrics and webometrics, and they are used to carry out Article-Level Metrics research (Stransky, 2016). According to the collected data of social media platforms, altmetrics can evaluate the popularity or social influence of publications (Chavda & Patel, 2016). As altmetrics, usage metrics, article-level metrics and other terms been proposed, impact evaluation of scholarly papers and journals cannot rely only on the amount and its citation count (Glänzel & Gorraiz, 2015; Moed & Halevi, 2015). The multi-source and multi-dimensional perspective in the measurement of research performs as the current trend.

Literature Review

Within the discussion of the relationship between citation and altmetrics, researches in traditional journals exceed that based on the new environment of Open Access (OA). Therefore, it is worthwhile to conduct a further study based on the OA papers in different cultural backgrounds. In the context of the OA movement, free online availability of scientific literature offers substantial benefits to science and society (Lawrence, 2001), and researchers can join several different websites to publicize their research productions (Thelwall & Kousha, 2016). In the early stage, the researches on the OA thesis mainly focused on its impact and advantages. Through the comparison of open access and non-open access (non-OA) (Davis et al., 2008; Joint, 2009; Moed, 2007; Norris et al., 2008), the value of open access can be comprehended. OA papers have reached or even outweighed non-OA papers in quality and influence (Hu & Chang 2008). This is a huge advantage in the sense of scientific dissemination

and the development of science & technology: each article may receive as much wider readership as possible, and does not matter whether the journal impact factor is high or low. Gargouri et al. (2010) analyzed 27,197 articles published in internationally peer-reviewed journals and found that open access had a significant effect on citations in different scientific disciplines. OA publications obtain more citations compared with those not openly accessible. From the investigation of 15 countries (Shu & Haustein, 2017), there are 14 countries in which twitter papers cited quantities excess 30% than non-twitter papers. Hence, the influence evaluation of OA papers is more closely related to the new measurement index by comparing with traditional papers.

Researches on altmetrics and their possible implications in calculating the influence of publications are becoming widespread (Bornmann & Haunschild, 2018; Bornmann et al., 2019; Chavda & Patel, 2016; Priem et al., 2010; Thelwall, 2018). Along with the deepened research gradually, scholars are attaching more importance to the correlation between citation and altmetrics (Dhiman, 2015; Ouchi et al., 2019; Peters et al., 2016; Thelwall et al., 2013; Waltman & Costas, 2014; Zhao & Wang, 2019). Some scholars investigated the correlation from different disciplines like social science, medical science, etc., while others analyzed the correlation between different kinds of altmetrics indicators and citations from other aspects. Costas et al. (2014) found that the mentions in blogs and news outlets had a relatively stronger correlation with citation than other altmetrics indicators. Eysenbach (2011) early analyzed that there was a moderate to significant positive correlation between Twitter mentions and citation indicators, and noted that social impact based on tweets are proposed to complement traditional citation metrics because social media activities could increase citations or reflect the underlying qualities of the article. Haustein et al. (2014) examined the extent to which biomedical papers are represented on Twitter and compared citations to the number of tweets containing links to these papers. There were low correlations between tweets and citations, implying that impact metrics based on tweets differ from those based on citations. Syamili and Rekha (2017) explored the correlation of citation and altmetrics based on a specific topic about "Ebola"and pointed out that the Twitter count had no correlation with citation frequency while other altmetrics values had a good correlation with it. Peters et al. (2016) surprisingly found that altmetrics had no correlation with citation, which may not correspond to the positive but relatively moderate correlation results from the study of other scholars (Thelwall et al., 2013; Waltman & Costas, 2014). Overall, it seems that altmetrics such as tweets, mentions, and readership counts (on Mendeley) might reflect the influence/impact of publications in society or the popularity/public attention, while their connection with the quality of scientific and scholarly literature (often be evaluated by the currently dominant paradigms of citation analysis) is loosely even none (Bornmann, 2015). At present, even though the use of altmetrics in measuring scientific research is still in controversy, some areas have started to apply altmetrics in their own research field to evaluate journals and get the popular magazines of their own field (Chisolm, 2017; Wang et al., 2017). The National Information Standards Organization (2016) has carried out the altmetrics assessment program, which also thought that the implication of altmetrics in the assessment of non-academic impact keeps increasing though the technical and implementation problems still remain.

