Received: 9 November 2020 | Revised: 26 July 2021 | Accepted: 9 August 2021

DOI: 10.1002/asi.24569

RESEARCH ARTICLE

JASIST WILEY

Measuring the citation context of national self-references

Liyue Chen[1,2] | **Jielan Ding**[1,2] | **Vincent Larivière**[3]

[1]National Science Library, Chinese Academy of Sciences, Beijing, China

[2]Department of Library, Information and Archives Management, School of Economics and Management, University of Chinese Academy of Sciences, Beijing, China

[3]École de Bibliothéconomie et des Sciences de l'information, Université de Montréal, Québec, Canada

Correspondence
Vincent Larivière, École de Bibliothéconomie et des Sciences de l'information, Université de Montréal, 3150 rue Jean-Brillant, Montréal, Québec H3T 1N8, Canada.
Email: vincent.lariviere@umontreal.ca

Abstract

The emphasis on research evaluation has brought scrutiny to the role of self-citations in the scholarly communication process. While author self-citations have been studied at length, little is known on national-level self-references (SRs). This paper analyses the citation context of national SRs, using the full-text of 184,859 papers published in PLOS journals. It investigates the differences between national SRs and nonself-references (NSRs) in terms of their in-text mention, presence in enumerations, and location features. For all countries, national SRs exhibit a higher level of engagement than NSRs. NSRs are more often found in enumerative citances than SRs, which suggests that researchers pay more attention to domestic than foreign studies. There are more mentions of national research in the methods section, which provides evidence that methodologies developed in a nation are more likely to be used by other researchers from the same nation. Publications from the United States are cited at a higher rate in each of the sections, indicating that the country still maintains a dominant position in science. On the whole, this paper contributes to a better understanding of the role of national SRs in the scholarly communication system, and how it varies across countries and over time.

1 | INTRODUCTION

The rising emphasis on research evaluation has brought greater scrutiny to the role of self-citations at various levels. Research found a recent increase in national self-citation rates (e.g., Jaffe, 2011), although the same could not be said for self-references (SRs) (Khelfaoui et al., 2020). Although a previous study suggested that national self-citations were influenced by many factors, including political, cultural, and geographic elements (Bakare & Lewison, 2017; Ladle et al., 2012), there is little research on national self-citing motivations. Self-citations have often been regarded as an inherently negative attribute of scholarly communication. It has even been considered, when done excessively, as a form of misconduct (MacRoberts & MacRoberts, 1989).

There is tremendous ambiguity in the interpretation of self-citations. At the individual level, one may consider that a moderate amount of self-citations is normal on the grounds that science is cumulative (Phelan, 1999)—one should refer to past work and their own work, which is likely to most topically relevant to their present work. Similar justifications could be made for national-level self-citations: if research is done in the interest of a country, the work of that country has a higher probability of relevance. However, there can also be normative violations of Mertonian ideals (Merton, 1973): citing a piece simply because of a higher awareness of national research than of international research (passive violation of Mertonian ideals) or citing to raise the citation impact of national research (active violation of Mertonian ideals).

The recent increase in the availability of full-text article data provides an opportunity to explore in-depth some features of self-citations and better understand how those can inform research evaluations. In this paper, we provide a novel examination of national self-citations and test the degree to which they are normatively problematic

by analyzing their citation context, based on their in-text mention, enumeration—multiple references mentioned together in an enumerative citance, and location features. We focus not only on the general patterns of national self-citing behavior but also compare these across various countries. Following the typology of diachronous and synchronous self-citations developed by Lawani (1982), our study focuses on the latter, which are the self-citations (references) a country gives. Hence, national self-citation in this research is labeled SR—that is, of all references made, the proportion that goes to other research from the same country. References made to research from other countries are labeled as nonself-references (NSRs).

Three research questions are considered:

1. Do national SRs differ from NSRs in their in-text mentions?
2. Is there a difference in the enumerative behavior of national SRs and NSRs? For example, are national SRs are more prone to appear in enumerative citances?
3. Are national SRs more likely to be located in specific sections of publications?

To answer these questions, we designed multiple indicators based on these three in-text features to reflect the behavioral differences between national SRs and NSRs, aiming to get a better understanding of the role of SRs in the scholarly communication system.

2 | RELATED WORK

2.1 | National self-citations

Citing oneself is quite common in science. Due to the cumulative nature of research, self-citations are considered natural and informative (Phelan, 1999). Self-citations (SRs) can be defined in different ways, including author self-citations (i.e., a publication of to which an author has contributed cites another publication on which that person is also an author), journal self-citations (i.e., an article in a given journal cites another article from the same journal), institutional self-citations (i.e., a publication from one institution cites another from the same institution), and national self-citations (i.e., a publication from a country cites another publication from the same country).

Many studies have investigated the motivations and factors for various levels of self-citation. For instance, at the author level, self-citations could be done for as researchers are building on earlier work, to identify related work (Bonzi & Snyder, 1991), to persist the importance of own theory (Gorry & Aichouchi, 2017), or as a result of egotism (Lawani, 1982). Recent studies found that self-citation is a typical behavior of those productive authors, and this behavior is not affected by gender (Mishra et al., 2018). At the journal level, there is a phenomenon called coercive journal self-citation (Mahian & Wongwises, 2015; Wilhite & Fong, 2012), which means that authors are under pressure from journal editors to cite the papers published in the journal they are submitting to (Chorus & Waltman, 2016). At the national level, factors are more complex: one could cite research from the same country as it responds to the national development needs because it focuses on a national topic (geographically, historically, politically, or sociologically), or because of poor referencing practices and overly nationalistic education in universities (Ladle et al., 2012).

Because of authors' perceived conflict of interests, self-citations are often treated as problematic when they are used as indicators for assessing scientific impact (Seglen, 1997). In this context, author self-citations have been extensively analyzed. For instance, at the level of individual authors, it has been suggested that author self-citations should be excluded in the calculation of indicators such as h-index and g-index (Gianoli & Molina-Montenegro, 2009; Schreiber, 2008; Vinkler, 2007). Others have established that these indicators have limited sensitivity to author self-citations and do not require special consideration (Engqvist & Frommen, 2008; Huang & Lin, 2011). At the level of institutions, Thijs and Glänzel (2006) argue that those citation-based indicators both including and excluding self-citations should be used since such studies are affected by national and subject standards. By contrast, others have argued that, at the level of countries, self-citation has a trivial effect and there is no need to exclude them (Aksnes, 2003; Glänzel & Thijs, 2004).

However, few studies have discussed national self-citations (SRs). In recent years, some studies have found a growth in national self-citations. For instance, using publication data from 1996 to 2008 in Scopus, Jaffe (2011) analyzed the relationships between rates of national self-citation and national publication output as well as citation impact. They found that many national self-citation rates are negatively correlated with the average citation impact of their countries' publications, and also suggested that support for international collaboration might increase national self-citation rates. Shehatta and Al-Rubaish (2019) examined a larger and updated data set to analyze the impact of national self-citations on several bibliometric indicators and country ranking. Their results not only showed a strong negative correlation between

national self-citations and average citation per paper without self-citations but declared that self-citations have a significant impact on the academic performance ranking of top countries. Thus, they suggested excluding these self-citations from evaluation at the country level.

Some scholars analyzed the reasons for the growth of national self-citations. Baccini et al. (2019) compared the self-citation changes of G10 countries. They found that, compared with other countries, Italy maintains both a low level of international collaboration and the highest level of self-citations and that this rate increased over the 2000–2016 period. The authors argue that the use of bibliometric indicators by the Italian scientific research performance evaluation system incentives researchers to adopt self-citation practices.

In terms of scholarly impact, Larivière et al. (2018) examined the percentile rank of selected countries' self-citations from 2009 to 2017. They found that all countries are more likely to cite other papers from the same country, yet publications from the United States are cited by researchers from all countries. Similarly, Cai et al. (2019) compared the research impact between China and the United States in Chemistry. They discovered that China's publications mainly benefit from other domestic research, whereas publications from the United States have more depth and breadth of influence throughout the world. In addition, they found that high domestic citing tendency is connected with high dominance in international cooperation and stronger support from national funding.

Bornmann et al. (2018), collecting a set of highly cited papers published by Germany, the Netherlands, and the UK, used regression models to analyze the effect of two types of references on the probability of being highly-cited, finding that less well-cited papers are more likely to cite domestic references (research authored by the authors from the same country), while those more highly-cited papers are inclined to cite international references. They suggest that over-citing domestic references might be the main issue.

