Examining the quality of the corresponding authorship field in Web of Science and Scopus

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ABSTRACT

Authorship is associated with scientific capital and prestige, and corresponding authorship is used in evaluation as a proxy for scientific status. However, there are no empirical analyses on the validity of the corresponding authorship metadata in bibliometric databases. This paper aims at looking at differences on the corresponding authorship metadata in Web of Science (WoS) and Scopus, to investigate how the relationship between author position and corresponding authors varies by discipline and country and analyzing changes in the position of corresponding authors over time. We find that both, WoS and Scopus, have accuracy issues when it comes to assigning corresponding authorship. Although the number of documents with a reprint author has increased over time in both databases, however, WoS indexed more of those papers than Scopus, and there are significant differences between the two databases in terms of who the corresponding author is. Although metadata is not complete in WoS, corresponding authors are normally first authors with a declining trend over time, favoring middle and last authors, especially in Medical, Natural & Engineering fields. These results reinforce the importance of considering how databases operationalize and index concepts like corresponding authors, being this particularly important when are used in research assessment.

KEYWORDS: corresponding author, Web of Science, Scopus, bibliographic data sources, research evaluation.

1. INTRODUCTION

Authorship plays an important role in career progression from an undergraduate student to professorship. Author order is usually used in the assessment of researchers' scientific contributions (Bhandari et al., 2014; Hess et al., 2015; Perneger et al., 2017). There are, however, disciplinary differences on how author contributions are represented in the byline of scientific papers (Pontille 2004). While some disciplines order authors by decreasing order of contribution (Grando & Bernhard 2003; Bu et al., 2020), most lab-based disciplines exhibit an inverted U-shape, with first authors and last authors having performed the most contributions (Larivière et al., 2016; Larivière, et al., 2021). This inverted U-shape is the most generalized distribution of credit assigned to authorship (Bhandari et al., 2004; Costas & Bordons 2011). There are

exceptions to those dominant trends—such as economics, mathematics and business, management and accounting—where researchers show a strong trend to sign in alphabetical order (Fernandes & Cortez 2020; Wohlrabe & Bornmann 2022).

Corresponding authorship is another role which is gaining relevance in many countries, as an alternative or complement to assigning credit based on author order (Moya-Anegón et al., 2013; Zhou & Leydesdorff, 2006; Chinchilla-Rodríguez et al., 2019). Corresponding authors take the lead in the manuscript submission for publication process, such that primary responsibility for communication with the journal during the manuscript submission, peer review, and publication process, and typically ensures that all the journal's administrative requirements are properly completed. Accordingly, the corresponding author should be available to respond to editorial queries in a timely way, and be available after publication to respond to critiques of the work and cooperate with any requests from the journal for data or additional information should questions about the paper arise after publication (ICMJE 2017).

It is generally assumed that corresponding authors are senior researchers or group leaders with experience on the submission and publishing process of scientific research. They do not only contribute to the paper significantly but also ensure that it goes through the publication process in a smooth and successful manner[1]. However, there is no clear consensus on the role corresponding author plays in terms of leadership (Willems & Plume, 2021) despite being increasingly used and perceived in evaluation as a proxy for leadership (Wren et al., 2007; Mattson, et al., 2011; González-Alcaide & Gorraiz, 2018). Furthermore, little is known about the quality of the metadata used in scientific databases to analyze this role. Bibliometric databases include a field, often named *reprint address*, with which the corresponding author is identified.

The goal of this paper is twofold. First, we examine the validity of such field as assigned by two different bibliometric databases. We focus our study on two of the major bibliometric databases, namely, Web of Science (WoS) and Scopus, as these tend to play an important role in research evaluation practices around the world. We do such comparison by working with an overlapping dataset of records common to both databases. Second, we critically investigate the author position of corresponding authors according to discipline and country in WoS, paying special attention to trends over time. We then discuss the implications of our findings both, from a technical point of view and in relation to the use of this field in evaluation exercises such as hiring, recruitment or promotion.

2. RELATED WORK

Evidence on what is a corresponding author and who from a research team should carry out such role are contradictory. For example, Weiss (2012) explicitly states that it is not appropriate for students and postdocs to play such role, as they lack stability and hence they will not be able to respond effectively to information requests. Indeed, Teunis, Nota and Schwab (2015) emailed corresponding authors from MEDLINE under the guise of a data request, showing that slightly more than half of researchers responded to the request. The higher proportion of undeliverable messages among basic/translational researcher might be explained most likely because an author leaves an institution or changes his or her email address.

Examining fields covering the journals subscribing to the ICMJEs guidelines in European countries, Mattsson, Sundberg, and Laget (2011) stated that in the Science Citation Index (SCI), the corresponding author is labelled as reprint author. Less than 60% of publications had a *reprint author* tag before 1998, while from 1998 and onwards on average 98% include the *reprint address*. They also found that the first

[1] https://scientific-publishing.webshop.elsevier.com/publication-recognition/what-corresponding-author/

author was more likely to be the corresponding author in small teams while for larger teams, it would be either the first or the last author, and observe differences based on the type of collaboration. Corresponding authors tend to be last authors in internationally co-authored papers, while first authors tend to be corresponding authors in domestic publications.

At the international level, corresponding authorship has been taken as a proxy for leadership. Although research groups are organized around different structures when they collaborate with other external colleagues, they delegate the responsibility and authority to a researcher who acts as the main contributor, and by extension, to their affiliated country and institution. For example, corresponding address has been used to study leadership at the national level (Zhou & Leydesdorff, 2006; Chinchilla-Rodríguez et al., 2019). More presence as first or corresponding authors confers greater leadership; in contrast, absence in these roles could be associated with subordination or a secondary role (González et al., 2017; Chinchilla et al., 2016, 2018).

The problem on how to count publications and credit authorship is neither clear nor generally accepted (Gauffriau et al., 2005, 2007, 2008, 2017; Frandsen 2010; Waltman 2016; Bornmann & Osorio 2018), especially since disciplines have different publication practices and treat authorship differently. In principle, collaborative papers could be considered as an achievement for all authors involved, and thus full credit should be given to all of them (full counting). But the existence of disciplinary differences on collaboration advice correcting for these differences to avoid an inflation of authorship. A way of doing this is by using fractional counting, but then again it would have a negative effect in the internationalization on the performance of collaboration (Leydesdorff, 1988). Some studies have concluded that there are no significant differences between full and fractional counting (Liu et al 2018). Furthermore, when differences are observed, the difficulties to interpret the findings correctly increase (Park et al., 2016; Perianes-Rodríguez et al., 2016). A recent proposal to find a balance between both, fractional and full counting, is to calculate the square root of the fractional contribution of each author (Sivertsen et al., 2022).

Huang, Lin, and Chen (2011) counted the difference between full counting, considering only first, only corresponding author, and fractional counting. They reported that less than 3% of the publications in their dataset lacked metadata on corresponding author (in WoS) for the 1989-2008 period in physics. They concluded that there were large differences in the use of corresponding author by country. Moya-Anegón et al. (2013) used the corresponding author to give full credit to the country to which the corresponding author was affiliated. They found a strong relationship between first and corresponding author (in Scopus). This approach was also used to examine the relationship between guarantorship and international collaboration and their effect upon citation impact (Moya-Anegón et al., 2018).