In total, the citation has a positive but relatively weak correlation with altmetrics, and different kinds of altmetrics indicators have different degrees of correlation with citation. But little research concretely considered whether different cultures or regions affect the correla

tion between them. Researches on regional distribution difference often focus on geographical collaboration at the departmental, institutional and national level and the distribution of authors (Abbasi & Jaafari, 2013; Bartneck & Hu, 2010; Gorraiz et al., 2012). Few scholars in-depth discussed the differences in the correlation between citation and altmetrics among countries. Based on that, this work analyzes the relationship between citation and altmetrics of OA papers from the perspective of different countries.

Methodology

PLoS (Public Library of Science) is an open-access journal platform based on peer review. There are"citation", "view", "save" and "share" in the PLoS ALM dataset, among which the last three are altmetric indicators. The "citation" is the sum of citation count from Scopus and Crossref, the "save" is the number of Mendeley bookmarks, the "view" is the total number of page views and downloads of PLoS and PubMed Central, and the "share" is the discussion counts by Twitter and Facebook. In this article, altmetric indicators include "PLoS view'', "Mendeley save" and "Facebook share" while citation indicator is the sum of citation count from Scopus and Crossref. We selected the papers published in 6 PLoS journals from 6 representative countries between 2009 and 2018 as the sample.

Table 1 The number of papers published by the 6 countries in each year

Countries	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	SUM
Brazil	29	51	58	89	93	137	125	140	127	119	968
China	55	74	106	126	179	206	207	213	223	259	1648
Germany	174	211	212	277	334	311	349	338	195	221	2622
Japan	69	77	93	107	103	102	121	130	107	111	1020
Russia	9	9	14	13	22	13	16	14	15	19	144
USA	874	1038	1120	1282	1513	1497	1587	1450	1627	1713	13701
SUM	1210	1460	1603	1894	2244	2266	2405	2285	2294	2442	20103

These 6 journals are PLoS Biology, PLoS Computation Biology, PLoS Genetics, PLoS Medicine, PLoS Neglected Tropical Diseases, and PLoS Pathogens, which belong to the field of biomedical technology. Countries including Brazil, China, Germany, Japan, Russia, and the USA are selected, involving developing (China and Brazil) and developed (Germany, Japan, Russia, and the USA) countries. Besides, the selection of countries reflects the geography and cultural concerns: Germany is located in Europe, Russia spans the Eurasian continent, the USA and Brazil pertain to America, China and Japan belong to Asia, and the USA is the English-speaking country while other countries are not. Given that the value of "view", "save", "share" and "citation" would be changed with time, the deadline for data collection is April 19, 2019. Table 1 presents the number of papers published in PLoS journals from the 6 countries every year.

Results

Descriptive Statistics

Table 1 demonstrates that the quantity of papers from the United States is much higher

than that of the other countries, and the number of papers published by each country keeps growing though there has been a slight fluctuation in recent 5 years. Figure 1 displays the percentage of the paper published by each country every year. Although the number of papers in each country is growing, the proportion of papers published annually (based on the total number of 6 countries in this paper) varies. In Figure 1, China and Russia are on the rise, Brazil and Japan remain stable. For the United States and Germany, their figure changed differently: the former was falling until 2016, the latter was increasing instability before 2016 and decreased in the latest 2 years. Generally, as a scientifically developed country, the amount of papers published by the United States is far ahead. Germany is the second though still far behind the United States, and China is slightly more than half of Germany's, Japan is close to Brazil with the approximately annual output of 1000 or so, which are fourth and fifth respectively, Russia is the least.

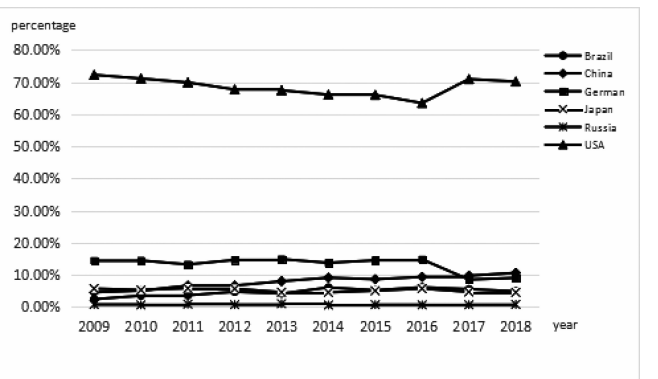

Figure 1 Percentage of papers published by each country in each year

Figure 2 contains the ratio of the United States and the other five countries in the 6 PLoS journals, which shows the advantages and disadvantages of each country in the biomedical domain. In the 6 countries, Brazil's development is extremely unbalanced, whose number of papers published in PLoS Neglected Tropical Diseases Journal surpasses the sum of the other 5 journals. China is similar to Brazil, whose number of papers published in the PLoS Genetics Journal is more than the other 5 journals. Germany's paper number in PLoS Medicine Journal is less than the other 5 journals, as do China, Japan, and Russia. The United States publishes a relatively balanced number of papers in all six journals and has an obvious advantage.

