Title	Exploring prestigious citations sourced from top universities across disciplines
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Citation	Luo, F., Sun, A., Erdt, M., Raamkumar, A. S., & Theng, Y.-L. (2017). Exploring prestigious citations sourced from top universities across disciplines. Proceedings of the Association for Information Science and Technology, 54(1), 251-259.
Date	2017
URL	http://hdl.handle.net/10220/44022
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Exploring Prestigious Citations Sourced from Top Universities across Disciplines

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ABSTRACT

There have been many studies on the factors influencing paper citation counts. A number of studies have focused on the citing papers, and corresponding methods were proposed to measure the prestige of citations based on the journal impact factors, the total citation counts and the PageRank algorithm values. However, there are drawbacks to these methods. In this paper, we proposed a novel method to identify prestigious citations from the affiliation of the citing paper. Specifically, if the authors of the citing paper are affiliated with a prestigious university, the citing paper could be counted as a prestigious citation. As a pilot, we used the top 200 universities on the QS World University Rankings 2015 to identify the prestigious universities so that the prestigious citations, named as QS citations, were identified accordingly. Experimental results validated that QS citations have more important impact on the cited papers than other citations. Papers with QS citations have better performance across most disciplines not only in total citation counts, but also in altmetrics such as the Altmetric Attension Score and Mendeley reader counts.

Keywords

citation analysis, university ranking, altmetrics, citation counts, QS citations

INTRODUCTION

Citation counts have been one of the most dominant indicators in assessing the impact of articles, researchers, journals and affiliations. Many researchers have been engaged in exploring the factors which affect citation counts. On the one hand, a number of researches have concentrated on the factors related to the papers such as the number of authors and the journal impact factor (Tahamtan et al., 2016; Aksnes, 2003; Khor & Yu, 2016; Didegah & Thelwall, 2013; Filion & Pless, 2008). These studies can be classified to two main categories. The first category of studies investigated the relationship between citation counts and the related factors (Bornmann et al., 2012; Slyder et al., 2011; Kulkarni et al., 2007; Didegah & Thelwall, 2013), while the other category predicted future citation counts using statistical regression approaches or progressively improved machine learning techniques with the related factors as input (Stegehuis, Litvak, & Waltman et al., 2015; Yu et al., 2014; Brizan et al., 2016; Chen, 2012). The findings from these studies showed that the impact of the related factors varied across disciplines. An influential factor in a particular discipline could be much less important in another discipline.

On the other hand, there were studies which focused on the citing papers instead of the cited papers (Chen et al., 2007; Ding & Cronin, 2011; Yan & Ding, 2010; Habibzadeh & Yadollahie, 2008; Bollen, Rodriquez, & Sompel, 2006). A citation can be considered as a scholarly vote, and thus these researchers held that the weight of citations should be differentiated to reflect the prestige of the citing paper (Ding & Cronin, 2011; Yan & Ding, 2010). According to Tahamtan (2016), the citation count of a paper could be influenced by its citing papers as the citing papers increase the cited paper's visibility and subsequently induce further citations. Hence, one can assume that a prestigious citation would have a more important impact on the cited paper than a less prestigious citation.

For measuring the prestige of citations, primarily three different ways have been proposed in the previous studies. However, there are drawbacks in all the three methods. The first method relies on the impact factors of the citing journals (Yan & Ding, 2010; Habibzadeh & Yadollahie, 2008). In this way, the possible flaws of journal impact factors such as the skewed distribution across all disciplines, would be subsequently propagated. Besides, impact factors are not available for conference proceedings, while proceeding papers also play a critical role in some disciplines such as computer science. The second method uses the citation counts of the citing paper (Ding & Cronin, 2011; Yan, Ding, & Sugimoto, 2011). One concern of this method is that the

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citing papers need to accumulate citations before they can become eligible as a highly-cited paper and eventually become a prestigious citation. The last method constructs a paper citation network and then applies the PageRank algorithm to evaluate the papers (Chen et al., 2007; Liu et al., 2005; Yan, Ding, & Sugimoto, 2011). Potential problems in this method include computing complexity and dynamic network structure caused by newly published papers.

In this paper, we proposed a novel method to identify prestigious citations. We postulated that a prestigious citation can be defined by the affiliation of the citing paper. Specifically, if the authors of the citing papers are affiliated with a prestigious affiliation, the citing papers could be counted as prestigious citations. An explicit advantage of our proposed method is that once the citing paper is published, it can be identified whether it is a prestigious citation or not. Complicated calculations are not required in our proposed method, and more importantly, our method does not suffer from the drawbacks mentioned above in the previous three methods. Furthermore, as will be shown in the following experiments, the prestigious citations identified by our method could be applied to all disciplines.