2.2 | Context of citations

Previous research has been done on in-text mentions, locations of citations, and enumerative nature of citations. Although early research on the topic could only be performed manually on small data sets, several studies showed how mentions and locations reflect the value of a reference for a citing document. Voos and Dagaev (1976) analyzed the mentions and locations in citing documents of four highly cited papers and found that their mentions were concentrated in the introduction, and all their mentioned numbers were quite high. They also found that these results also varied over time and across disciplines. Ding et al. (2013) also showed that highly cited papers generally appeared in the introduction and the literature review sections of citing papers. Otto et al. (2019) analyzed the in-text usage of highly cited papers based on the PLOS ONE corpus and found that the longer the citation interval, the more likely the highly cited papers appear in the method section. Bornmann and Daniel (2008) investigated 350 in-text citations based on the IMRaD structure and found that although fewer references appeared in the methods and results section, these references commonly got more citations. Hou et al. (2011) used the number of shared references to represent the relevance between citing and cited articles and found that cited papers got more mentions if they were more similar to citing documents.

Other studies proceed directly from the value judgment of citing authors. For example, Herlach (1978) invited the authors of citing papers to judge the 'relevance' and "usefulness" of three source references. They found that most of the citing papers mentioned source references multiply considered these references to be very relevant or useful. Since then, Hooten (1991) analyzed 63 articles and also found that references with high in-text mentions seemed to be more relevant and important than those mentioned once. Based on the annotation results of citation function and utility, Cano (1989) found that one-third of mentions in introductory sections were perfunctory, which may indicate that references appeared in that section have very little informational utility to citing papers. Maričić et al. (1998) examined 375 papers and found similar results. Tang and Safer (2008) collected 49 articles in biology and 50 papers in psychology, combining with citing authors' judgments on the citation importance and motivation, and found that the importance of references increased with the mentioned numbers in the citing paper.

In addition to mentions and locations, enumerative citations were also studied. Moravcsik and Murugesan (1975) suggested that such referencing behavior was redundant and that these cited references may be 'perfunctory' (Cano, 1989; Chubin & Moitra, 1975). Small (1982) found that enumerative citations are quite common, and suggested that they could introduce new works and hold literature together. Hu et al. (2017) also assumed that references found in enumerative citances are perfunctory, while multi-mentioned references may represent crucial references. By calculating Pearson's correlation coefficient between the multi-mentioned reference ratio and enumerative citance ratio, they found a very weak negative correlation between the two indicators.

With the emergence of a large amount of full-text data, there have been many large-scale analyses to explore the rules of these in-text features. Bertin

et al. (2016) used the full-text of 45,000 papers published in PLOS journals to analyze the relationship between the in-text location and the citation interval of references. They found that all papers have invariant distributions of references in IMRaD structure, where most papers are cited in the introduction, little in the methods and results, and more in the discussion. They also found a relationship between papers cited in the introduction and in the discussion, and older references appeared at the beginning of the introduction and in the methods section, while young references were referred to in the discussion. Poncela-Casasnovas et al. (2019) used a larger-scale PLOS data set, and also proved that compared to the methods and results chapters, the introduction and discussion chapters have more young references. Boyack et al. (2018) examined the largest dataset in existing studies, including Elsevier and PubMed, they found that there are significant differences in the reference position, reference age, and mentioned numbers among different disciplines. Hsiao and Chen (2018) analyzed 4,255 papers in the field of library and information science and found that the average frequency of references increased slightly in 10 years, and the number of mentions gradually decreased with text progression.

In-text features of citations have also been used in evaluation practices. Lu et al. (2017) explored the influence of a single highly cited paper based on its number of mentions and location and found that, over time, the mentioned number of the paper declined gradually, and it was more likely to be cited in the Methods section while decreasingly in the introduction and discussion sections. Some studies designed weighted citation indicators using in-text features to improve the accuracy of paper and author evaluations (Wan & Liu, 2014; Zhao & Strotmann, 2016). Along these lines, Zhu et al. (2015) and Valenzuela et al. (2015) identified the importance of citations based on text classification, using some in-text features and external features such as reference age, and found that frequency of mention had the greatest effect on recognition.

Few studies have studied self-citations using full-text analysis. In one existing study on the topic, Hu et al. (2017) analyzed references mentioned multiple times, and compared self-citing and NSRs at the author and journal level. They found that SRs are more likely to be mentioned multiple times than nonself-citations, both at the level of authors and journals. Zhao et al. (2018) used 14 papers in information science and 189,877 papers from PubMed Central to analyze the frequency and location features of author self-citations. They found a much higher percentage of self-citations than nonself-citations in the higher frequency situations, while the proportion of self-citations that appeared in background and literature review sections are much lower than those of nonself-citations. On the whole, there are very few studies using full-text data to explore the citation behavior of national self-citations, and those are mostly based on small-scale data, or that analyzed only a few dimensions.

3 | DATA AND METHODS

3.1 | Data

The full-text of 263,549 documents published in PLOS journals were first downloaded in XML format from PLOS Text and Data Mining[1] in December 2019. Using their DOIs, we matched each document with their record Web of Science (WOS) to get the institutional addresses of authors.[2] This resulted in the loss of 131 documents from PLOS, which could not be matched with WOS. Figure 1 presents the distribution of documents over years in the WOS-linked PLOS data. We filtered the top 10 countries with the highest publication output and limited the data to research articles from 2008 to 2018. After the above processing, the dataset was reduced to 184,859 documents, which represents the set of citing documents used in our analysis.

For the sake of distinguishing whether a reference in each PLOS publication is a nation-level SR or NSR, we also had to identify the address information of the cited references from the 184,859 citing documents. For each cited reference, the first author, publication year, volume, first page, and journal name were used to be matched with the data from the WOS to obtain the countries of authors of cited references. We matched 82.2% of all references cited by the 10 countries—several references were made to journals not indexed in WOS or to non-journal material. This percentage is similar to that obtained (85%) by Sugimoto and Larivière (2018) and did not vary much across countries, 78.5%–86.7%.

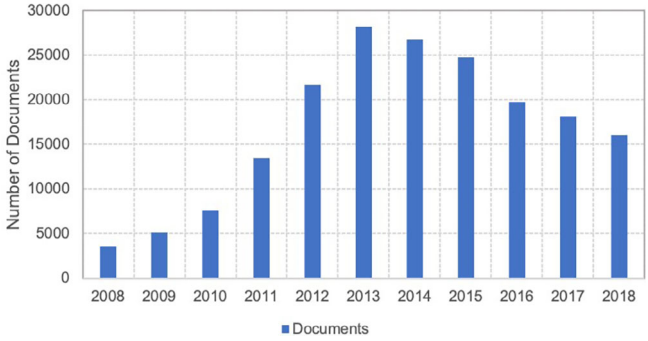

FIGURE 1 The distribution of documents over years in the WOS-linked PLOS data

After collecting the address information of the cited references and the citing documents, national SR or NSR can be distinguished: a cited reference is an SR if the affiliated country (or one of the affiliated countries, when the first author has more than one affiliated country) of the first author of the cited reference is included in the affiliated countries of a citing document. Note that we do not exclude author-SRs from national SRs.

The XML of citing documents were parsed to extract each in-text citation: the bibliography id and section title where the in-text citation appeared were identified using XML tags, considering only major sections; with regard to citances (the sentence includes references), which could not be extracted directly using XML tags, we used a combination of rule-based method and Natural Language Toolkit (NLTK) package in python. In total, 7,750,591 unique citances were identified. After parsing and extracting, all the data were imported into database tables. By querying these database tables, the number of times each reference was mentioned in the publication and how many references appeared in a citance could be calculated.

Basic descriptive data on the seven PLOS journals are provided in Table 1. PLOS ONE has by far the largest number of publications, about 87% of the total, while PLOS Medicine represents about 0.6% of the total. By comparing the average level of citances and mentions between seven journals, we observe different citation behaviors in these disciplines. For example, the average number of citances per publication in PLOS ONE, PLOS Neglected Tropical Diseases, and PLOS Medicine are similar, 40.18, 41.98, and 40.71, but much lower than those found in PLOS Genetics, PLOS Pathogens, and PLOS Biology.

Table 2 shows the publication and reference data from PLOS and WOS of the 10 most prolific countries (using full counting method) in our dataset (also see Table S1). The country with the largest output is the United States, followed by China, and the UK. The reference matching rate of each country is above 80%. Comparing the proportion of SRs and NSRs, the United States has the largest percentage of SR, which account for 63.59% of references, while in other nine countries, the percentages of SR take up no more than 30%: the next highest percentage of SRs is the UK, 27.4%; and the lowest percentage is Canada, 14.48%. The very high percentage of SRs for the United States—which has also been observed in WOS as a whole (Larivière et al., 2018) is likely due to the fact that their papers remain, on average, among the most cited, and therefore, also attract citations from other US authors. It may also be due to the fact that the United States is the largest contributor to PLOS; accounting for more than 43% of papers published in the journal. We compared the data of PLOS and WOS and found that these 10 countries basically ranked top 10 in WOS, except for Australia and the Netherlands, 11th and 14th, respectively. The percentage of SRs in PLOS is generally higher than that of WOS, which is likely due to the fact that PLOS papers and all WOS papers have a different disciplinary composition—PLOS papers having a strong focus on biological sciences (Siler et al., 2020).