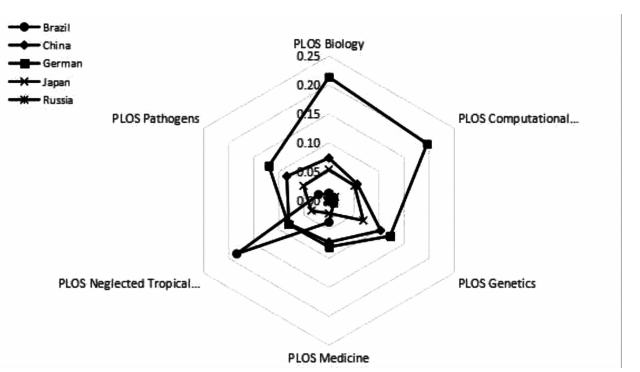

Figure 2 Distribution of publications in the 6 journals of each country

Mean and Coverage Statistics

Different kinds of altmetric indicators of PLoS papers have different coverage, which refers to the percentage of papers with non-zero data of indicators in total number of sample papers, as an important means to measure the integrity of indicators (Xia et al., 2020). Table 2 shows the mean value and coverage of the 6 countries from 2014 to 2018 and from 2009 to 2018.

Table 2 Mean(M) and coverage(C) of the "altmetrics" and "citation" of each country

Index	Item	Brazil		China		Germany		Japan		Russia		USA	
		5 Y	10Y	5 Y	10Y	5 Y	10Y	5 Y	10Y	5 Y	10Y	5 Y	10Y
View	M	5416.58	6281.54	6346.63	7147.29	6499.70	8337.70	6109.38	7424.84	8107.38	10313.30	6797.14	8342.36
	C	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Save	M	38.68	45.83	32.03	40.95	44.03	62.96	37.39	51.86	53.00	70.42	41.26	59.02
	C	0.93	0.95	0.92	0.95	0.95	0.97	0.95	0.97	0.91	0.95	0.93	0.96
Share	M	28.62	23.32	11.04	8.62	19.49	13.69	15.70	10.00	29.25	18.68	27.42	19.03
	C	0.75	0.68	0.69	0.58	0.78	0.62	0.75	0.55	0.84	0.66	0.80	0.63
Citation	M	12.33	19.14	16.30	25.85	15.49	30.78	14.40	27.98	21.40	36.56	14.05	28.27
	C	0.92	0.94	0.93	0.95	0.93	0.95	0.93	0.96	0.92	0.96	0.91	0.94

For one thing, the mean and coverage of "citation", "view" and "save" in recent 10 years are higher than or equal to that in latest 5 years, while the trend in "share" seems to be opposite, which indicates that the life cycle of "share" is shorter than that of the others, such as the papers can be twitted in several days even hours after published. The coverage of "view" in each country is 100%, which testifies that each paper published by the 6 countries has been viewed or downloaded in PLoS and PubMed Central at least once. And the coverage of "citation" is more than 91% in different countries, which presents that open access papers are easily accessible and thus cited. Only the coverage degree of "share" is relatively lower, which is no more than 85%, and there are significant differences between the latest 5 years and the recent 10 years. For another thing, when comparing citation with altmetrics of different countries in 5 years, two kinds of indicators show different performance. For example, the mean of "citation" in China is the second highest one which is next to Russia, however both the mean of "share" and "save" in China is the lowest; also the "view" in China is lower than Russia, USA, Germany; for Russia, both indicators show the highest values in the six countries, which indicate consistence. In 10 years though some rankings have changed, the two index performances are similar to that in 5 years.