The value of the corresponding author at the individual level, however, seems to be still disputed. In late nineties, Laurance (1997) expressed his concerns about the necessity of a set of coherent authorship rules after being informed by his peers that the British Research Assessment Exercise gave greater credit to the last author than the rest of authors except for the corresponding author. Indeed, the criteria followed by some national funding agencies (Ancaiani et al., 2015; Buckle & Creedy 2022) which evaluate and recognize merits for the promotion and tenure (P&T) process, tend to push for publication counts. This means that the structure of collaboration is not fairly rewarding. Furthermore, they tend to prioritize academic leadership in the byline of publications, leaving aside other roles (Robinson-Garcia et al., 2020). Hence, evaluators perceive corresponding authors as playing a bigger role than other authors (e.g., middle authors) (Wren et al., 2007) and the prestige of the last author tends to increase when also designated as corresponding (Bhandari et al., 2014).

Assuming that the designation as corresponding author is meaningful, some articles have examined the change in individual publication practices, such as an increase in the number of papers with more than one corresponding author (Liu et al., 2018). Other studies have sampled only corresponding authors to ask about the roots of their creative ideas, assuming that these authors were involved in the design of the work (Tahamtan & Bornmann, 2018), or to analyze statements on research contribution in order to study the degree of adherence to ICMJE authorship criteria in one biomedical journal (Marušić et al., 2004).

Motivated by the scandal of fake reviews submitted with fake e-mails from non-institutional accounts and its retractions in one Springer' journal (Stigbrand, 2017), Shen, Rousseau, and Wang (2018) examined whether the differences in institutional and non-institutional email address influenced citation patterns. The email of the corresponding author from WoS (*reprint address*) or in its absence, the email of the first author in the list of authors was taken as unit of analysis. They found out that papers with an institutional e-mail address receive more citations than others, agreeing with publishers who require authors to provide their institutional e-mail. Wang and Wang (2017) look at how collaborations between China and the European Union are established examining whether corresponding authors are Chinese local, Chinese abroad, and non-Chinese, it seems that that academic collaborations between China and the EU28 have been mainly set up by Chinese researchers. Although, Chinese corresponding authors may be the result of the incentive structure in China (Fuyuno & Cyranosky 2006; Franzoni, et al., 2011; Quan, et al., 2017).

Author order has also been used to understand how different roles in academia are affected by gender (e.g., Ghiasi, et al., 2018), observing an under-representation of women as authors in academic publications, and in more prestigious authorship positions (West et al., 2013). For instance, Boekhout, van der Weijden and Waltman (2021) found that in biomedical disciplines, men are about 25% more likely than women to be last authors, suggesting that men tend to have more senior roles than women. Garg and Kumar (2014) looked at corresponding vs. other author roles by gender showing that women tend to work in small teams, and they represent about a quarter of corresponding authors in some fields. Macaluso et al. (2016) reported that the relationship between team size and proportional contribution to various tasks differs considering the gender of the corresponding author. Women appearing as first or corresponding authors are more likely to be associated with all tasks except contributing materials. In the case of male corresponding or first authors, these were more likely to be associated with all tasks except experimentation. Studies focused on gender and geographic location of first, last, and corresponding authorship (Fox, et al., 2018) found that female first authors were less likely to serve as corresponding in their papers. This difference increased with the degree of gender inequality in the author's home country. First authors from non-English-speaking countries were less likely to serve as corresponding authors, especially if the last author was from an English-speaking country.

Recently, there has been an increasing trend for including more than one corresponding author. Between 1999 and 2008 the percentage of papers with more than one corresponding author has steadily been on the rise. However, neither WoS or Scopus provided this information. Hu (2009) argued that the fact that major databases do not mention "equal first authorship" has severe implications and that as more and more journals require disclosure of the exact contribution of each author, it should be considered in scientometric investigations. Since then, there have been studies analyzing this phenomenon in specific disciplines, like biomedicine (Hu, et al., 2010, Akhabue & Lautenbach 2010) or pharmacy and anesthesia (Huang, et al., 2016).

3. DATA AND METHODS

A total of about 33 million documents from WoS Core Collection and 43 million of documents from Scopus were retrieved from the in-house version of the Web of Science (WoS) and Scopus maintained at CWTS

(Leiden University) for all document types, which is a common practice in these types of studies (see for example Martin et al., 2018, Visser et al., 2021; Huang et. al., 2020). We used Digital Objects Identifiers (DOIs) to match more than 23 million publications published between 1998 and 2017 (n=23,426,742) from both databases. The matched dataset represents 62% of all WoS publications and 54% of all Scopus publications (Figure 1).

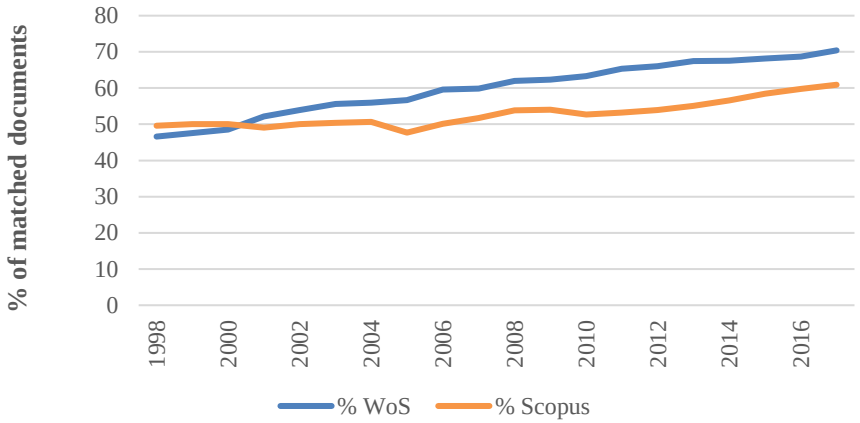


Figure 1. Percentage of full databases represented by the set of publications matched with DOIs.

Both databases are expanding the inclusion of DOIs over time, with the matched set representing in 2017, 70% of WoS and 60% of Scopus (Figure 1). The lower proportion of documents with DOIs in Scopus might be explained by differences in coverage. Scopus includes a wider representation of countries and languages than WoS (Moya et al., 2007). DOI registration requires investment and infrastructure that may be lacking for some countries or institutions: according to the Scopus Content Coverage Guide, 60% of journals of more than 5,000 international journals do not belong to the most consolidated publishers, such as Elsevier, Springer, etc. [2] That suggests that there are journals published by universities, associations, etc. which do not assign DOIs to their records. For a comprehensive database comparison, see Martín-Martín et al. (2021) Visser, et al. (2021) and Gusenbauer (2022).

Bibliometric databases do not include metadata for corresponding author explicitly (Huang, et al., 2016). Rather, the *reprint address* is the indication of the author to whom correspondence should be addressed[3]. Therefore, we operationalize corresponding author as reprint author and will use these terms interchangeably. We calculate the number of authors for each published paper and consider author positions in the byline of all co-authored publications, namely, first, middle, last and corresponding author.

Each publication was categorized into four broad categories and fourteen disciplines which are used for the disciplinary breakdown of the numbers presented in this paper. Medicine (MED) including biomedical research, clinical medicine and health; natural sciences and engineering (NSE) composed by biology, chemistry, earth and space; engineering and technology, mathematics and physics; social sciences (SS): professional fields, psychology and social sciences, and arts and humanities (AH) with arts and humanities.