3.2 | Measurements

Three in-text features are assessed: in-text mentions, in-text enumeration, and in-text locations. For each of those, we designed several indicators to compare the differences between national SRs and NSRs, which are briefly reported in Table 3. All the indicators are calculated for each cited reference in the dataset of the top 10 countries.

3.2.1 | Mentions

Previous studies found that a single-mentioned reference is likely to make a less contribution to the citing paper than multi-mentioned one (Herlach, 1978; Voos & Dagaev, 1976), and Hu et al. (2017) found that references

TABLE 1 Basic descriptive data on PLOS journals

	PLOS ALL	PLOS One	PLOS Genetics	PLOS Pathogens	PLOS N. T. Diseases	PLOS Comp. Biology	PLOS Biology	PLOS Medicine
N. Publications	184,859	161,317	6,060	5,351	4,669	4,554	1,724	1,184
N. References	9,092,342	7,700,785	383,239	338,122	226,479	270,054	112,332	61,331
Avg references	49.19	47.74	63.24	63.19	48.51	59.30	65.16	51.80
Avg sentences	228.05	214.84	354.64	350.48	212.83	342.29	387.97	214.84
Avg citances	41.92	40.18	60.36	58.51	41.98	53.19	59.75	40.71
Avg mentions	80.50	76.60	109.34	107.06	77.79	104.67	113.79	86.38
Avg enumerative citance	17.26	16.57	23.98	24.01	16.72	22.40	25.40	16.74

TABLE 2 Publication and reference data for 10 most productive countries in PLOS journals and their corresponding data in Web of Science, 2008–2018

Country	Number of publications in PLOS	SR% in PLOS	Number of publications in WOS	SR% in WOS
USA	80,778	63.59%	4,235,203	44.02%
China	33,056	16.44%	2,554,841	17.02%
UK	25,053	27.40%	1,212,044	15.72%
Germany	20,832	20.77%	1,120,558	14.61%
Canada	16,574	14.48%	700,015	10.88%
France	14,575	18.78%	783,005	12.17%
Japan	12,753	21.30%	865,020	17.03%
Australia	11,562	18.96%	589,608	9.21%
Netherlands	10,053	17.14%	405,511	8.70%
Spain	9,574	14.93%	594,991	8.93%

TABLE 3 Indicators used in the study

Features	Indicator	Description
In-text mentions	P_SSR and P_SNSR	Percentage of single-mentioned self / nonself-references in all references
	P_MSR and P_MNSR	Percentage of multi-mentioned self/nonself-references in all references
	RP_SSR	Percentage of single-mentioned self-references in all single-mentioned references
	RP_MSR	Percentage of multi-mentioned self-references in all multi-mentioned reference
	AM_SR and AM_NSR	Average mention numbers of self/nonself-references appeared in the whole paper
In-text enumeration	EP_SR and EP_NSR	The enumeration preference indicator of self/nonself-references
	CEP_SSR and CEP_SNSR	The combined enumeration preference indicator of single-mentioned self/ nonself-references
In-text locations	P^l_SR and P^l_NSR	Percentage of self/nonself-references by section
	P^l_$R_{\text{citing country}}$	Percentage of one country's references cited by citing country in one section

mentioned only once in a paper are the most common type. Hence, we classified those mentioned once as single-mentioned references and those appearing more than once as multi-mentioned references. We calculated the following indicators.

1. P_SSR (P_SNSR) and P_MSR (P_MNSR): the percentage of single-mentioned SR (or NSR) and multi-mentioned SR (or NSR) in all references.
2. RP_SSR and RP_MSR: the percentage of single-mentioned SR in all single-mentioned references and multi-mentioned SR in all multi-mentioned references, in order to explore if there is a change in mention behavior.
3. AM_SR and AM_NSR: the average mentions of SR and NSR.

We also divided SRs into three categories according to the degree of national dominance in each article:

1. No collaboration (no_co): the authors of a cited reference come from only one country, which is included in the citing countries;
2. Leading collaboration (co_lead): the authors of the reference come from more than one country and the first or corresponding author comes from one of the citing countries;
3. Assisted collaboration (co_assist): the authors of the reference come from more than one country and neither the first nor corresponding author come from the citing country, while one of the countries of other authors (not first nor corresponding author) is included in the citing countries.

3.2.2 | Enumerations

Earlier research pointed out that references combined in one citance may be redundant or perfunctory since each

of these references makes the same point and the multiple reference is just to make everyone happy in the priority hunting game (Moravcsik & Murugesan, 1975). Later, Cano (1989) and Hu et al. (2017) used a small amount of full-text data to verify that those references cited together contributed less to the citing articles. In this sense, it is assumed that those references that appeared alone in the citance may have more explicit contributions than those that appeared in groups, such as being characterized as operational or confirmative. Therefore, we compiled two indicators to measure the enumeration of references based on these citances.

To assess, which types of references are more likely to be cited in an enumerative form, we compared whether the distributions of SR and NSR in enumerative citances and single citances are different. Specifically, our algorithm calculates the difference in the normalized proportion of two types of citances, which are the enumeration preference of SRs and the enumeration preference of NSRs, calculated as:

$$EP_{SR} = \frac{EC_{SR}}{EC_{all}} \div \frac{SC_{SR}}{SC_{all}} \text{ or } EP_{NSR} = \frac{EC_{NSR}}{EC_{all}} \div \frac{SC_{NSR}}{SC_{all}}, \quad (1)$$

EC_{SR} is the enumerative citance number of SR, EC_{all} is the total number of enumerative citances in one country, EC_{SR}/EC_{all} is the proportion of enumerative citance containing SR, SC_{SR} is the single citance number of SR references, SC_{all} is the total number of single citances in one country, and SC_{NSR}/SC_{all} is the proportion of single citance containing SR. This explanation also applied to NSR.

Two issues are taken into account in the compilation of the indicator. First, considering that enumerative citances contain different numbers and types of references, the numbers of enumerative citances in each country's SR and NSR are calculated using fractional counting. Second, since the enumerative and alone citances have different proportions in the 10 countries, we used the relative proportion of citances in order to perform comparisons.

The proportion of references mentioned only once in a paper is very high—about 70% in our dataset. We combined in-text mentions and enumerations, with the assumption that references that are both single-mentions and bundled in a single citance are likely of little contribution to the citing paper. Our measurement is based on the number of unique citances in which single-mentioned references appeared, and here we assume that the expected value of this number equals the number of references being analyzed, which also means that each reference appears in one single citance. The combined enumeration preference of single-mentioned references is calculated as:

$$CEP\_SSR = \frac{OBC_{SR}}{EXC_{SR}} \text{ or } CEP\_SNSR = \frac{OBC_{NSR}}{EXC_{NSR}}, \quad (2)$$

OBC_{SR} is the observed number of citances of SR that were mentioned once and EXC_{SR} is the expected number of citances of SR that were mentioned once. This explanation also applied to NSR.

3.2.3 | Locations

In terms of locations, we use the IMRaD structure (introduction, methods, results, and discussion), which is used by most articles in our dataset. Based on the number of SR and NSR mentioned in each section, we used the following indicators.

1) Percentage of SR or NSR by section:

$$P^l\_SR = \frac{N^l_{SR}}{N_{SR}} \text{ or } P^l\_NSR = \frac{N^l_{NSR}}{N_{NSR}} \quad (3)$$

2) Percentage of one country's references cited by citing country in one section:

$$P^l\_R_{\text{citing country}} = \frac{N^l_{R\_cited\_country}}{N^l_R} \quad (4)$$

N^l_{SR} is the mentioned number of SR in l section, N_{SR} is the mentioned number of SR in full-text of publication, $N^l_{R\_cited\_country}$ is the mentioned number of one country's references cited by citing country in l section, and N^l_R is the mentioned number of all references of citing country in l section. l is limited to the section set, including introduction, methods and materials, results, and discussion. This explanation also applied to NSR.