Correlation analysis of Citation and Altmetrics

In this paper, we select Spearman for correlation analysis in order to deal with the presence of zero value. Spearman could fit well with data that contains numerous zeroes, and measure the underlying relationship between pairs of variables with obscuring the multidimensional relationships between variables (Thelwall & Nevill, 2018; Zhao & Wang, 2019). As is shown in Table 3, we can see that whatever the country is, "citation" has strong correlations with "view" or "save". However, the correlation between "citation" and "share" in China and Russia are not significant which means "citation" has no influence on "share" in

these two countries while the correlations in other countries are significant at the 0.05 level or at the 0.01 level though most of them have weak correlations. From the above analysis, it is clear that correlation coefficients between citations and part of altmetrics of the 6 countries are strong correlations, but different countries may cause different performances of some indicators.

Table 3 Correlation coefficients between different indexes of the 6 countries

Cor.	View	Save	Share
Citation (Brazil)	0.714556995**	0.756788094**	0.076196384*
Citation (China)	0.755038197**	0.808202254**	0.002956998
Citation (Germany)	0.735796999**	0.737906617**	–0.192310765**
Citation (Japan)	0.762207350**	0.753003825**	–0.179578338**
Citation (Russia)	0.805850672**	0.799028859**	0.040922930
Citation (USA)	0.688062988**	0.767937599**	–0.145536290**

Note: **Correlation is significant at the 0.01 level; *Correlation is significant at the 0.05 level(2-tailed).