In order to evaluate our proposed method, we used the top 200 universities on the QS World University Rankings 2015[1] in our study to identify prestigious affiliations so that the prestigious citations could be identified accordingly. These prestigious citations are referred to as *QS citations* in this paper. Comparative experiments are designed to detect and analyse the relationship between QS citations and total citation counts for papers. Additionally, since altmetrics have attracted increased attention as an alternative measure of impact (Costas, Zahedi, & Wouters, 2015; Bornmann, 2015; Erdt et al., 2016), we also analysed the relationship between QS citations and the Altmetric Attention Score[2] provided by Altmetric.com[3], and the relationship between QS citations and Mendeley[4] reader counts. Therefore, the following research questions (RQs) were investigated in this study:

- **RQ1**: Do papers with QS citations outperform papers without QS citations in terms of total citation counts across disciplines?
- **RQ2**: Do papers with QS citations outperform papers without QS citations in terms of the Altmetric Attention Score and Mendeley reader counts across disciplines?

In the following sections, we present related work, followed by a description of the methodology applied, explaining how the data was collected and how the experiments were designed. We then present the results and conclude with a discussion and future work section.

RELATED WORK

As mentioned in the previous section, there are two main sets of studies on the factors influencing citation counts. The first set of studies investigated the relationship between the factors and the citation counts, and in the second set, statistical or machine learning techniques were used to predict future citation counts based on the factors. A recent literature review by Tahamtan et al (2016), summarized 28 related factors from 198 relevant papers. They classified the factors into three categories: paper related factors, journal related factors, and author related factors. They found that several factors such as the journal impact factor and the number of authors could be more important than other factors in the growth of citation counts. In addition, the relationship between social media factors and citation counts have also been investigated. Erdt et al. (2016) give an overview of studies comparing altmetrics with citations, with a meta-analysis showing low to medium correlations between most altmetrics and citation counts, thereby confirming the findings in a previous meta-analysis by Bornmann (2015) investigating studies on Twitter[5], Mendeley, CiteULike[6] and blogs.

Moreover, many researchers have studied the impact of related factors in some disciplines. Slyder et al. (2011) examined the influence of seven different factors in geography and forestry disciplines, in which the seniority of author and journal impact factor have shown stronger impacts on the citation counts. In chemistry discipline, according to Bornmann et al. (2012), there were correlations between citation counts and four factors: the citation performance of the cited references, the language of the publishing journal, the chemical subfield, and the reputation of the authors, but no statistically significant correlation was detected between citation counts and number of authors. As for medical research fields, Kulkarni et al. (2007) found the industry related factors, such as declared industry funding, were the most impactful factors. A study by Costas, Zahedi, & Wouters (2015) found the highest presence of altmetrics in the fields of social sciences, humanities, medical and life sciences, but the relationship between citation counts and altmetrics remained weak, implying that altmetrics might measure a different aspect of impact than citations. Haustein et al. (2014) also measured low correlations between citation counts and tweets in the medical research fields. Another study by Mohammadi & Thelwall (2014) found low to

[1]https://www.topuniversities.com/university-rankings/world-university-rankings/2015

[2]https://www.altmetric.com/blog/the-altmetric-score-is-now-the-altmetric-attention-score/

[3]https://www.altmetric.com

[4]https://www.mendeley.com

[5]https://twitter.com

[6]http://www.citeulike.org

medium correlations between citation counts and Mendeley reader counts across several disciplines.

Furthermore, when researchers predicted future citation counts, different sets of factors were selected based on the predictive model. In a study by Stegehuis et al. (2015), a quantile regression approach was employed with the journal impact factor and the first year citation counts as input, to predict the long term citation impact. Brizan et al. (2016) converted the prediction to a binary classification problem. They extracted six categories of 48 factors from the papers and then input them into the well-known classifiers such as Random Forest and SVM. Yu et al. (2014) built a predictive model based on regression analysis of 24 chosen factors.

From all these previous studies, we observe that a wide range of factors have been covered. However, only a few were concerned about the citations, i.e., the citing papers, and the prestigious citations defined by the affiliations as proposed in this paper have never been discussed. Furthermore, most of the studied factors have varied extents of impact in different disciplines. As the number of authors, while it was concluded as a stronger factor in the literature review (Tahamtan et al., 2016), it did not correlate with citation counts in chemistry (Bornmann et al., 2012).