[2] https://www.elsevier.com/__data/assets/pdf_file/0007/69451/Scopus_ContentCoverage_Guide_WEB.pdf
[3] https://support.clarivate.com/ScientificandAcademicResearch/s/article/Web-of-Science-Core-Collection-Explanation-of-Reprint-Address?language=en_US

4. RESULTS

Next, we report our main findings. This section is structured as follows. First, we compare corresponding authorship metadata as shown in Web of Science and Scopus. For this, we focus on a global analysis of the levels of disagreement between the information reported in each database. In order to validate our findings, we randomly select three different samples and manually inspect them. In the second section of the results, we focus on the information reported by WoS and we investigate differences on corresponding authorship by scientific field and geographic regions. We conclude the reporting of our findings showcasing some specific countries.

4.1.Comparison of the corresponding author in Web of Science and Scopus

The number of documents with corresponding authors has increased steadily across time (Figure 2A). In the entire matched dataset, on average about 97% of WoS documents contain at least one reprint author, whereas 85% of Scopus documents have these metadata, derived from fluctuations in the data before 2004 and after 2012. These fluctuations seem to be derived from indexing errors in specific Physics journals. To understand the reasoning behind these fluctuations, we manually inspected the source of records with no correspondence in Scopus, but with at least one corresponding author in WoS. We observe that the corresponding author field of over 80% of records from journals such as Physics Review Letters, Physics Review D or Physics Review B among others has not been indexed in the early period. During 2002 and 2012 the top journals for which the corresponding author field is not indexed changed, and the share of non-indexed records lowers to around 50% for these journals. Also, these journals publish less papers per year (between 300 and 4000 papers). Throughout 2013 to 2017 again the share of papers for which this field is not indexed increases in journals such as Astrophysics J. (94% of its records do not include a corresponding authoring 2016) or Proc SPIE Int Soc Opt Eng (i.e., this journal produces around 14,000 papers a year, in 2012 10% of its papers did not include a corresponding author, this share increases to over 60% within the 2013-2017 period).

For those with reprint authors (Figure 2B), WoS starts indexing significantly documents with more than one reprint author from 2014 onwards—reaching 10% of our sample by 2016—and increasing at a more rapid pace than the inclusion of multiple reprint authors in Scopus.

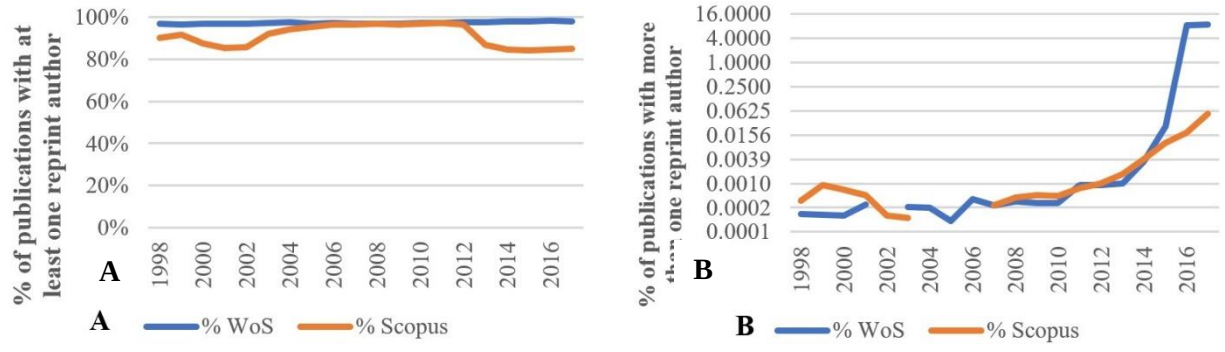


Figure 2. Number of documents within the database with at least one corresponding author (A) and more than one corresponding author (B)

Table 1 shows the position of the corresponding author in the author byline (first, middle or last) for: 1) all publications matched with DOI in both databases; and 2) by number of co-authors (single vs. co-authored)

related to the coverage of the corresponding author. For all publications, the percentage of documents with the same corresponding author in both databases is close to 86%. There are significant differences in documents where only one database identifies a corresponding author, and WoS registers corresponding authors in 12% of documents that Scopus does not, and only 1% of documents have no corresponding author in both databases.

For publications with a single author (11.8% of all matched documents), nearly 80% have the same corresponding author in both databases, whereas significant differences remain in documents where only one database identifies the corresponding author. WoS always has a higher percentage of documents with corresponding authors than Scopus (10.5% and 5.4% respectively). Around 4.5% of documents do not register corresponding author in both databases.

Table 1. Distribution of the place of corresponding author (CA) in author order

% documents	Same CA	CA in Wos and not in Scopus	CA in Scopus and not WoS	No CA in both databases
All	85.70	12.19	1.05	1.06
Single authored	79.55	10.51	5.38	4.56
Co-authored	86.51	12.41	0.48	0.60
First	47.60	9.79	1.52	41.10
Middle	13.42	1.97	0.82	83.79
Last	25.51	3.76	1.08	69.65

For publications with more than one author and where the first, middle and last author appears as corresponding, 48%, 13% and 25% respectively of documents have the same corresponding author. WoS assigns a corresponding author to a larger number of unique documents than Scopus (second and third columns) and only 0.6% of documents has no corresponding author in both databases.

Validation

To verify how discrepancies between databases matched reality - that is, how was corresponding author originally assigned by the journals, - we manually inspected three random samples. The first sample (Set 1) consisted of a random selection of 100 co-authored papers for which both databases reported the same corresponding author. The second sample (Set 2) included 100 publications for which Scopus reported a corresponding author, but WoS did not. The third sample (Set 3) also included 100 papers, in this case, WoS reported a corresponding author but Scopus did not. For each of these, the full text was manually examined to determine the validity of the identification of corresponding authorship. We looked into three items: (a) whether a corresponding author was explicitly labeled; (b) whether contact information was provided; and (c) the author position of corresponding author.

Set 1. In the cases where Scopus and WoS both agreed on corresponding first authors, this was indicated by either a single email address or a corresponding author indicator (100% in WoS and in 97% in Scopus). For these three documents with no explicit indication of corresponding author, we found different document types (article, conference, and editorial material). However, Scopus had a higher proportion of documents with an email address than WoS (88% vs. 77%)

Both databases showed the same data in all cases but four in which the corresponding author occupied a middle position. In that case, an email address was provided. However, in three cases, more than one email addresses were provided for both the last and middle authors and in one case for all authors in WoS. In Scopus, for those publications with more than one email (9% of our sample), first or last positions were clearly indicated while WoS defaulted to the first listed email address. Therefore, middle corresponding authorships may be undercounted.

Similarly, in corresponding last authorships, WoS specifically indicated a corresponding author while Scopus miss this data in all but 6 of the 100 sampled records. Only in one of those missing cases, an email was not provided. For those publications with more than one corresponding author, in all cases Scopus provides more than one email for each corresponding author, while WoS only for last authors. This reinforces that WoS may be undercounting corresponding authorships.

Set 2. Twenty-one of the papers sampled in Set 2 were not research articles—e.g., book reviews, corrections, editorials, and errata—with either no explicit author or a single author (7%). No email was provided, or corresponding author indicated. This suggests that Scopus might be more liberal in assigning a corresponding author to this front material. Only 27% of other records did not explicitly state an email for the corresponding author. In one case, there was an email provided and for another a mailing address. In one instance, there was a collaborative author (STAR Collaboration). The remaining records had an author explicitly labeled as corresponding: 43% as first, 20% as middle, and 37% as last author. More than half of those with an explicitly labeled corresponding author did not have an email address provided on the manuscript. This may suggest that WoS is more likely to avoid assigning a corresponding author without an email address.