Comparative analysis between Citation and Altmetrics for the 6 Countries

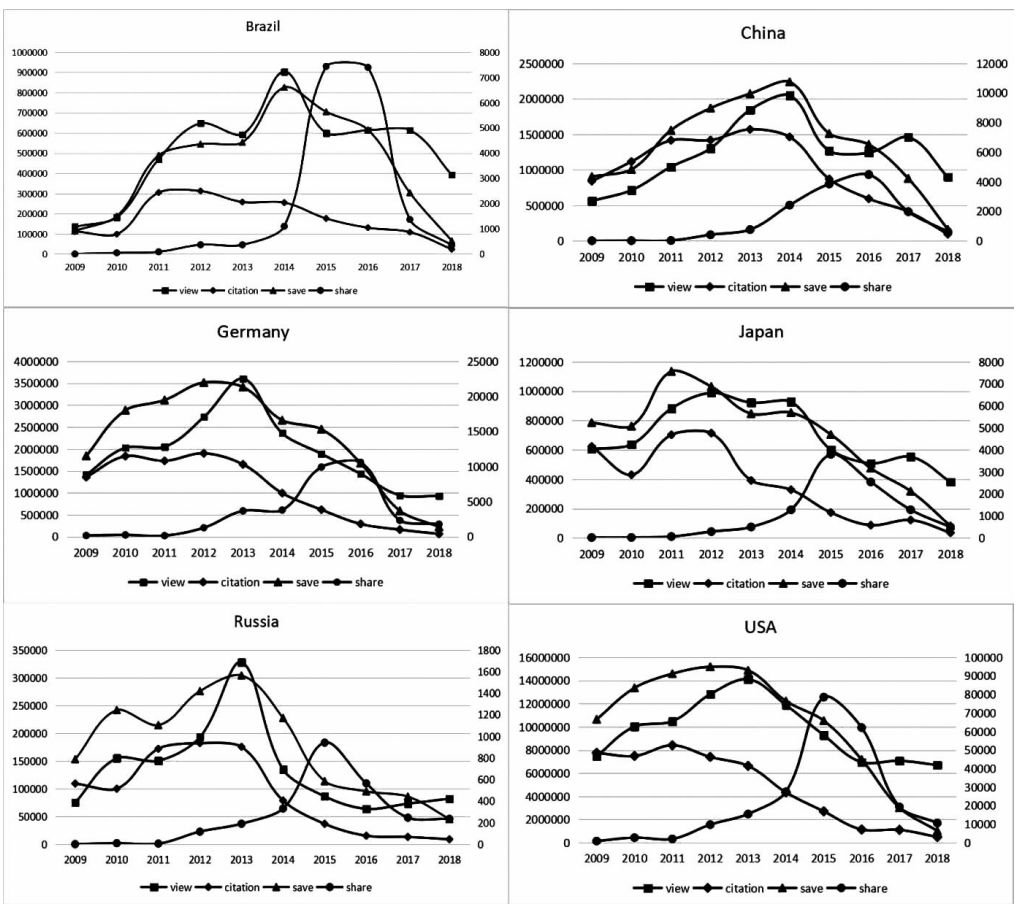

Figure 3 Changes of citation and altmetrics in 10 years for the 6 countries

In Figure 3, the curve peaks of "citation", "view", "save" and "share" of each country occurred in different years. Among them, the "citation" peak of the United States occurred in 2011, and the maximum citation age of PLoS papers published by the country is 8 years as 2019 is the observational year, i.e., these papers are active and cited in the latest 8 years after publication. Similarly, the "citation" peaks of Germany, Brazil, Japan, China, and Russia respectively occurred in 2012, 2012, 2012, 2013, 2012, accordingly, whose maximum citation age separately is 7,7,7,6,7 years. Then the "view" peaks of the United States, Germany, Brazil, Japan, China, and Russia respectively occurred in 2013, 2013, 2014, 2012, 2014, 2013, and the "save" peaks of them respectively occurred in 2012, 2012, 2014, 2011, 2014, 2013, and the curves of "share" among 6 countries reached their peaks in 2015 or 2016. We can draw Table 4 from Figure 3. As a whole, the PLoS papers for each country firstly reach the "share" peak at 3 or 4 years after publication, then reach the "save" or "view" peak after 5 or more years, and finally reach the "citation" peak.

On the other hand, though the curves of "citation", "view" and "save" nearly keep a similar fluctuation trend, differently, the peak in developing countries occurred later than that in developed countries, which shows the advantages of technology in developed countries in some degree. Also, the curves of "share" in 6 countries start to grow obviously from 2011 and reach their peaks in 2015 or 2016 (until to the date analyzed), which shows the different change from the other 3 indicators-articles published in recent 3 or 4 years have been shared more often.

Table 4 The year in which the index peak appeared in the 6 countries

Peak	USA	Germany	Brazil	Japan	China	Russia
Citation	2011	2012	2012	2012	2013	2012
View	2013	2013	2014	2012	2014	2013
Save	2012	2012	2014	2011	2014	2013
Share	2015	2016	2015	2015	2016	2015

Note: the date of collecting data is April 19, 2019.

Discussions

This article is mainly aimed to analyze citation and altmetrics, and explore whether the different geographical regions have an effect on the "citation" and "altemetrics" ("view", "save", "share"), in other words, whether there are differences between the citation performance and altmetrics indexes performance in different countries, thus to improve the quality of research evaluation. The discussion here is based on the following 3 aspects.

The influence of different geographical regions on the "citation", "altmetrics"

As shown in Table 2, the average of "citation", "view", "save" of China and Brazil are lower than that of the United States, Germany, Russia, and Japan from 2009 to 2018, the former two countries are developing countries, and the latter are developed countries. Therefore, the geographical regions affect these indicators since different countries have different development levels of science and technology, information policy, user types and habits (Costas et al., 2014; Saberi & Ekhtiyari, 2019; Thelwall, 2017), etc. But the average "share" of Brazil is the biggest among the 6 countries in 10 years period, which may be due to that Brazil published more papers in PLoS Neglected Tropical Diseases Journal than the other 5

journals. The public tends to focus on topics (e.g., infectious diseases) that are closely related to personal health. So the level of scientific development and publication content in different countries have a more significant effect on these 4 indicators than the native language. For example, with the rapid development of science and technology in China, whose mean of citation has been slightly higher than some developed countries, while the USA always has a relatively high mean of citation and altmetrics because of the great power of economy recently.

Figure 3 and Table 4 display that the peaks of "citation", "view", "save" and "share" are different among the 6 countries. For the "citation", the peak of the United States occurred in 2011, and the maximum citation age of the papers published by the United States is 8 years, i.e., these papers are active and cited in the recent 8 years after publication. The peak of China occurred the earliest among the 6 countries, whose maximum citation age is 6 years. These manifest that different geographical regions also influence the active time of papers. Papers published in developed countries have been active slightly longer than those published in developing countries.

The relationship among indicators of "citation", "altmetrics"performance

The means of the "citation", "view" and "save" of PLoS papers in recent 10 years are bigger than that in latest 5 years among the 6 countries in Table 2, which indicates that these three indicators share the common characteristic as their values all increase with the extent of publication time. However, the change in the "share" means is on the contrary. Although articles will be shared quickly after being published, they will not likely be mentioned as time goes on, i.e., the "share" is transient and timely, whose life cycle is shorter than that of the other 3 indicators.