4 | RESULTS

4.1 | Mentions analysis

4.1.1 | Single-mentioned and Multi-mentioned references

First, we explored the distribution of single−/multi-mentioned SR and NSR in papers (Figure 2). Single-mentioned references account for the majority, about 70%, of references for the countries analyzed. Among these countries, China has the largest ratio of single-mentioned references, at 73.65%. By calculating the proportions of single-mentioned

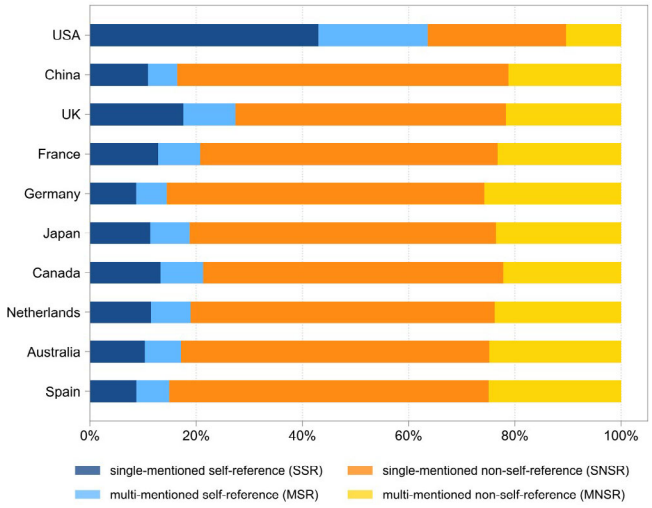

FIGURE 2 Percentages of single-mentioned and multi-mentioned SR and NSR in 10 countries

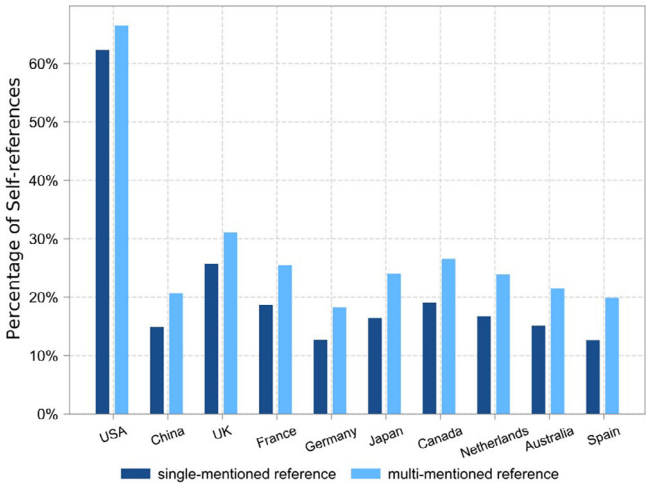

FIGURE 3 Percentages of self-references for single-mentioned and multi-mentioned references, by country

SR (or NSR) and multi-mentioned SR (or NSR) in all references, we found that both SR and NSR are generally mentioned only once in citing papers. Figure 2 also illustrates that the difference between the mentioned frequency of SR and NSR is country-dependent. In most countries, NSR account for a substantial proportion of both single−/multi-mentioned references. On the contrary, the proportions of SR in the two categories are relatively low, with average proportions of 11.7% and 7.2%, respectively. The exception here is the United States, with a much higher percentage of SR than of NSR, which may be due to the big publication volume of the United States (Table 2). Furthermore, we measured the age characteristics of SRs and NSRs in each country (see Table S2) and found that SRs are generally younger than NSRs. This phenomenon is most obvious in China, which is likely a consequence of its recent exponential increase.

In order to investigate whether SR and NSR differ in the two types of mentions, we calculated the percentage of single-mentioned self-references (SSR) in all single-mentioned references, and multi-mentioned self-references (MSR) in all multi-mentioned references (shown in Figure 3). It shows that the percentages of SRs are always higher in the case of multi-mention than single-mention, suggesting that SRs are given more attention in citing papers.

Given the changes in countries' share of world publications—especially of China and the United States—one can expect that SR and NSR to evolve over time. Figure 4 shows that this is the case for the United States and China, while the trends for the other eight countries remain stable over time (see Figure S1). More specifically, the percentages of single-mentioned and multi-mentioned SR in the United States decrease moderately and they show a similar decline, the percentage points dipped about 2%. In terms of NSR, there is an increase in the proportions of single-mentioned and multi-mentioned NSR, and yet the proportion of single-mentioned NSR increased from 24% in 2008 to 28% in 2018. The opposite trend is observed for China: the percentages of single-mentioned and multi-mentioned NSR declined by about 7%. The proportion of SR is increasing during the period, although single-mentioned SR are rising at a significantly higher rate than MSR.

Figure 4 also shows that publications from the United States increasingly contain single-mentioned references from other countries—this might be affected by the exponential increase of Chinese publications over the last two decades. By analyzing the percentages of three types of single-mentioned SR in the United States and China (Figure 5), we observed that the decreasing trend of single-mentioned SR in the United States is mainly due to the decline of SRs from noncollaborative publications. Inversely, the increasing trend in China is primarily due to the rapid growth of SRs (no_co SR) from noncollaborative work. With the considerable increase in the number of Chinese publications, Chinese authors have more opportunities to cite national research. However, these national references mostly receive single mentions, which may suggest that they are not critically relevant references.

4.1.2 | Average mentions

There are no restrictions on the frequency that a reference can be cited in an article—some references in our dataset were mentioned more than 100 times in a single paper. Therefore, in order to further analyze the difference in mentions between SR and NSR, we calculated

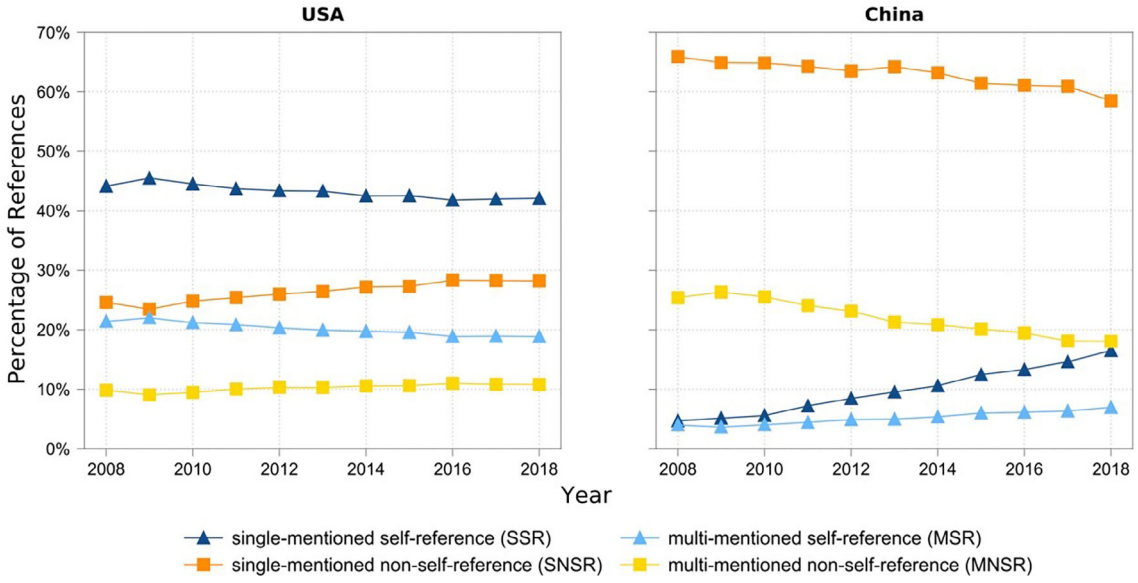

FIGURE 4 Percentages of four types of references for the United States and China, by year. The black-blue triangle mark represents single-mentioned self-reference, the light blue triangle mark represents multi-mentioned self-reference, the orange square represents single-mentioned nonself-references, and the yellow square represents multi-mentioned nonself-reference