Set 3. 24% of the documents sampled in Set 3 were collaborative authorships from high energy physics (e.g., The CMS Collaboration, ATLAS Collaboration). This comprises almost a quarter of the records where WoS identified a corresponding author but Scopus did not, suggesting that Scopus' practices tend to ignore corresponding authorships in large-scale collaborations. In each of these cases, two emails was for the network, rather than an individual and in 7 cases email was not provided. In all these cases, the corresponding author occupies the first position, suggesting that WoS simply chose the first available email for the corresponding author. For the remaining records, 12 not explicitly identify an email for the corresponding author. When a clear corresponding author was listed, a single email was provided in 53 cases, which was likely interpreted as corresponding. In 50 cases it was the first author, last author in ten cases, and middle in 6 cases. Multiple email addresses were provided for four of the records ((1) all authors, (1) first and last author, and (3) last two authors). In short, of those with a WoS corresponding, but no Scopus corresponding author, 53% were unambiguous upon examination. Table 2 summarizes the validation process.

Table 2. Validation process.

	WOS			**SCOPUS**		
	A)	B)	C)	A)	B)	C)
Set 1 (First)	100	77	100	97	88	100
Set 1 (Middle)	100	68	100	96	76	100
Set 1 (Last)	100	94	100	94	99	100
Set 2				100	27	100
Set 3	100	71	F(76); M(6); L(16)			

Legend: A) whether the CA was explicit labeled; B) whether contact information was provided; and C) the author position of CA

4.2. Country and discipline differences on corresponding authorship in to WoS

20% of documents in WoS did not include reprint author metadata, for the rest of papers, corresponding authors appeared as first authors in 47%, 10% as middle authors and 22% as the last authors. Excluding 20% of papers without reprint author metadata, 59% of papers are assigned to the first author, 13% to

middle authors and 28% of last author (Figure 3). For those documents with at least one email, WoS registers the corresponding author of more than 55% of papers to the first author and more than 61% have more than one email. When at least one corresponding author appears in the author table, it is usually assigned to the first author (56%), whereas when more than one corresponding author appear, they are usually assigned to middle author position (66%).

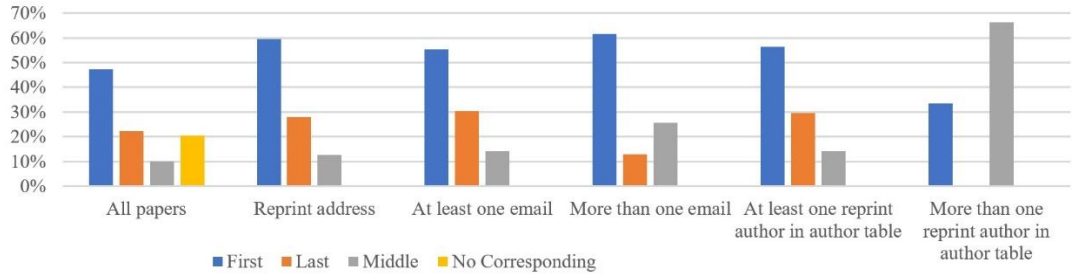


Figure 3. Percentage of papers by type of reprint author metadata in Web of Science (1998-2018)

The distribution of papers over time with reprint address metadata shows that for nearly 28% of all papers in 1998, and 20% in 2018, there is no metadata for reprint address (Figure 4A). For single authored papers, this percentage raises from 57% in 1998 to 67% in 2018, while for co-authored papers, percentages are higher (from 83% in 1998 to 85% in 2018) [4]

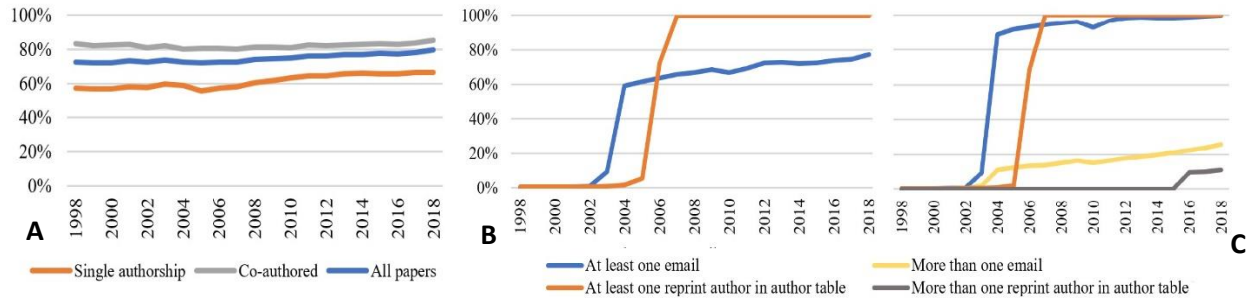


Figure 4. Percentage of papers with reprint address metadata in WoS for all, single and co-authored papers (A); percentage of single-authored (B) and co-authored papers (C) with email addresses and reprint author metadata in WoS in relation with those that have a reprint address.

In the right panel, we can observe that WoS starts registering email addresses from 2001 onwards. As of 2004, it seems consistent but there is still incomplete in single-authored papers (in 2018, 21% of papers lack this information) (Figure 4B). Email addresses in reprint address field have been completely recorded over the last years in collaborative papers (Figure 4C). Besides, WoS starts registering consistently reprint

[4] The WoS user guide (2019) provides some insight into the indexing practices. Beginning with 1998 data, we do not remove a duplicate address if it appears as both a research and a reprint address. If you want to count unique addresses, exclude <reprint_addresses> data. Prior to 1998, a research address that matches a reprint address is not included in the list of research addresses. To count unique addresses, create a table for all addresses and eliminate duplicates for all years. Then, on an ongoing basis, match addresses to the existing table and move the duplication.

author metadata in 2005; more than one email address in collaborative papers in 2004 increasing steadily over time (more than 25% of papers in 2018); and more than one corresponding author per paper in 2016[5].

We also explored the position of corresponding authors over time (Figure 5). From 1998 to 2018, the most common position for corresponding authors is the first one, although it begins to decline in favor of middle (more than 30% of papers) and last positions (more than 20%) (left panel).

When considering collaborative papers with reprint author metadata in all disciplines (right panel), the percentage of papers with corresponding author as first author descend 46% over time (from 88% to 47%) while papers with last author as corresponding author multiply by four times and middle authors increase 6 times their presence in WoS. It seems that correspondence was assigned by default to first authors, while more recently it is assigned to last authors. Besides, middle authors are increasing at a higher rate than the rest. However, the percentage of papers with no corresponding author remains steady over time (around 20%).