In the prestigious citation studies, the 'prestige' was quantified primarily in three different ways. Yan & Ding (2010) held that the prestige of citing journal and citation time interval should be considered, and thus designed a formula to calculate weighted citations based on the impact factors of citing journals and publication time of the citing papers. In the study by Ding & Cronin (2011), prestige was defined by the citation counts of citing papers. Besides, Chen et al. (2007) constructed a paper citation network, and applied the PageRank algorithm to the network. The citation prestige is intrinsically involved in the algorithm. Compared to the three methods, our proposed prestigious citations identified by the affiliations have the following advantages: easy recognition, simple calculation and applicability to all disciplines. Specifically, it can be determined whether it is a prestigious citation as soon as the citing paper is published. The method does not require complex calculation such as PageRank algorithm. In addition, it will be shown in the following experiments that the method is applicable to all disciplines.

METHODOLOGY

The overall aim of this study was to investigate the impact of QS citations on papers across different disciplines from the dual perspectives of bibliometrics and altmetrics. In order to answer RQ1, comparisons on total citation counts were made between papers with QS citations and papers without QS citations. To answer RQ2, similar comparisons were made on the Altmetric Attention Score and the Mendeley reader counts between papers with QS citations and papers without QS citations. The following sections will describe the data used in our study, and the experiment design will be subsequently explained.

Data collection

This study considered four data sources: (1) Microsoft Academic Graph (MAG) dataset (Sinha et al., 2015), (2) QS World University Rankings 2015 (QS ranking), (3) Scopus source list[7], and (4) Data collected from Altmetric.com. The MAG dataset was our main data source, from which we retrieved papers, related citing papers, authors and the affiliations of the authors. The MAG dataset version used in this paper, was released on 5th February 2016. Since most of the papers contained in the MAG dataset were published before 2016, the QS ranking list for year 2015 was utilized in our study. The Scopus source list contains all research journals indexed in Scopus, and also classifies them into different disciplines. The Scopus source list is updated three times a year, and the version used in our study was downloaded in February 2017. As for the altmetric data, it was collected via an official API provided by Altmetric.com.

Data from MAG dataset

In the Scopus source list, there are 26 disciplines along with a generic entry called as General (GEN) which includes multidisciplinary journals such as *Science* and *Nature*. A mapping of journal entries was made between the Scopus source list and the MAG dataset, and then according to these mapped journals, we retrieved related papers as well as their citing papers from the MAG dataset for all disciplines. Table 1 shows the numbers of mapped journals and retrieved papers for each discipline. It is to be noted that some journals were classified into multiple disciplines in the Scopus source list, and thus related journals and papers were duplicated. The papers that have never been cited were not considered in our study. Another mapping of affiliation entries was made between the QS ranking and the MAG dataset. If a university was one of the top 200 universities on the QS ranking, it was referred to as a *QS university*. Consequently, each citation can be identified as a *QS citation* or *non-QS citation*, according to the affiliation of the first author of the citing paper.

Data from Altmetric.com

Since Altmetric.com was founded in 2011, the papers with DOIs that were published between 2011 and 2013 were considered for collecting altmetric data. The numbers of these considered papers and related journals for each discipline are presented in Table 1. However, it would be intensely time consuming if we collected altmetric data for all 5,547,742 papers. Therefore, we made a stratified sampling based on the number of papers per discipline, and obtained a paper sample of size 100,000. The number of sampled papers for each discipline is also shown in Table 1. For example, with Agricultural and Biological Sciences

[7] https://www.elsevier.com/solutions/scopus/content

Scopus Discipline	# of Journals	# of Papers	Papers with DOI Published between 2011 and 2013 for Altmetric Data Collection		
			# of Journals	# of Papers	# of Sampled Papers (N = 100,000)
Agricultural and Biological Sciences (AGRI)	1,385	3,712,125	1,114	339,281	6,116
Arts and Humanities (ARTS)	1,934	2,538,486	1,193	44,855	809
Biochemistry, Genetics and Molecular Biology (BIOC)	1,419	7,134,763	1,283	637,537	11,492
Business, Management and Accounting (BUSI)	847	832,677	763	90,706	1,635
Chemical Engineering (CENG)	633	4,853,863	538	344,676	6,213
Chemistry (CHEM)	364	1,636,927	315	159,620	2,877
Computer Science (COMP)	1,013	1,567,820	923	174,802	3,151
Decision Sciences (DECI)	244	389,949	223	31,775	573
Dentistry (DENT)	107	289,642	98	22,696	409
Earth and Planetary Sciences (EART)	673	1,947,342	579	153,393	2,765
Economics, Econometrics and Finance (ECON)	630	793,170	558	49,191	887
Energy (ENER)	190	698,310	171	74,084	1,335
Engineering (ENGI)	1,439	3,946,128	1,251	393,842	7,099
Environmental Science (ENVI)	813	1,825,014	706	181,120	3,265
General (GEN)	65	712,424	46	29,947	540
Health Professions (HEAL)	271	508,011	238	33,268	600
Immunology and Microbiology (IMMU)	381	1,556,296	334	143,670	2,590
Materials Science (MATE)	704	3,415,533	569	282,391	5,090
Mathematics (MATH)	974	2,308,453	867	161,686	2,914
Medicine (MEDI)	4,073	15,066,308	3,586	1,162,438	20,951
Neuroscience (NEUR)	390	1,599,651	367	141,109	2,544
Nursing (NURS)	355	723,835	326	57,921	1,044
Pharmacology, Toxicology and Pharmaceutics (PHAR)	453	1,654,308	396	125,863	2,269
Physics and Astronomy (PHYS)	774	6,040,032	705	405,952	7,317
Psychology (PSYC)	870	1,328,573	745	94,023	1,695
Social Sciences (SOCI)	3,608	4,530,485	2,751	181,282	3,268
Veterinary (VETE)	164	404,876	106	30,614	552
Total	24,773	72,015,001	20,751	5,547,742	100,000