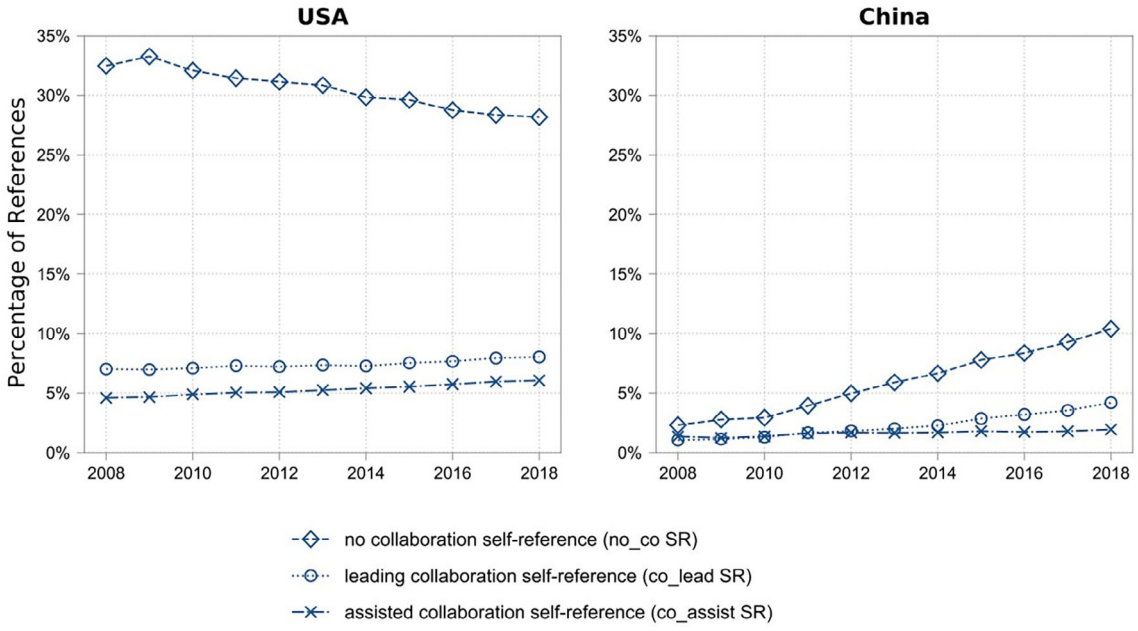

FIGURE 5 The percentages of three types of single-mentioned self-reference for the United States and China, by year

their average number of mentions and displayed it as a heatmap (see Figure 6). The horizontal axis represents five cited paper types: all NSR (all_non_self), no collaboration SR (no_co self), leading collaboration SR (co_lead_self), assisted collaboration SR (co_assist_self), and all SR (all_self). The vertical axis is divided into the three categories based on national dominance in research: papers are not in international collaboration (no_co), papers in international collaboration and the country are leading the collaboration (co_lead), and papers in international collaboration and the country is not leading (co_assist).

Figure 6 shows the average number of mentions of SR marginally outnumbered that of NSR in 10 countries. For the sake of excluding the scale effect of single-mentioned references, we also calculated the average mentions of MSR and still found the same result.

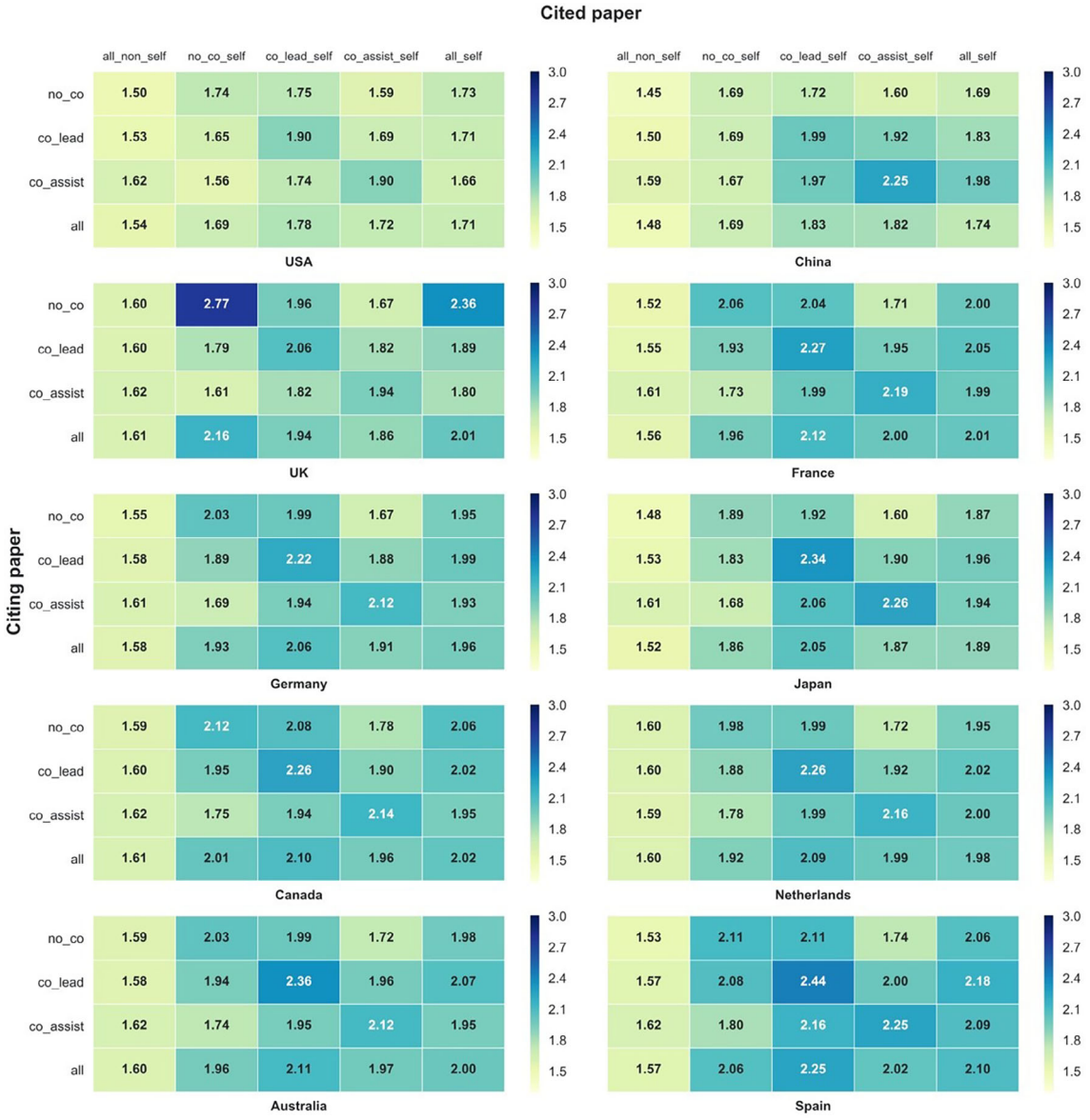

FIGURE 6 Average number of mentions of references in 10 countries. For each country, the horizontal axis represents five cited paper types: all_non_self means all references not cited by that country; no_co_self means self-references without international collaboration cited by that country; co_lead_self means international collaboration self-references and the citing country is leading in these references; co_assist_self means international collaboration self-references but the citing country is not leading in these references; and all_self means all references cited by that country

For example, in the sub figure of the United States, when citing paper is 'no_co' and the cited paper is 'all_non_self', the average in-text mentions of citing papers without international collaboration to NSRs is 1.5. These numbers in all_self column of each sub figure are greater than those in all_non_self column, which suggests that SR obtain more in-text mentions than NSR. We further analyzed the average number of mentions of three types of SR. From the perspective of all citing papers, it seems that leading collaboration SR gets more in-text mentions than the other two SR. And when examining citing documents separately, we found that, in most countries, the average number of mentions, which the co_lead and co_assist citing papers give to the same types of cited papers, are higher than those in other cases. This suggests that, for each country, international collaboration tends to multiply the emphasis on other cited references written in international collaboration to which the country participated.

4.2 | Enumeration analysis

The mean number of citances and enumerative citances per article in our study is 41.92 and 17.26, respectively.

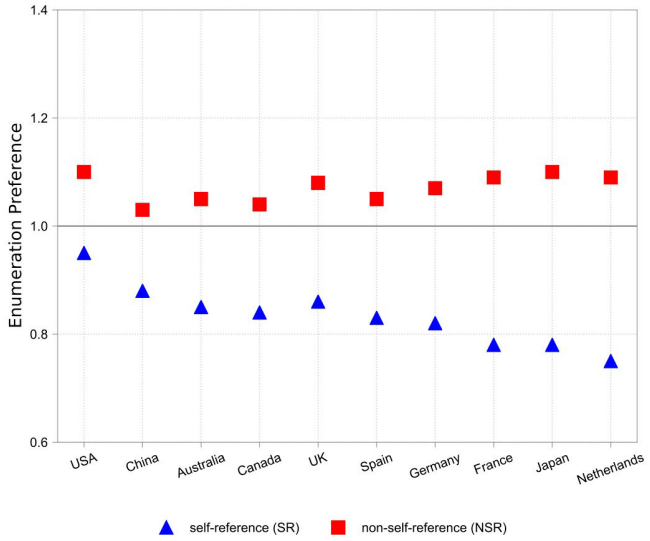

FIGURE 7 The enumeration preference of SR and NSR in 10 countries

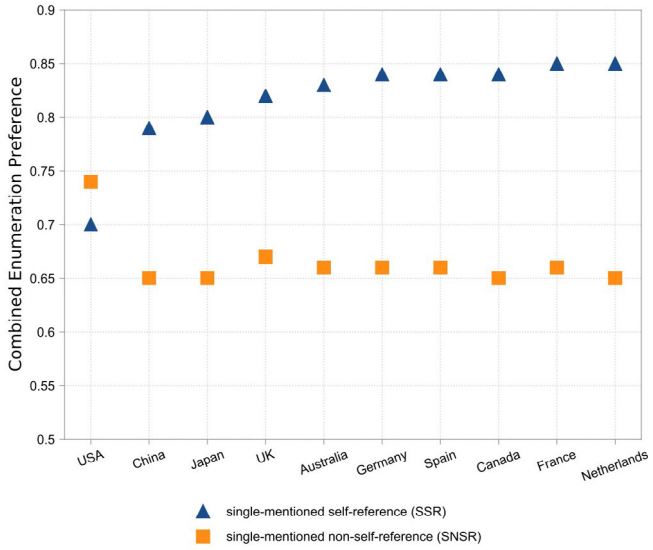

FIGURE 8 Combined enumeration preference of single-mentioned references in 10 countries