Table 3 and Figure 3 also show that "citation", "view" and "save" have significant correlations and similar variation patterns and accumulate with time for the 6 countries, i.e., the newly published papers need a maturity period to receive more "citation" (Syamili & Rekha, 2017), "view" and "save". Hence, we could induce that the altmetrics indexes of "view" and "save" could be used to evaluate the scientific influence as a complement measurement of traditional citation analysis, though they do not reflect the same kind of impact as a citation (Costas et al., 2014). The convenience of open access platforms like PLoS and the wide appliance of online reference managers such as Mendeley, Endnote, and CiteULike have improved the availability and ability of readers to visit, read, download, save, share and cite scientific papers. Though the role of open access and online platforms in promoting the dissemination of scientific papers couldn't be ignored, we should be careful not to overstate the value of altmetrics. Barnes (2015) said that scientific assessors should recognize the limitation of altmetrics when using it to evaluate the influence of country, institution, and individual. The altmetrics indicators could reflect social influence does not mean absolutely that it is the sole measure of social influence. Scientists should have a critical view of the social media that are still not extensively used for scientific purposes and altmetrics can only be used to complement citations rather than replace them (Heydari et al., 2019; Zhao & Wang, 2019). As analyzed in this paper, the "share" has no significant correlation with citation.

The above conclusion is consistent with other findings as Mendeley reader counts have the strongest association with citation counts (Thelwall, 2017)-the value of "save" was obtained by counting Mendeley bookmarks, and other altmetric indicators include Tweet counts have a weak association with citation counts.

The analysis of the "share" performance in each country

The "share" of the PLoS platform means that the total number of a paper discussed or mentioned by Twitter, Facebook, etc. It can be seen from Table 2 that the mean of "share" of papers published in latest 5 years is more than that in recent 10 years, the curves of "share" for the 6 countries start to grow from 2011 and quickly reach their peaks in 2015 or 2016 (the date of collect data is April 19, 2019) in Figure 3. So the articles published in latest 5 years, especially in latest 3 years would be discussed easily by the users of Twitter, Facebook, etc., i.e., the life cycle of "share" of PLoS papers is short, which can be instantly tweeted after publication, while their citation needs a long time for accumulation. Moreover, the social impact of articles published within the United States is higher than OA articles published in China (Ming et al., 2021), which can be one of the reason of both mean of "share" and "save" in China is the lowest in six countries in Table 2. Considering the weak correlation between "share" and "citation" according to Table 3, we believe that the "share" of PLoS papers seemingly just reflects the attention/mention of the user rather than the academic influence.

Conclusions

This paper makes an analysis and comparison of the Article-Level Metrics data of OA documents published in PLoS series journals by different countries. Choosing the USA, Germany, Japan, Russia, Brazil, and China as research objects and exploring whether the differences of geographical regions have an influence on the relationship between altmetrics and citation indicators. We obtain the following conclusions: First, the geographical regions have an effect on the value of "citation", "view", "save" and "share" due to different development levels of science and technology, information policy, user types and habits (Costas et al., 2014; Saberi & Ekhtiyari, 2019; Thelwall, 2017), etc. in different countries. Indicators of papers published by scholars in developing countries are inferior to those in developed countries. And the curve peaks of 6 countries occurred in different years, papers published by developed countries have been active for slightly longer than that by developing countries. Besides, there are different forms of changing with time for the four indexes according to Figure 3, such as the PLoS papers for each country firstly reach the "share"peak at 3 or 4 years after publication, then reach the "save" or "view" peak after 5 or more years, and finally reach the "citation" peak. Second, in the 6 countries, there is a significantly positive correlation between "save" and "citation", so as the "view" and "citation". They accumulate with time and have similar variation patterns, while the "share" shows the difference, which has a weak even none correlation with citation. Therefore, to some extent, the "view" and "save" could be used to evaluate the scientific influence of papers as a complementary measurement of traditional citation analysis. For example, extending the author-based influence measurement to the reader's range. And the "share" of PLoS papers seemingly just reflects the attention/mention of the user rather than the academic influence because it is transient and uncorrelated with the citation.

Yet, limitations do exist in our research. The quantity and discipline of the sample papers in this article are not extensive enough because we just choose papers published in PLOS ONE in the biomedical technology field which just can be easy acess to and cannot represent all of open acess papers.Next, the evaluation of open access papers from different online platforms, disciplines and periods, etc. would be conducted in our further researches. Moreover, we'll continually discuss and focus on the factors that influence the relationship between ci-

tation and altmetrics of open access papers in different geographical areas in the future.

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