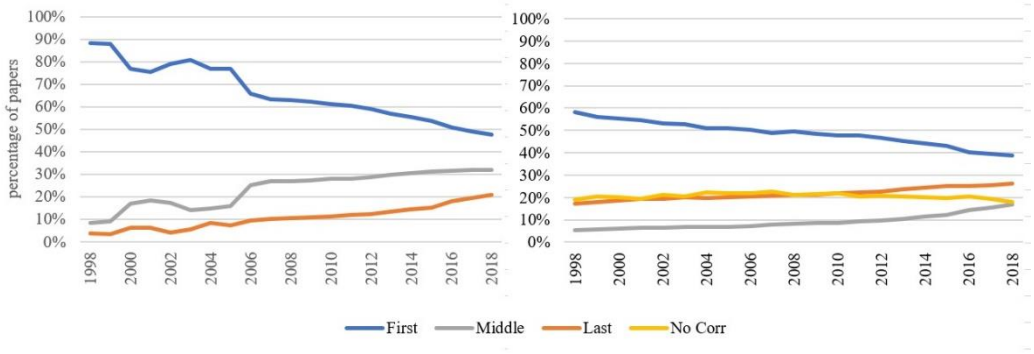


Figure 5. Evolution over time of author order positon as corresponding author in all papers (left) and in collaborative papers (right) with at least one corresponding author in the author table.

Differences by field

Next, we explore the evolution over time of the percentage of papers by broad scientific fields (Figure 6). Percentages of papers with first author as corresponding author are decreasing over time in medicine (MED), natural science and engineering (NSE), and social sciences (SS). In arts and humanities (AH), first authorship shows two different phases: until 2002 it accumulates around 60% of papers and 40% of papers with no corresponding author. As of 2002 first authorship increases (up to 80%) while the share of papers with no corresponding author decreases significantly from 60% to 5%. NSE presents the higher decrease (around 40%) of first authorship as corresponding (from around 74% to 45%) favoring last and especially middle positions (growth rate of 96% and 322% respectively). Papers with no corresponding author also decrease over time (from 6% to 1.7%). MED shows a lower decrease in first authorship than NSE (from

[5] Practices, however, are always changing. As noted on the Clarivate website (2021): Although many journals specify only one corresponding author, there is no limit to the number of contributors who may be designated to receive correspondence for a paper. As of January 27, 2016, multiple reprint addresses will be captured and displayed on the *Web of Science Core Collection* Full Record. For records indexed prior to January, 2016, only the first reprint address will be displayed. See https://support.clarivate.com/ScientificandAcademicResearch/s/article/Web-of-Science-Core-Collection-Explanation-of-Reprint-Address?language=en_US

54% to 40%), with the highest proportion of papers for which last authors appear as the corresponding authors. This trend remains over time with around 35% of papers in 2018. In SS, first authorship is the most common position (77% in 2018) with a slight decrease (10%) over time, while last and middle authorship multiply by two and three times respectively their presence as corresponding authors (15% and 10% respectively in 2018).

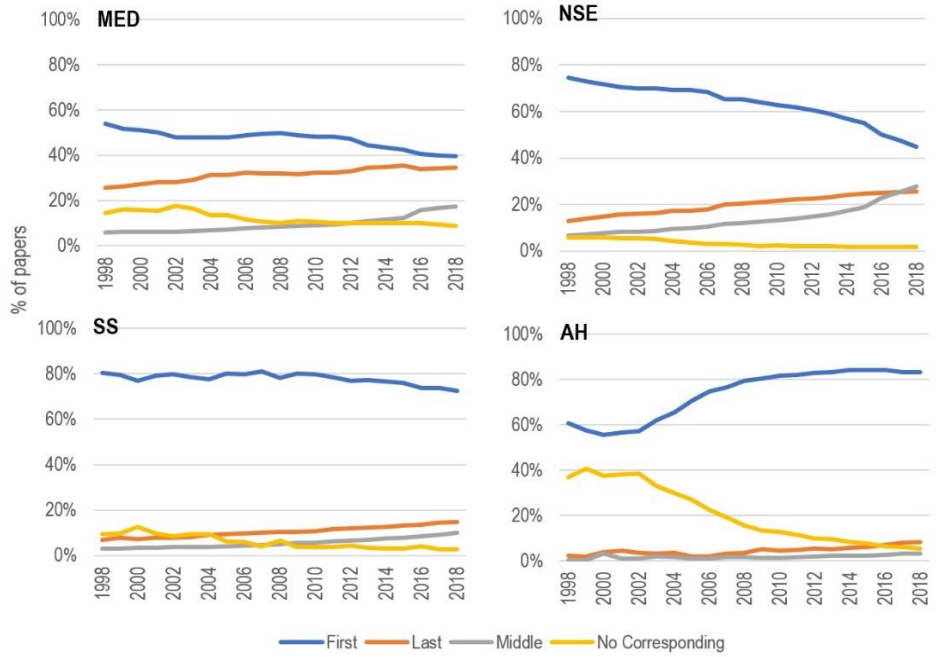


Figure 6. Percentage of collaborative papers by corresponding authorship and broad scientific field

Figure 7 shows a heat map by disciplines and types of author information metadata in collaborative papers in the left panel (sorted in descending order by the column 'At least one email'). Overall, more than 39% of documents do not record at least one email and 43% of papers do not have one corresponding author in the author table, which means that there is a huge proportion of papers without this information. There is certain correspondence between papers having an email and at least one corresponding author in the author table. Some discrepancies are observed in Psychology and especially in Arts and for Humanities, where there is a high proportion of papers with at least a corresponding author and low proportion of papers with at least one email. The case of Physics is more balanced but particularly striking showing low values in both variables (less than 50%).

Only 12% of papers register more than one email; however, Mathematics (46%) Humanities (29%), followed by Social Sciences, Professional Fields and Engineering and Technology (around a quarter of papers) shows the higher percentages of papers with more than one email in WoS. Papers with more than one corresponding author in the author table barely represent 2% in all disciplines, being more likely to appear in Chemistry, Biomedical Research and Engineering.

Discipline	All papers				Papers in collaboration			
	First	Middle	Last	No Corr	First	Middle	Last	No Corr
Social Sciences	85.1%	5.5%	2.9%	6.5%	77.8%	12.5%	6.5%	3.3%
Professional Fields	82.0%	6.5%	4.7%	6.8%	78.1%	11.3%	8.2%	2.3%
Mathematics	78.9%	12.9%	6.4%	1.9%	72.1%	17.7%	8.8%	1.5%
Humanities	78.6%	0.3%	0.1%	21.0%	83.0%	5.3%	1.3%	10.4%
Psychology	77.1%	9.4%	4.3%	9.2%	74.8%	11.8%	5.4%	7.9%
Earth and Space	76.4%	9.8%	11.4%	2.4%	74.9%	10.7%	12.6%	1.8%
Health	74.1%	9.8%	5.5%	10.7%	71.7%	12.4%	7.0%	9.0%
Physics	74.0%	13.3%	11.2%	1.5%	71.7%	14.8%	12.5%	1.0%
Engineering and Te	63.4%	16.5%	16.7%	3.4%	62.1%	18.2%	18.5%	1.2%
Biology	59.6%	22.8%	10.7%	6.9%	57.1%	25.0%	11.8%	6.1%
Clinical Medicine	51.4%	25.6%	8.9%	14.0%	48.2%	28.5%	10.0%	13.4%
Arts	47.8%	0.6%	0.4%	51.1%	68.1%	5.8%	4.3%	21.7%
Biomedical Researc	38.1%	43.0%	12.5%	6.4%	35.0%	46.4%	13.5%	5.0%
Chemistry	37.0%	35.4%	21.8%	5.8%	35.2%	37.5%	23.1%	4.2%
All disciplines	58.5%	22.0%	11.0%	8.4%	54.1%	26.2%	13.2%	6.6%