This illustrates that enumerative citation form is quite common in paper context, and confirms the range from 20 to 60 obtained by Small (1982). Based on these citances, we calculated the enumeration preference indicator of SR and NSR and combined enumeration preference indicator of single-mentioned SR and NSR. Figure 7 shows that the enumeration preference of NSR is generally higher than that of SR, indicating that NSRs are more likely to appear in enumerative forms than SRs. This suggests that NSRs can be suspected of linking more to "redundant" or "perfunctory" in their intention than SRs.

In terms of discrepancies across the 10 countries, the index of the two types of references in the United States and China papers differs only by 0.14, which means that SR and NSR of the two countries are relatively similar in their enumeration behavior. However, in France, Japan, and the Netherlands the scores differ by more than 0.3, which is mainly caused by the lower value of enumeration preference of SR. This might illustrate that these countries have a clearer tendency to state native work separately, mostly for the purpose of emphasis. Their motivations for citing may be more targeted, such as drawing on certain concepts or methods, agreeing or denying previous research results.

Figure 8 shows that the United States has the lowest value of single-mentioned SR, 0.70, followed by China and Japan, 0.79 and 0.80, respectively. In terms of the single-mentioned NSR, the combined enumeration preference of the United States is the highest one, and the values in other countries are very similar, around 0.66. This may indicate that binding single-mentioned SR is more common for US publications, while this behavior is more frequent in the NSR of other countries. Such single-mentioned references are more likely to appear in the introduction or discussion section (Tables S4 and S5), and indicators of SR and NSR remain steady over the period (See Figure S2 and S3).

4.3 | Location analysis

4.3.1 | Percentages of SR and NSR by section

Figure 9 shows the distribution of all references and SR for PLOS ONE, by section. It shows that mentions of references are mainly distributed in introduction and discussion sections and less in methods and results, confirming previous research (Bertin et al., 2016; Bornmann & Daniel, 2008; Hu et al., 2013). However, it is worth noting that the proportion of SR in the methods section is significantly higher than that in other sections, particularly for the UK and Germany.

4.3.2 | National citation behavior by section

Finally, we explored national citation behavior by section. Figure 10 shows that, in each section, all countries cited publications from the United States at the highest proportion, followed by their national research. However, US papers are less likely to be cited in the methods than in other sections. China, on the other hand, accounts for a relatively small proportion of all references in each

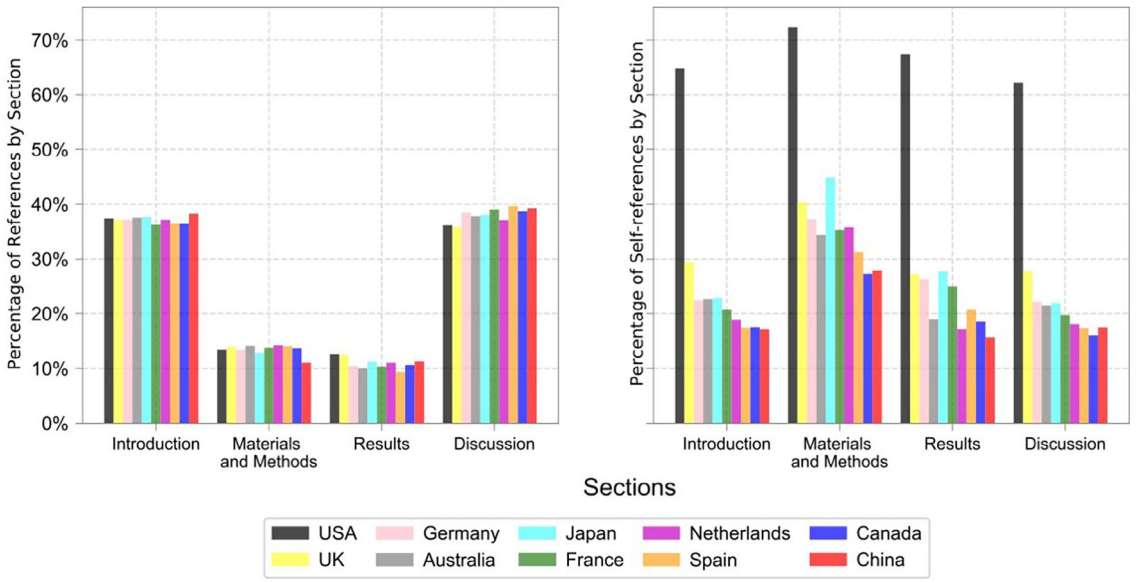

FIGURE 9 Distribution of references by section (left panel), and percentage of self-references, by section (right panel). Figure S4 provides the same results for the disciplinary PLOS journals

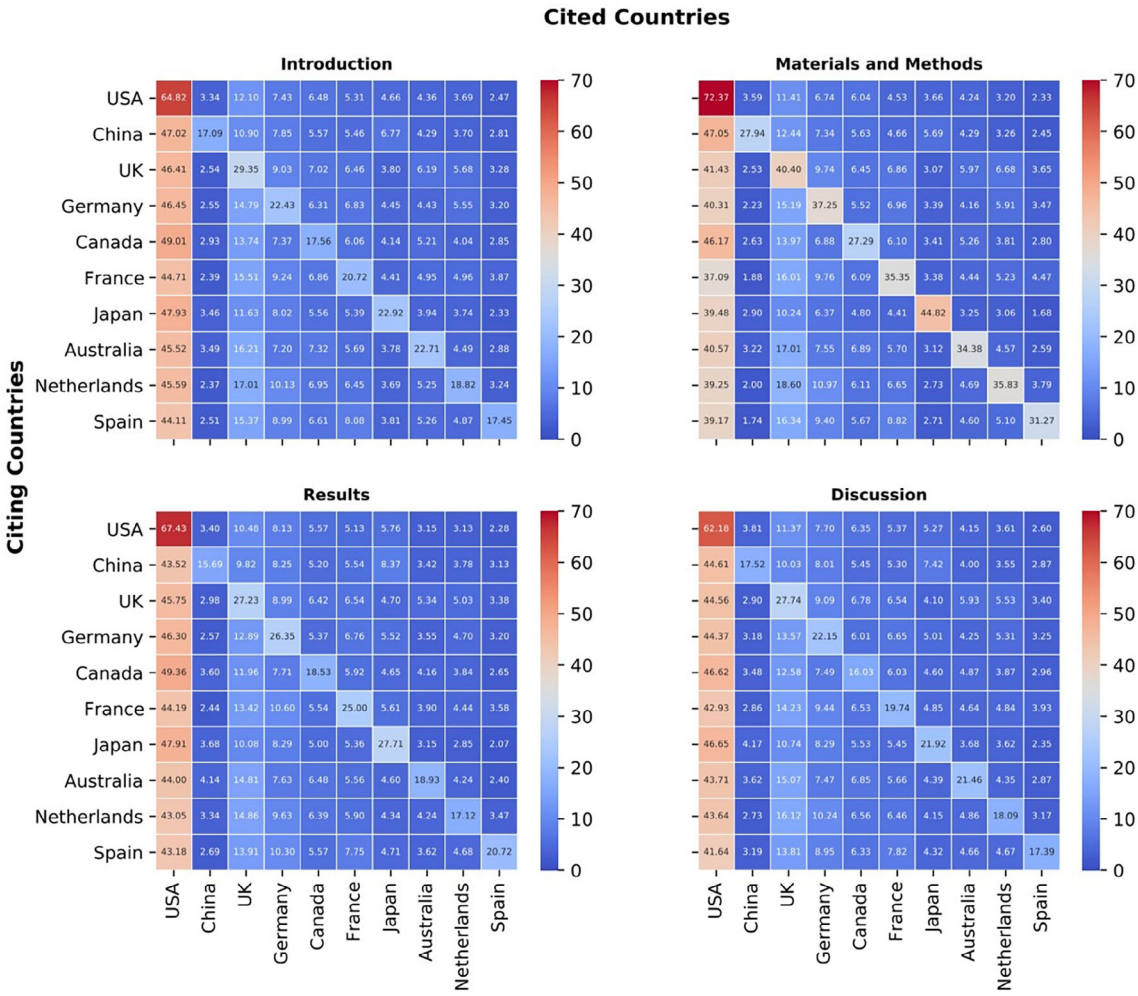

FIGURE 10 Percentage of references cited by 10 citing countries in four sections. For each country, a color block represents the mentioned number of references cited by the citing country divided by the total mentioned numbers appearing in the corresponding section

section, despite its recent rise of China as the world's largest producer of scholarly papers (Tollefson, 2018). The diagonal shows that the percentage of SR of each country in the methods section is higher than that in other sections (especially for the UK and Japan), which may suggest that methodologies have a strong national component, even in medical fields.