Table 1. Numbers of mapped journals, retrieved papers, and sampled papers for altmetric data collection.

(AGRI) discipline, there were 339,281 papers considered for altmetric data collection, accounting for 6.116% over 5,547,742 considered papers. The overall sample size is set as 100,000, and thus 6,116 papers were sampled for this discipline.

Experiments

To address RQ1 and RQ2, a series of comparative experiments were designed. In each experiment, papers were classified into different groups so that differences could be observed and analyzed to better understand the impact of QS citations. All 72,015,001 papers were divided into two groups based on whether they had QS citations or not. A paper with at least one QS citation was referred to as a *QS-Ci paper*, otherwise it was a *non-QS-Ci paper* as it had no QS citation. Besides, it was found in the literature review that papers from highly-ranked universities had more citations (Tahamtan et al., 2016). Thus, for comparisons to *QS-Ci papers*, all papers were also classified based on affiliation, i.e., whether the affiliation entry was a QS university or not. A paper from a QS university was referred to as a *QS-Pub paper*, otherwise as a *non-QS-Pub paper*. It is to be noted that a *QS-Ci paper* is identified by its citation, while a *QS-Pub paper* is by itself. A *QS-Ci paper* is not necessarily a *QS-Pub paper* and vice versa. For a better comparison, *QS-Ci papers* were further split into groups based on whether they were from QS universities or not, hence two more groups were created: (1) *QS-Pub & QS-Ci papers*, which consisted of papers that were published by QS universities and had QS citations; (2) *non-QS-Pub & QS-Ci papers*, which consisted of papers that were published by other universities other than QS universities and had QS citations. When comparing citation performance amongst groups of papers, the median of total citation counts for each group was utilized.

We also investigated the difference in impact linked to QS citations and non-QS citations. We examined if a QS citation really had more important impact on the cited paper than a non-QS citation. If a QS citation and a non-QS citation have similar or even identical impact on the cited papers in terms of total citation counts, it should be observed that with comparable counts of QS citations and non-QS citations, the papers should have a comparable citation performance, i.e., the total citation counts for these papers should be almost the same. For instance, if Paper A has 11 QS citations and Paper B has 12 non-QS citations, it should be observed that the two papers have approximately similar total citation counts. However, if a considerable difference in total citation counts was observed, it could be inferred that QS citations and non-QS citations have distinctively different impact. Therefore, based on the number of QS citations and the number of non-QS citations, papers were classified into two groups and each group had seven count ranges: 1 to 5, 6 to10, 11 to 15, 16 to 20, 21 to 25, 26 to 30, and 30 to the maximum. For example, Paper A with 11 QS citations belongs to QS group at the range 11 to 15, while Paper B with 12 non-QS citations belongs to non-QS group at the same range 11 to 15. It is to be noted that when classifying the papers, the QS citation counts and the non-QS citation counts were considered, but when comparing citation performance between the groups, the medians of the total citation counts of the groups were considered.

Regarding altmetrics, the altmetric data we collected from Altmetric.com via the official API included not only the Altmetric Attention Score, but also Mendeley reader counts, tweet counts and others. The Altmetric Attention Score is calculated and provided by Altmetric.com for each indexed paper. It is an aggregated value, which is intended to measure the online influence of the paper based on the collected social media metrics (e.g., tweet counts, blog mentions). In our study, the Altmetric Attention Score, and Mendeley reader counts were considered in the comparison amongst the groups of *QS-Pub papers*, *non-QS-Pub papers*, *QS-Ci papers* and *non-QS-Ci papers*, since the coverage of other metrics was too low for analysis.

RESULTS

Addressing RQ1, the citation performance of *QS-Ci papers* and *non-QS-Ci papers* are illustrated using a column chart in Figure 1. Each column in Figure 1 denotes the median of the total citation counts for the paper group and discipline. It can be observed that, across all disciplines, the *QS-Ci papers* had higher citation counts than *non-QS-Ci papers*. Specifically, the values for *QS-Ci papers* were approximately four times higher than the values for *non-QS-Ci papers*.