Discipline	At least one email	More than one	At least one reprint author in	More than one reprint author in
Health	79.9%	7.1%	75.1%	0.4%
Mathematics	72.8%	46.6%	69.0%	0.9%
Psychology	68.6%	7.2%	59.0%	0.6%
Engineering and Techn	67.4%	24.1%	65.0%	2.8%
Earth and Space	66.0%	14.5%	61.8%	1.4%
Professional Fields	64.9%	25.8%	66.4%	0.5%
Chemistry	64.4%	13.1%	53.3%	3.8%
Biomedical Research	62.8%	9.5%	56.1%	3.0%
Social Sciences	62.7%	26.1%	64.9%	0.6%
Biology	61.6%	8.9%	55.8%	1.2%
Clinical Medicine	60.1%	4.2%	55.4%	1.1%
Arts	47.2%	19.8%	65.5%	0.5%
Physics	46.3%	10.8%	46.8%	1.2%
Humanities	46.2%	29.2%	63.8%	1.0%
All disciplines	61.7%	11.9%	57.1%	1.9%

Figure 7. Percentage of all and collaborative papers with corresponding author and email addresses metadata by discipline. Red color refers to the highest values and blue color refers to the lowest values

In the right panel (Figure 7), a heat map shows authors position by disciplines in collaborative papers. First authors as corresponding authors accumulates the higher proportion of papers in almost all disciplines, except for those related with NSE and MED broad scientific fields. Biomedical Research (46%), Chemistry (38%), and Biology (28%) present the higher values for papers with Middle authors as corresponding authors; while last authorship as corresponding author is usual in Chemistry (23%), Engineering & Technology (18%).

Differences by number of authors

Considering the number of authors per paper, the distribution of corresponding authors in distinct order positions is shown in Figure 8. Left-top panel shows that in all papers, first authorship is the most prevalent decreasing over time (- 30%) in favor of middle (149%) and last (20%) positions, which evolve in parallel. The right-top panel shows authors appearing in co-authored papers with at least one corresponding author in the author table. In this case, there is no metadata of corresponding authorship for around 23% of authors. In 2006, there is a clear change of pattern which is consistent with Figure 2 (WoS starts registering consistently *reprint autho*r' metadata in papers from 2005 onwards). Corresponding authors in first position descend from 66% to 46% whereas authors who appear in the last position evolve from around 23% in 1998 to 28% in 2018. The most evident shift is observed in authors appearing in middle positions, going from 11% to 30% in 2018 in MED, while middle authorship overtaking last authorship in NSE.

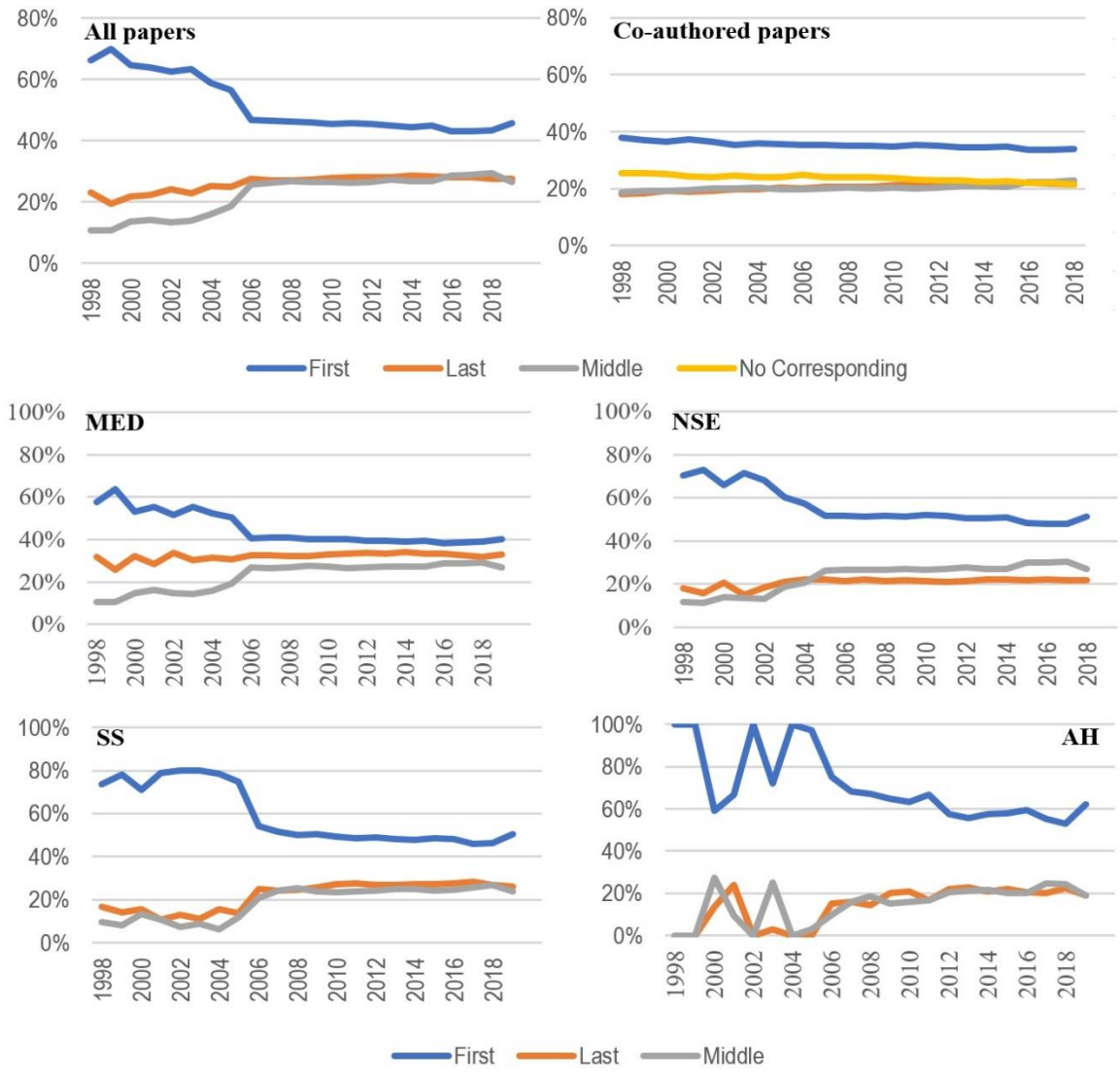
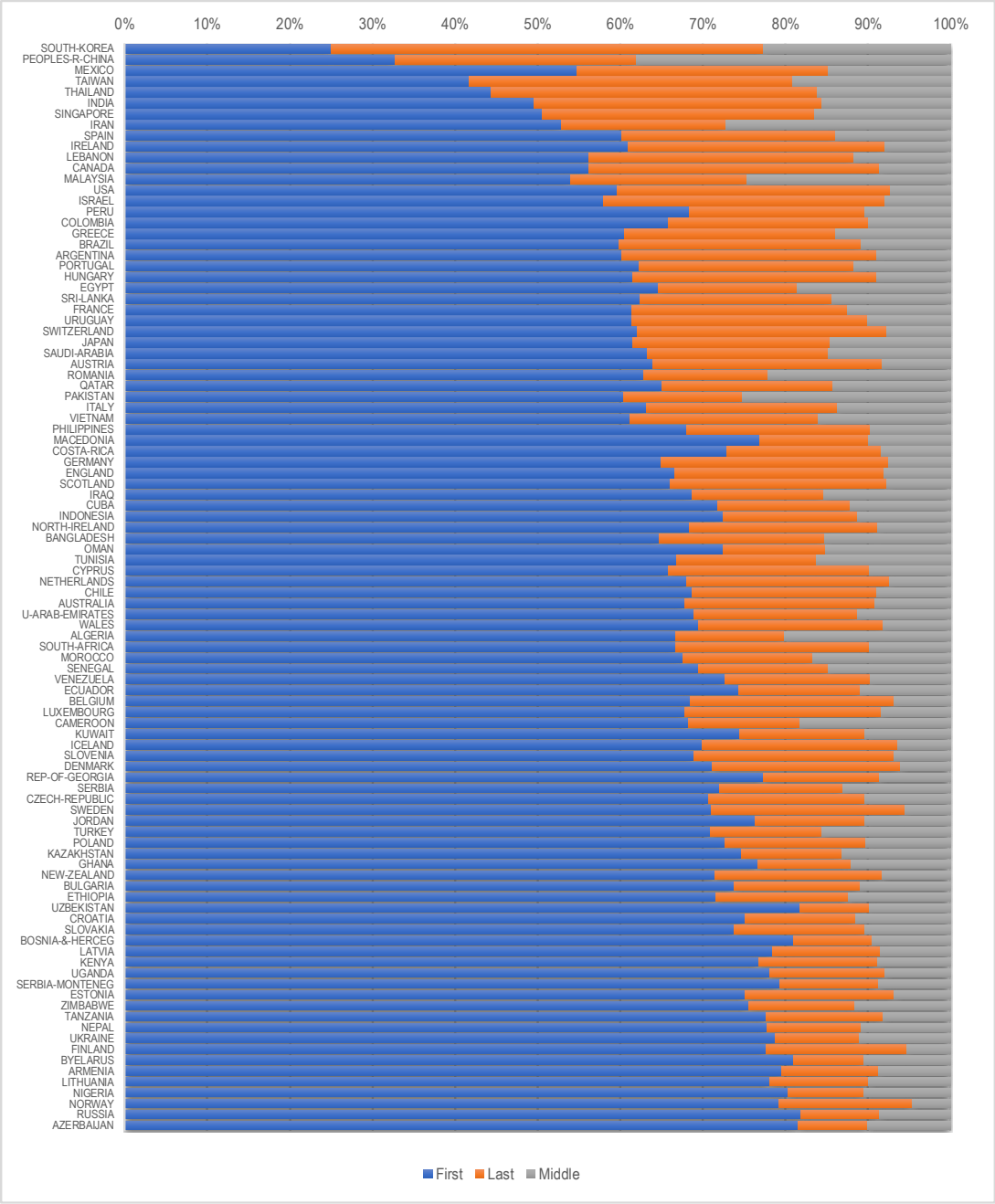