5 | DISCUSSION AND CONCLUSION

This study explored the in-text features (mentions, enumerations, and locations) of national SRs for the 10 most productive countries in PLOS journals, identified from over 180,000 articles published in PLOS journals. Globally, our results show that SRs account for a sizable share of references for all nations, which confirms previous results obtained (Shehatta & Al-Rubaish, 2019).

5.1 | Comparison of SR and NSR in terms of mentions

Our findings regarding the differences between national SRs and NSRs in terms of mentions, enumerations, and locations are as follows. The analysis of mentions showed that references from the same countries have the highest average number of mentions in papers, suggesting that researchers pay more attention to domestic than foreign studies, not only in terms of overall references (Larivière et al., 2018) but also in terms of how much they engage with them in their own papers. Our results also show an evolution over time, with an increase of single-mentioned and multi-mentioned self-references (SR) of China, especially those without international collaboration, and a decrease of single-mentioned and multi-mentioned NSRs. Despite a rapid rise of China's publications in recent years, these papers remain mostly cited by Chinese papers, and are, therefore, considered to be less important to citing papers than those mentioned multiple times.

5.2 | Comparison of SR and NSR in terms of enumerations

The analysis of enumerative citances showed that NSRs may be more likely to be "perfunctory" than SRs since they are more often found in enumerative citances. Those results are consistent with those obtained by Hu et al. (2017) who investigated SRs located in enumerative citances at the author and journal level. The enumeration preference of single-mentioned SR and NSR showed no difference for American publications, and this trend is stable within our time window. However, single-mentioned SR and NSR in other countries are significantly different and have changed to varying degrees in their enumeration behavior, which may be affected by the growth of publications from countries, the availability of papers, or the tendency to (over)recognize the work of one's fellow countrymen.

5.3 | Comparison of SR and NSR in terms of in-text locations

The analysis of in-text location showed that both types of references follow the distribution of references found in the previous studies (Bertin et al., 2016; Bornmann & Daniel, 2008; Hu et al., 2013): most cited references are found in the introduction and discussion, and less in the methods and results section. The percentage of SRs by section has shown that there are more mentions of national research in the methods section, which suggests that citing publications are building on research materials, data, tools, or methods from the same country.

We also examined how the percentage of self-citing and NSRs in each section evolved over time, considering the influence of paper growth (NSB, 2018; Zhu & Liu, 2020). We found that the growth of SRs of Chinese articles is more important in the introduction and discussion sections than elsewhere in the manuscript. A large number of SRs mentioned once are found in the introduction, which suggests that these references may be mainly used as background, and contribute less to the citing paper (Cano, 1989; Maričić et al., 1998). By analyzing the percentage of references cited by 10 citing countries in four sections, we found that all countries have increased the mentioned numbers of their own research in the methods section. Countries are also citing US papers at high rates in each of the sections, indicating that the United States still maintains a dominant position in all aspects of scholarly literature. On the other hand, Chinese publications remain less cited by other countries, despite the fact that the country is the largest publisher of research papers (Tollefson, 2018). This may be due to the fact that these papers remain on average younger than those of countries such as the United States, and therefore, may not have yet reached their peak in terms of citations.

5.4 | Limitations and future research

This study also has limitations. First, our analysis does not distinguish between author-level and nation-level SRs, and in the vast majority of cases (i.e., except with author's change country), author's SRs are included in

countries' SRs. This may affect our conclusions of national SRs to some extent and we will analyze this effect in the future study. Second, the data are limited to the full-text data of PLOS journals, which mostly cover disciplines of the life sciences. Other disciplines may exhibit different patterns: studies have shown that there are obvious differences between SR behaviors among disciplines (e.g., Lievers & Pilkey, 2012). Third, several factors may affect national SRs, from the proximity of research topics (Larivière, 2018) to the adoption of policy-rewarding citations (Baccini et al., 2019). More qualitative interpretations at the historical, cultural, and policy levels are still needed. Despite these limitations, our results contribute to a better understanding of how the citation context of national SRs differs from that of NSRs.

We hope that the development of natural language processing (NLP) and machine learning techniques will allow us to provide a better understanding of the function of citances and that national SRs can be further analyzed at the semantic level. National self-referencing behavior analysis in other disciplines could be studied in a similar way as we have done for life science, thanks to the increasing number of full-text datasets available for research. For countries with distinctive behaviors (such as China and the United States), further research could work on more fine-grained datasets, including institutional and author SRs, to better understand the factors that affect the trends observed.

ACKNOWLEDGMENTS

We thank Cassidy R. Sugimoto (School of Public Policy, Georgia Institute of Technology) for valuable comments and suggestions. We thank Xiwen Liu (National Science Library, Chinese Academy of Sciences) and Bikun Chen (School of Economics and Management, Nanjing University of Science and Technology) for inspiring discussions. We also thank the three anonymous reviewers as well as the academic editor of the paper for their numerous comments and suggestions that helped to improve the paper.

ENDNOTES

[1] https://plos.org/text-and-data-mining/

[2] The address information in the XML format document is not cleaned and the affiliated country information is not standardized, so we used the address information from the WoS record instead of extracting the address information from the XML format document.

REFERENCES

Aksnes, D. W. (2003). A macro study of self-citation. *Scientometrics*, *56*(2), 235–246.

Baccini, A., Nicolao, G. D., & Petrovich, E. (2019). Citation gaming induced by bibliometric evaluation: A country-level comparative analysis. *PLoS ONE*, *14*(9), e0221212.

Bakare, V., & Lewison, G. (2017). Country over-citation ratios. *Scientometrics*, *113*(2), 1199–1207.

Bertin, M., Atanassova, I., Gingras, Y., & Larivière, V. (2016). The invariant distribution of references in scientific articles. *Journal of the Association for Information Science and Technology*, *67*(1), 164–177.

Bonzi, S., & Snyder, H. (1991). Motivations for citation: A comparison of self citation and citation to others. *Scientometrics*, *21*(2), 245–254.

Bornmann, L., Adams, J., & Leydesdorff, L. (2018). The negative effects of citing with a national orientation in terms of recognition: National and international citations in natural-sciences papers from Germany, The Netherlands, and the UK. *Journal of Informetrics*, *12*(3), 931–949.

Bornmann, L., & Daniel, H. D. (2008). Functional use of frequently and infrequently cited articles in citing publications. A content analysis of citations to articles with low and high citation counts. *European Science Editing*, *34*(2), 35–38.

Boyack, K. W., van Eck, N. J., Colavizza, G., & Waltman, L. (2018). Characterizing in-text citations in scientific articles: A large-scale analysis. *Journal of Informetrics*, *12*(1), 59–73.

Cai, X., Lyu, X., & Zhou, P. (2019). A comparative study of domestic and cross-country impact of Chinese and US publications in chemistry. *Proceedings of the Association for Information Science and Technology*, *56*(1), 43–50.

Cano, V. (1989). Citation behavior: Classification, utility, and location. *Journal of the American Society for Information Science*, *40*(4), 284–290.

Chorus, C., & Waltman, L. (2016). A large-scale analysis of impact factor biased journal self-citations. *PLoS ONE*, *11*(8), e0161021. https://doi.org/10.1371/journal.pone.0161021

Chubin, D. E., & Moitra, S. D. (1975). Content analysis of references: Adjunct or alternative to citation counting? *Social Studies of Science*, *5*(4), 423–441.

Ding, Y., Liu, X., Guo, C., & Cronin, B. (2013). The distribution of references across texts: Some implications for citation analysis. *Journal of Informetrics*, *7*(3), 583–592.