Citation performance of *QS-Pub papers*, *non-QS-Pub papers*, *QS-Pub & QS-Ci papers*, and *non-QS-Pub & QS-Ci papers* are illustrated in Figure 2. The columns in Figure 2 also denote the medians of total citation counts. It can be observed that for 21 out of 27 disciplines, *QS-Pub papers*

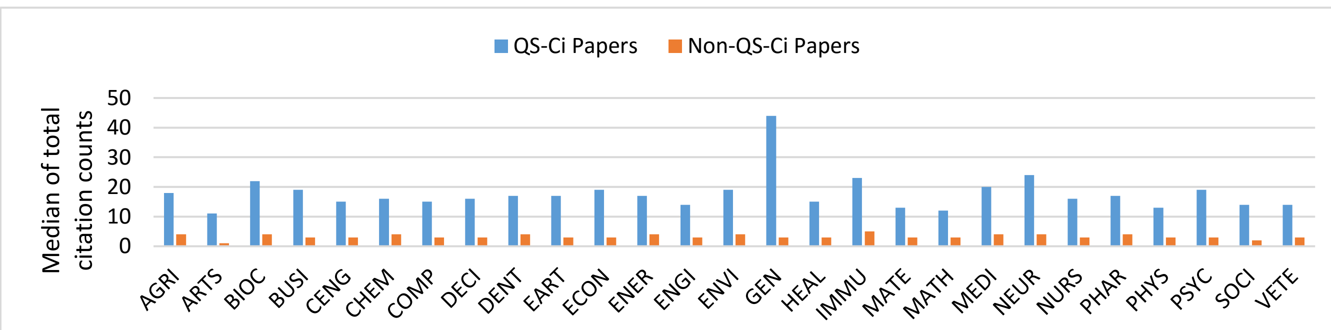

Figure 1. Citation performance of QS-Ci and non-QS-Ci papers across disciplines.

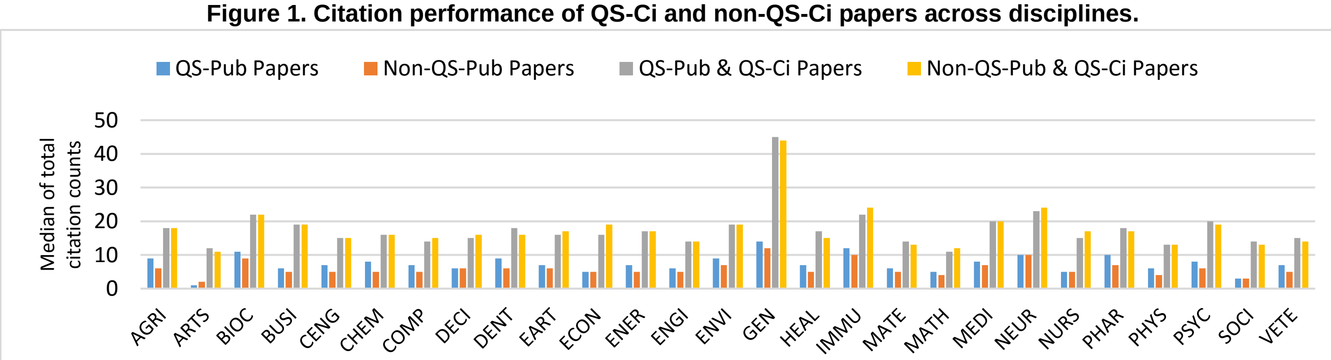

Figure 2. Citation performance of QS-Pub, non-QS-Pub, QS-Pub & QS-Ci and non-QS-Pub & QS-Ci papers.

had more citations than *non-QS-Pub papers*, which is in accordance with the finding in previous studies (Tahamtan et al., 2016), while there were exceptions in 6 disciplines such as Arts and Humanities (ARTS) and Decision Sciences (DECI). However, when only *QS-Ci papers* were considered, as seen in the last two columns for each discipline, *QS-Pub & QS-Ci papers* did not show stronger performance than *non-QS-Pub & QS-Ci papers*. This means if a paper received QS citations, it could have relatively higher citation counts even though it was not from a highly-ranked university. Furthermore, the last two columns were higher than the first two columns across all disciplines, which means papers with higher citation counts in the first two groups were identified by QS citations.