Figure 8. Evolution of the percentage of authors in collaborative papers by corresponding authorship and broad scientific field

Differences by country

Next, we explore differences between countries and regions. Figure 9 shows the distribution of papers of the 100 most productive countries by the number of papers with first, last and middle author as corresponding author (sorted ascending by first authors). It seems that some Asian and Latin American countries tend to accumulate a higher proportion of papers with middle and last authors as corresponding authors.



412

413 **Figure 9.** Distribution of papers by order position of corresponding author in 100 most prolific countries.

414 To have a better understanding of how order position of corresponding authorship varies across countries,
415 figure 10 shows the distributions of countries by regions according to the order position of the
416 corresponding author. The higher proportion in first authorship is observed in all regions with variations.
417 The general pattern that emerges is that, for all groups, there appears to be a high concentration of first
418 authorship. Although we do observe extreme cases, such as South Korea in East Asia & Pacific (25% of
419 first and 50% of middle position as corresponding authors). China, Taiwan and Indonesia have a higher
420 proportion of last and middle corresponding authorship and lower first corresponding authorship.

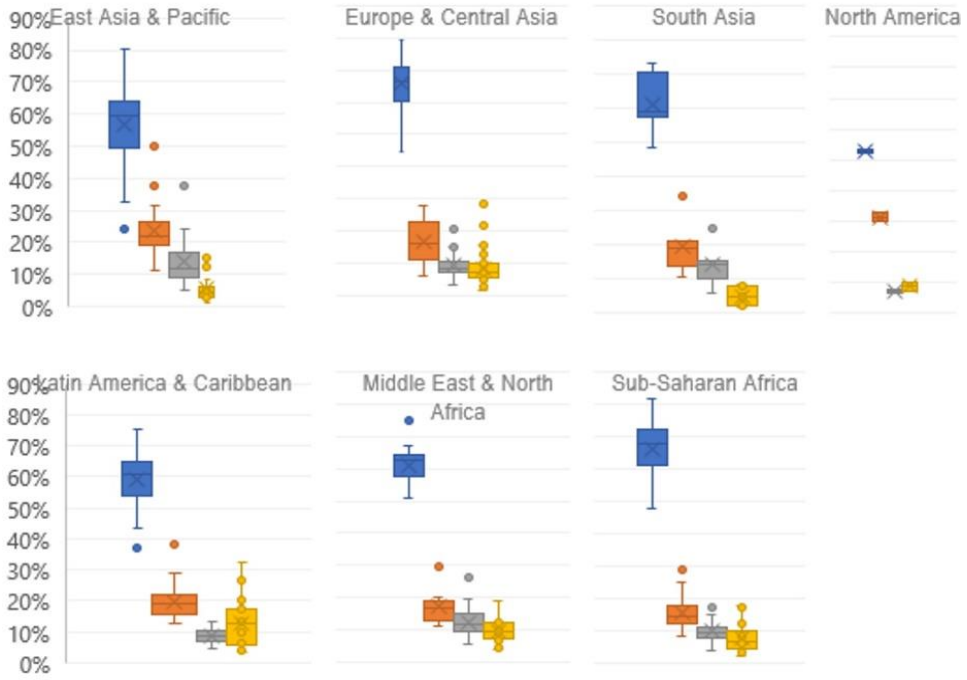


Figure 10. Distribution of papers according to the order position of corresponding author in countries classified by geographical regions. Legend: First author (blue); last author (orange); middle author (grey) and no corresponding author (yellow)

Indeed, there are some country differences. Even there are no consensus about the status and meaning of the corresponding author in all universities, publishers and/or authors (Willems and Plume 2022), some countries gone so far as to monetized this position of leadership: Korea, China, and Pakistan all have governmentally funded incentive structures for those who are first and corresponding authors on papers in journals such as *Science*, *Nature*, or *Cell* (Fuyuno & Cyranosky 2006; Franzoni, et al., 2011; Quan, et al., 2017). That suggests that different scientific cultures and incentives may also play a role in the choice of the corresponding author and for extension, in the behavior of research groups that tend to adapt in evaluative research assessment. So that, the validity of corresponding author in major databases are important in order to assign correctly the position of authors in evaluation studies and it should be further investigated in future studies (Figure 11).