Engqvist, L., & Frommen, J. G. (2008). The h-index and self-citations. *Trends in Ecology & Evolution*, *23*(5), 250–252.

Gianoli, E., & Molina-Montenegro, M. A. (2009). Insights into the relationship between the h-index and self-citations. *Journal of the American Society for Information Science and Technology*, *60*(6), 1283–1285.

Glänzel, W., & Thijs, B. (2004). The influence of author self-citations on bibliometric macro indicators. *Scientometrics*, *59*(3), 281–310.

Gorry, P., & Aichouchi, A. E. (2017). Sleeping Beauty awakened by self-citation of a review: A case study of Judah Folkman hypothesis on angiogenesis. Paper presented at the the 16th international society of scientometrics and informetrics conference, 778–786.

Herlach, G. (1978). Can retrieval of information from citation indexes be simplified? Multiple mention of a reference as a characteristic of the link between cited and citing article. *Journal of the American Society for Information Science*, *29*(6), 308–310.

Hooten, P. A. (1991). Frequency and functional use of cited documents in information science. *Journal of the American Society for Information Science*, *42*(6), 397–404.

Hou, W. R., Li, M., & Niu, D. K. (2011). Counting citations in texts rather than reference lists to improve the accuracy of assessing scientific contribution. *BioEssays*, *33*(10), 724–727.

Hsiao, T. M., & Chen, K. H. (2018). How authors cite references? A study of characteristics of in-text citations. *Proceedings of the Association for Information Science and Technology*, *55*(1), 179–187.

Hu, Z., Chen, C., & Liu, Z. (2013). Where are citations located in the body of scientific articles? A study of the distributions of citation locations. *Journal of Informetrics*, *7*(4), 887–896.

Hu, Z., Lin, G., Sun, T., & Hou, H. (2017). Understanding multiply mentioned references. *Journal of Informetrics*, *11*(4), 948–958.

Huang, M. H., & Lin, W. Y. C. (2011). Probing the effect of author self-citations on h index: A case study of environmental engineering. *Journal of Information Science*, *37*(5), 453–461.

Jaffe, K. (2011). Do countries with lower self-citation rates produce higher impact papers? Or, does humility pay? *Interciencia*, *36*(9), 694–698.

Khelfaoui, M., Larrègue, J., Larivière, V., & Gingras, Y. (2020). Measuring national self-referencing patterns of major science producers. *Scientometrics*, *123*, 979–996.

Ladle, R. J., Todd, P. A., & Malhado, A. C. M. (2012). Assessing insularity in global science. *Scientometrics*, *93*(3), 745–750.

Larivière, V. (2018). Le français, langue seconde? De l'évolution des lieux et langues de publication des chercheurs au Québec, en France et en Allemagne. *Recherches sociographiques*, *59*(3), 339–363.

Larivière, V., Gong, K., & Sugimoto, C. R. (2018). Citations strength begins at home. *Nature*, *564*(7735), S70–S71.

Lawani, S. M. (1982). On the heterogeneity and classification of author self-citations. *Journal of the American Society for Information Science*, *33*(5), 281–284.

Lievers, W. B., & Pilkey, A. K. (2012). Characterizing the frequency of repeated citations: The effects of journal, subject area, and self-citation. *Information Processing & Management*, *48*(6), 1116–1123.

Lu, C., Ding, Y., & Zhang, C. (2017). Understanding the impact change of a highly cited article: A content-based citation analysis. *Scientometrics*, *112*(2), 927–945.

MacRoberts, M. H., & MacRoberts, B. R. (1989). Problems of citation analysis: A critical review. *Journal of the American Society for Information Science*, *40*(5), 342–349.

Mahian, O., & Wongwises, S. (2015). Is it ethical for journals to request self-citation? *Science and Engineering Ethics*, *21*(2), 531–533.

Maričić, S., Spaventi, J., Pavičić, L., & Pifat-Mrzljak, G. (1998). Citation context versus the frequency counts of citation histories. *Journal of the American Society for Information Science*, *49*(6), 530–540.

Merton, R. K. (1973). *The sociology of science: Theoretical and empirical investigations*. University of Chicago press.

Mishra, S., Fegley, B. D., Diesner, J., & Torvik, V. I. (2018). Self-citation is the hallmark of productive authors, of any gender. *PLoS ONE*, *13*(9), e0195773.

Moravcsik, M. J., & Murugesan, P. (1975). Some results on the function and quality of citations. *Social Studies of Science*, *5*(1), 86–92.

National Science Board. (2018). Science and engineering indicators 2018 (NSB-2018-1). Retrieved from https://www.nsf.gov/statistics/2018/nsb20181/assets/nsb20181.pdf

Otto, W., Ghavimi, B., Mayr, P., Piryani, R., & Singh, V. K. (2019). Highly cited references in plos one and their in-text usage over time. Paper presented at the 17th international society of scientometrics and informetrics conference, 1531–1536.

Phelan, T. J. (1999). A compendium of issues for citation analysis. *Scientometrics*, *45*(1), 117–136.

Poncela-Casasnovas, J., Gerlach, M., Aguirre, N., & Amaral, L. A. (2019). Large-scale analysis of micro-level citation patterns reveals nuanced selection criteria. *Nature Human Behaviour*, *3*(6), 568–575.

Schreiber, M. (2008). The influence of self-citation corrections on Egghe's g index. *Scientometrics*, *76*(1), 187–200.

Seglen, P. O. (1997). Citations and journal impact factors: Questionable indicators of research quality. *Allergy*, *52*(11), 1050–1056.

Shehatta, I., & Al-Rubaish, A. M. (2019). Impact of national self-citations on biblometric indicators and ranking of most productive countries. *Scientometrics*, *120*(2), 775–791.

Siler, K., Larivière, V., & Sugimoto, C. R. (2020). The diverse niches of megajournals: Specialism within generalism. *Journal of the Association for Information Science and Technology*, *71*(7), 800–816.

Small, H. G. (1982). Citation context analysis. In B. J. Dervin & M. J. Voigt (Eds.), *Progress in Communication Sciences* (pp. 287–310). Ablex Pub.

Tang, R., & Safer, M. A. (2008). Author-rated importance of cited references in biology and psychology publications. *Journal of Documentation*, *64*(2), 246–272.

Thijs, B., & Glänzel, W. (2006). The influence of author self-citations on bibliometric meso-indicators. The case of European universities. *Scientometrics*, *66*(1), 71–80.

Tollefson, J. (2018). China declared world's largest producer of scientific articles. *Nature*, *553*(7689), 390.

Valenzuela, M., Ha, V., & Etzioni, O. (2015). Identifying meaningful citations. In Workshops at the twenty-ninth AAAI conference on artificial intelligence, Austin, Texas, USA. https://www.aaai.org/ocs/index.php/WS/AAAIW15/paper/viewFile/10185/10244

Vinkler, P. (2007). Eminence of scientists in the light of the h-index and other scientometric indicators. *Journal of Information Science*, *33*(4), 481–491.

Voos, H., & Dagaev, K. S. (1976). Are All Citations Equal? Or, Did We Op. Cit. Your Idem? *Journal of Academic Librarianship*, *1*(6), 19–21.

Wan, X., & Liu, F. (2014). WL-index: Leveraging citation mention number to quantify an individual's scientific impact. *Journal of the Association for Information Science and Technology*, *65*(12), 2509–2517.

Wilhite, A. W., & Fong, E. A. (2012). Coercive citation in academic publishing. *Science*, *335*(6068), 542–543.

Zhao, D., & Strotmann, A. (2016). Dimensions and uncertainties of author citation rankings: Lessons learned from frequency-weighted in-text citation counting. *Journal of the Association for Information Science and Technology*, *67*(3), 671–682.

Zhao, D., Strotmann, A., & Cappello, A. (2018). In-text function of author self-citations: Implications for research evaluation practice. *Journal of the Association for Information Science and Technology*, *69*(7), 949–952.

Zhu, J., & Liu, W. (2020). Comparing like with like: China ranks first in SCI-indexed research articles since 2018. *Scientometrics*, *124*, 1691–1700.

Zhu, X., Turney, P., Lemire, D., & Vellino, A. (2015). Measuring academic influence: Not all citations are equal. *Journal of the Association for Information Science and Technology*, *66*(2), 408–427.

SUPPORTING INFORMATION

Additional supporting information may be found in the online version of the article at the publisher's website.

How to cite this article: Chen, L., Ding, J., & Larivière, V. (2022). Measuring the citation context of national self-references. *Journal of the Association for Information Science and Technology*, *73*(5), 671–686. https://doi.org/10.1002/asi.24569