The citation impact comparison between QS citations and non-QS citations is illustrated in Figure 3. For each

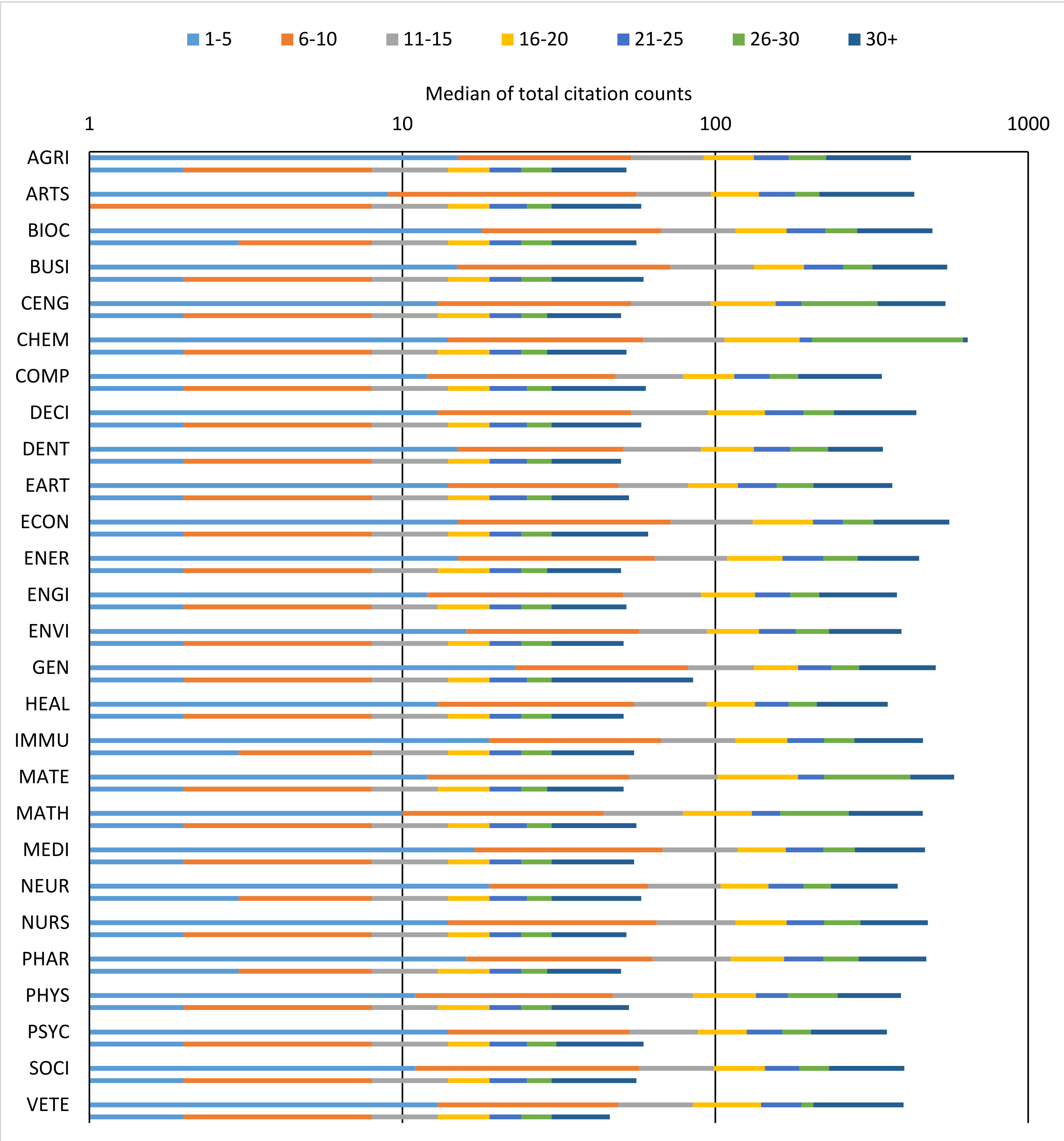

Figure 3. Citation impact comparison between QS citations (upper bar) and non-QS citations (lower bar).

discipline, the upper bar indicates the median values of the total citation counts for the different groups of papers that were allocated by the QS citation counts, while the lower bar indicates the median values for papers grouped by the non-QS citation counts. Let us take Biochemistry, Genetics and Molecular Biology (BIOC) as an example. As seen in Figure 3, for papers that had 1 to 5 QS citations, the median of the total citation counts was slightly higher than 10, and for papers that had 6 to 10 QS citations, the median of the total citation counts was close to 100. In contrast, for papers that had 1 to 5 non-QS citations, the median of the total citation counts was lower than 10, and even for papers that had 6 to 10 non-QS citations, the median of the total citation counts was still lower than 10. Similar patterns are observed across all disciplines. Therefore, in answer to RQ1, it was detected that QS citations and non-QS citations have distinctly different impact. The QS citations were clearly associated with papers that had higher total citation counts. From the perspective of Altmetrics, and in answer to RQ2, the results of comparison on the Altmetric Attention Score amongst the *QS-Ci, non-QS-Ci, QS-Pub and non-QS-Pub papers* are presented in Figure 4, and the comparison results on Mendeley reader counts amongst the 4 groups of papers are presented in Figure 5. The columns in both Figure 4 and Figure 5 denote the average values of the groups. As shown in Figure 4, overall, the values of the Altmetric Attention