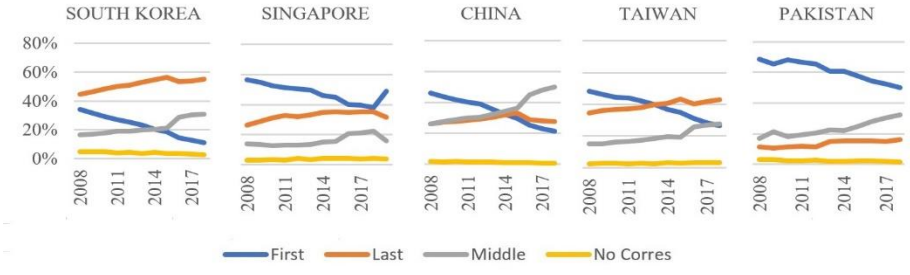


Figure 11. Evolution over time of corresponding authorship by order position in most prolific countries by geographical region

5. DISCUSSION AND CONCLUDING REMARKS

Gaining authorship in a published paper is a prestigious endeavor that is sought out by everyone in the academic-research world (Cuschieri 2022). Several studies have examined the relationship between corresponding author and author order. However, most of these studies just focus on a small portion of data, covering only a limited research fields or time range, which may not be ultimately generalized to other situations (Yu & Yin 2021).

In this study, we present an empirical analysis of the use of corresponding authorship in scientific publishing. As metadata for corresponding author is not explicitly reported in the Scopus and Web of Science databases (Hu 2009), we use the reprint address field as the indication of the author to whom correspondence should be addressed. We observe that Web of Science and Scopus have increased over time the number of records for which they include reprint metadata. WoS has a higher percentage of papers that contain this information. But the percentage of documents with more than one corresponding author is higher in Scopus than in WoS. There are significant differences in documents where only one database identifies a corresponding author or the corresponding author is not the same. After manually inspecting some random samples, we observe that when multiple email addresses are provided, WoS will simply include one of the available emails, while Scopus ignores this information if the number of co-authors is extremely high (e.g., high energy physics).

These two data sources are important in bibliometric studies and have often been compared with regard to the coverage of fields, countries, languages (Mongeon, & Paul-Haus, 2016; Singh et al., 2021; Gusenbauer 2022), but rarely used to analyze authors' positions related to corresponding authorship. So, this study contributes to the literature bringing insights about their indexation practices in corresponding authorship. We also acknowledge that much more work is still to be done in the future related to this comparison of the operationalization and coverage of corresponding authors in scientometric databases. Particularly relevant will be to expand comparison with new and larger data sources in the field (e.g. OpenAlex, Dimensions, Lens.org, etc.).

We further explore changes on the position of corresponding authors over time in WoS, by fields and by countries. We found that reprint address metadata is not complete neither in single authored (more than 30%) or co-authored papers (15%). WoS starts registering consistently reprint author metadata from 2005 onwards and more than one reprint author from 2016.

We find that first authorship is the most common position in all papers holding the corresponding author role, although this trend is changing in favor of middle and last author positions, especially in MED and NSE fields. It seems that first authors were the corresponding authors by default, while middle authors appearing as corresponding authors are increasing at a higher rate than the rest, for example in NSE. Yet, the average of percentage of papers with no corresponding author remain steady over time (around 20%). This appears to be related with the document type rather than with systematic biases in the database.

When considering the number of authors per paper, we found that close to a third of authors do not appear as corresponding authors , In line with the results of Milojevic et al. (2018), our hypothesis is that technical staff might be behind this figure, which might have some effect in research evaluation assessments. Further research needs to be conducted in future studies. Besides, there are country differences of the percentage of position in the byline of corresponding author. Although first authorship is more likely to serve as corresponding author in most countries, there are exceptions such as for example South Korea, China, Pakistan or Taiwan where last and middle positions are more likely to appear as corresponding. This could be due to the introduction of incentives with regard to the corresponding author, and seems to be consistent with other studies (Ding and Herbert 2022).

5.1. Policy implications

The complexity of evaluating intellectual contributions in increasingly interdisciplinary research and collaboration, and the competitiveness environment of the labor market (Larivière et al., 2016) has important practical implications for scientists, funding providers, and research evaluators. Corresponding authorship have become an indication of seniority and leadership on the team driven by incentives initiatives for funding agencies and research institutions, rather than a particular set of responsibilities (Willems & Plume 2021). The use of author order as a primary source of credit (Egghe, et al., 2000) can be problematic and it has consequences for evaluation studies, as the inaccurate assessment of collaborators can harm the sustainability of scientific collaborations (Wang et al., 2020; Lu et al., 2022); lead to a dramatic drop out of scientific career (Milojevic et al. 2018), especially in early career stages and for female researchers (Robinson-García et al., 2020); may lead to unethical practices (ghost, gift and/or honoraric authors (Texeira da Silva, 2021).

At the individual level, it seems that the greatest driver behind the selection of corresponding authorship in collaborative papers is the competitive environment in which researchers and institutions are now operating in. In order to secure job opportunities and funding, researchers will use the role of corresponding author as a means to get credit regardless of their position on the author list (Willems & Plume 2021). Last decades have witnessed an increasing number of corresponding authors and equally contributing authors growing stress on teamwork if not properly acknowledged in research evaluation exercises (Fuyuno & Cyranosky 2006; Franzoni, et al., 2011; Quan, et al., 2017), journals (Dubansky & Omary 2012; Omary et al., 2014; Dubrin, 2014), and bibliographic databases (Hu, 2009). This study contributes to shed light on the validity of corresponding authors in bibliographic databases showing that there is not a systematic and accurate standard to index this author position in two of the major bibliographic databases. So, studies focused on the figure of corresponding author should be cautious on their interpretation of these findings.

At the country level, we show that incentives may play a role. The significant shift in the position of corresponding author in some countries also increases geographic inequalities, as authors providing funding will automatically adopt the corresponding author role, leaving other positions to the rest of collaborators. Besides, the individual incentives for publishing as corresponding authors in some countries, universities are increasingly reaching agreements with publishers where it specifies that corresponding author must be an employee of a participating university (Willems & Plume 2021). However, not all researchers have access to the same resources (Chinchilla et al., 2019) which leads to an underrepresentation of institutions from less developed countries (Gumpenberger et al., 2018; Powell et al., 2020), and research publishing will be closed to those who cannot make and institution or project money payment (Zhang et al., 2022), which opens new research questions to be further investigated.

Given the potential value of publications indexed in bibliographical databases and its use as bibliometric data source for large-scale analyses in research assessment, research landscape studies, science policy evaluation, or university ranking (Baas, et al., 2020) and its consequences in the reward system of science (Butler, 2003; Hornibrook, 2012; Crespo & Simoes, 2021), it is important to assess their strengths and weaknesses (Mongeon & Paul-Haus 2016; Bornmann, 2018; Guerrero et al., 2021) in order to guarantee the bibliometric relevance completeness, and accuracy of the sources.

The results of this study are currently relevant since more bibliometric databases are being developed (e.g., Dimensions.ai or OpenAlex). How these databases conceptualize and operationalize specific metadata elements may differ substantially among them, and sometimes important metadata elements like the corresponding authors may even be overlooked (e.g., the current version of OpenAlex does not include corresponding author identification). We plan to continue studying these differences among data sources in

a more complete study on the concept of corresponding authorship and how it is captured among the different database. In this way, it will provide better evidence for researchers to choose those which better represent their ultimate goals before drawing conclusions that can be used for policymakers and other stakeholders.

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AUTHOR CONTRIBUTIONS

Conceptualization: ZCR, NRG, RC, VL; Data curation RC, VL; Formal Analysis ZCR, NRG; Supervision RC, VL; Funding acquisition ZCR, NRG; Methodology ZCR, NRG, RC, VL; Writing – original draft ZCR; Writing – review & editing ZCR, NRG, RC, VL

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DATA AVAILABILITY

The data sets (Web of Science and Scopus) used for analyses in the current study are not publicly available due to licensing clauses.

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