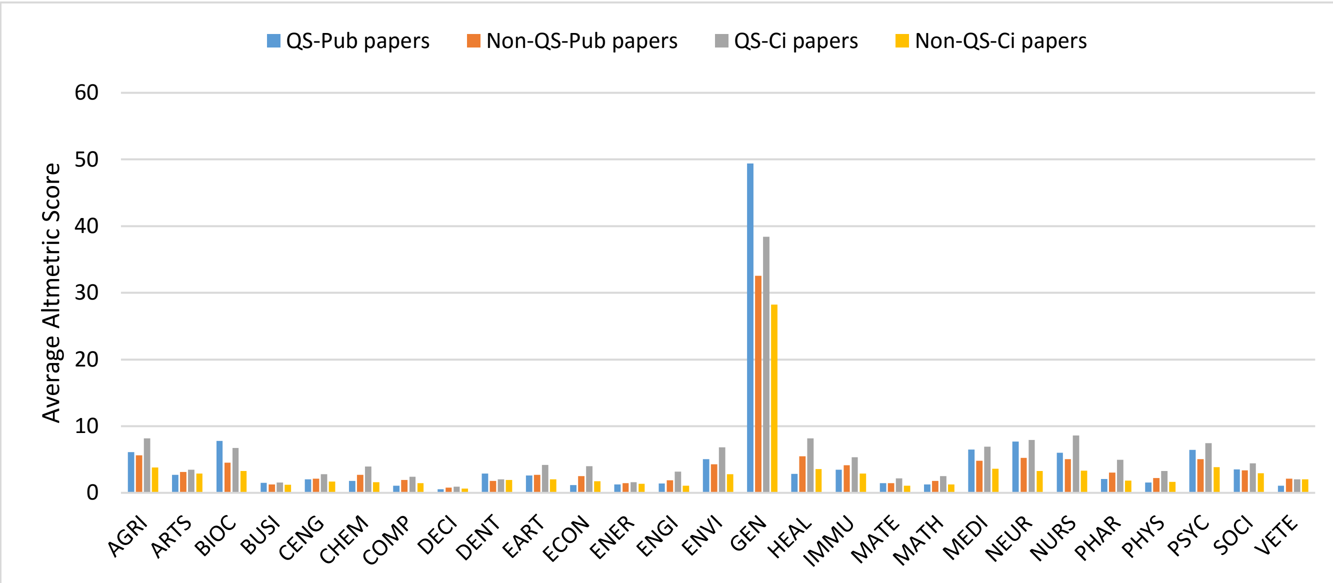

Figure 4. Altmetric Attention Score comparison amongst QS-Pub, non-QS-Pub, QS-Ci and non-QS-Ci papers.

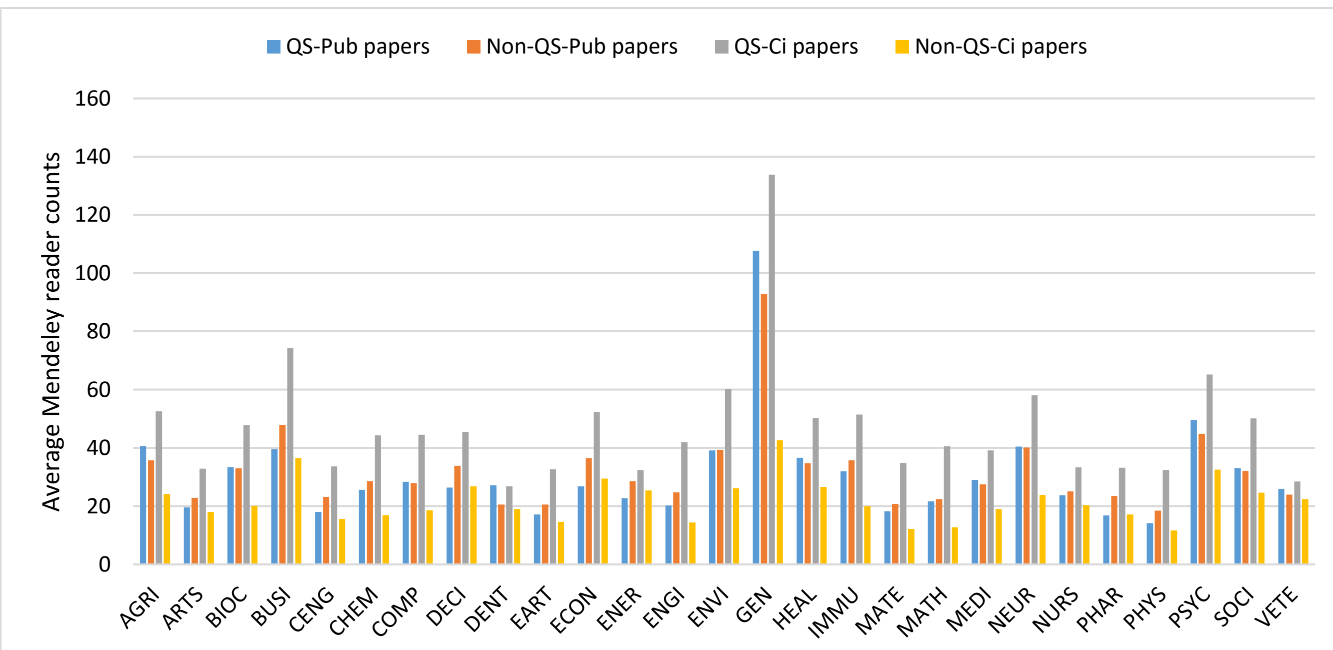

Figure 5. Mendeley reader counts comparison amongst QS-Pub, non-QS-Pub, QS-Ci and non-QS-Ci papers.

Score for most disciplines were low, except for General discipline (GEN) which contains the most influential journals such as *Science* and *Nature*. When comparing the four paper groups within the same discipline, the *QS-Pub papers* in the three disciplines Biochemistry, Genetics and Molecular Biology (BIOC), Dentistry (DENT) and General Discipline (GEN) had the highest values, the *non-QS-Pub papers* in Veterinary (VETE) had the highest value, while the *QS-Ci papers* had the highest values across the remaining 23 disciplines. In addition, across all disciplines, *QS-Ci papers* had higher values than *non-QS-Ci papers*. However, this pattern cannot be observed between *QS-Pub* and *non-QS-Pub papers*.

In Figure 5, the Mendeley reader counts are displayed. Overall, the values of Mendeley reader counts are higher than the values of the Altmetric Attention Score. Similar to Figure 4, the four paper groups in General discipline (GEN) had highest values, compared to other disciplines. When comparing the four paper groups within the same discipline, *QS-Ci papers* had highest values across all disciplines, and *non-QS-Ci papers* had lowest values in most disciplines except for Decision Sciences (DECI), Economics, Econometrics and Finance (ECON), Energy (ENER) and Pharmacology, Toxicology and Pharmaceutics (PHAR). Furthermore, in both figures, almost for all disciplines, the difference between *QS-Ci* and *non-QS-Ci papers* was larger than the difference between *QS-Pub* and *non-QS-Pub papers*. Therefore, answering RQ2, it was illustrated that QS citations were also associated with the papers that had higher values in Altmetrics.

CONCLUSION

In this paper, we proposed to identify prestigious citations by the affiliations of the citing papers. Our claim was that citations could be considered as prestigious citations, if the authors of the citing papers are affiliated with prestigious universities. In order to evaluate our proposed method, we used the top 200 universities on the QS World University Rankings 2015 to identify the prestigious citations, named QS citations. A series of comparative experiments were designed across most disciplines. Results from the experiments in our study demonstrated that papers with QS citations had considerably higher total citation counts than papers without QS citations. Besides, findings also showed that the QS citations had distinctly different impact, compared to the non-QS citations. In fact, papers with a certain number of QS citations had higher total citation counts than papers with a comparable number of non-QS citations. While absolute numbers were used in the comparison in this paper, we will compare the impact of QS citations and non-QS citations based on percentiles in future work. Furthermore, from the perspective of altmetrics, papers with QS citations also had stronger performance in terms of the Altmetric Attention Score and Mendeley reader counts. It is to be noted that these findings were observed across all disciplines. Therefore, our proposed method identifying prestigious citations by the affiliations of the citing papers can be considered to be well validated. This approach is not only effective and efficient, but also applicable to all disciplines. While the QS ranking was employed in this paper, it is reasonable to infer that prestigious citations identified using other university ranking schemes should have similar impact. One limitation of using universities to identify prestigious citation is that some influential researchers who are affiliated with less prestigious universities or research centers might be overlooked. In future studies, we will address this issue. We also plan an in-depth investigation into the relationship between QS citations and total citation counts, with the aim of developing an effective model for predicting future citation counts of papers.

ACKNOWLEDGMENTS

This research is supported by the National Research Foundation, Prime Minister's Office, Singapore under its Science of Research, Innovation and Enterprise programme (SRIE Award No. NRF2014-NRF-SRIE001-019).

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