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Title	Scientific authorship in DSS research: Past trends and future opportunities
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Publication date	2023-05-18
Original Citation	Keenan, P. B. and Heavin, C. (2023) 'Scientific authorship in DSS research: Past trends and future opportunities', in: Liu, S., Zaraté, P., Kamissoko, D., Linden, I. and Papathanasiou, J. (eds) Decision Support Systems XIII. Decision Support Systems in An Uncertain World: The Contribution of Digital Twins . ICDSST 2023. Lecture Notes in Business Information Processing, vol 474, pp. 287-301. Springer, Cham. doi: 10.1007/978-3-031-32534-2_21
Type of publication	Article (peer-reviewed);Book chapter;Conference item
Link to publisher's version	10.1007/978-3-031-32534-2_21
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Download date	2026-11-17 11:25:55
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Scientific Authorship in DSS Research: Past Trends and Future Opportunities

Abstract
As an area of research, Decision Support Systems (DSS) has undergone various changes over the last 60 years. Drawing on contributions from fields including Economics, Operations Research/Management Science (OR/MS), Information Systems (IS), and management, DSS research has traditionally focused on supporting managerial decision-making. In recent years, with the exponential increase in the volume of research characterised as "Business Intelligence and Analytics," the boundary of the DSS area is unclear, rendering the future of the field uncertain. To better understand the DSS landscape, this article uses a bibliometric analysis to investigate current publishing trends in DSS as a research area, co-authorship by gender, and location. By leveraging Scopus, we identify notable patterns and developments in DSS research over a five-year period from 2018 to 2022. Finally, we present initial recommendations to guide the future research efforts of both DSS academics and practitioners.

Keywords: Decision Support, Decision Support Systems, DSS, bibliometric analysis, gender, author, location.

Introduction

1.1 Decision Support Systems

The field of Decision Support Systems (DSS), a sub domain of the Information Systems (IS) discipline, has a history of looking to the past to prepare for the future. DSS is the area of the IS discipline that has traditionally focused on supporting and improving managerial decision-making (Arnott and Parvan, 2016). Power [1] defined a DSS as "…an interactive computer-based system or subsystem intended to help decision makers use communications technologies, data, documents, knowledge and/or models to identify and solve problems, complete decision process tasks, and make decisions". These are computer-based solutions that may be used to support difficult decision-making and problem-solving [2]. Existing research characterises DSS in terms of (i) database management capabilities, (ii) modelling functions, and (iii) simple, accessible user interface designs that facilitate engagement by an end user [2].

Building on the tradition of Blanning's [3] and Keen's [4] work predicting the trajectory of DSS's research, IS scholars such as Shim et al.[2], Arnott and Parvan [5,6] and Hosack [7] considered the successes of DSS, the nature of the problems solved and the approaches deployed to tackle existing and new challenges. Just over ten years ago, Bryan Hosack and colleagues [7] examined the relevance of DSS as a research area. At

that time, DSS was viewed as a mature research domain where many difficult problems had been solved (Hosack et al., 2012). They highlighted the growth of DSS in new disciplines, notably the Shim et al. [2] paper had been widely cited in several domains outside the traditional business area [7]. Since the publication of this seminal article, there has not been a widely cited contribution central to the DSS area [8].

Extensive accessible data resources are now available capturing data about academic article citations and references. These data can help the DSS research community understand how knowledge has been disseminated and shared, but screening and assessing search results and citations can be cumbersome. A quick search on Google Scholar shows that the term DSS, or decision support systems, appeared in the academic literature 394 in the 1970s, 5,830 times in the 1980s, 11,500 times in the last decade of the previous century, 14,700 times from 2000 to 2010, and since 16,300 times to 2023. These rudimentary measures provide us an interesting sense of the DSS research landscape, these data reveal that in this new "era of Analytics" DSS continues to persist and grow as an area of research.

This study builds on previous work by [9] which leverages WoS scientific data resources to uncover an aggregated view of the authors publishing on the research subjects of DSS globally between 2011 and 2020. Further, a recent research-in-progress work identifies the geographical differences in DSS interest in these areas across the Association for Information Systems (AIS) regions and the application areas in which DSS research is conducted [8]. The ongoing scientific recent global research conversation on gender in academic publishing has been exacerbated by trends in publishing observed during the covid-19 pandemic [10,11], this has prompted us to consider the area of DSS in terms of the gender of publishing authors. The implications of gender has been examined in DSS research [12]. The implications of gender-based differences in IS-related contexts is under-researched in the IS domain and more specifically in IS-based decision-making research [9]. This research extends previous work [8] by conducting further analysis of geographic origins of DSS research and to better understand representation of authors by gender. Our aim is to investigate the publication trends in the DSS domain, paying particular attention to trends in co-authorship.

The next section presents the research approach, the dataset, and the techniques used to complete the bibliometric analysis. As such, the remaining text in this section presents the research approach undertaken, and details of the Scopus dataset analysed. Next, further sections characterise the DSS landscape by research area, leverage Scopus to present a bibliometric analysis of recent DSS research, and examine the co-authorship patterns by gender and geographical distribution of DSS research output. The final section presents a discussion of the data presented and considers the limitations of this approach. Finally, we offer conclusions and consider opportunities for future research.

1.2 Research Approach

Bibliographic databases such as Scopus and Web of Science (WOS) provide valuable information on academic disciplines as they contain both the articles published and the articles cited [13]. In conducting this study, the researchers took advantage of the strengths and limitations of Scopus. Scopus indexes scientific journals, allows the download of the abstracts and cited articles for aggregate sets of papers and there are

bibliographic tools to analyse this data. Scopus indexes more publications than WOS, and allows download of aggregate information, but has limitations in terms of the availability of older research publications, so is more useful for recent time periods [14]. In 2022, Scopus had over 87 million records drawn from over 27,000 serial publications. In May 2022, Scopus introduced the facility to download bibliographic data including the full names of authors instead of the author initials previously available. In December 2022, we conducted a preliminary investigation of the DSS literature using this enhanced feature of Scopus. Our focus was on interrogating DSS article authorship where we relied on the authors' first name to determine their gender.

We used a search following [13], searching the titles, abstracts, and keywords in Scopus for the search terms "decision support systems" "decision support software" and "decision support tool" and the combination (DSS and "decision support"). We have only included journal articles as the Scopus indexing of book chapters and conference proceedings is less consistent than that of journals. Our search returned 19,363 records representing journal articles for a 5-year period from 2018 to 2022. We used the full record download from Scopus, this contained a field containing full names with the required information available for most authors.

1.3 Bibliographic Dataset and Techniques

On average, there were 5.5 authors per paper in our download, therefore there were 106,866 authors in the dataset and papers had from 1 author to 388 authors per paper. Papers with many authors were not typical and were difficult to process reliably, so we decided to process only the first 12 authors, as 95% of articles in the dataset had this number of authors or less. Some records had formatting issues which meant that certain author names could not be processed. The limit of 12 authors meant the removal of 11,664 authors from 972 records. After this adjustment and other issues with record formatting, we were able to process 82,374 author names drawn from 17,860 articles from 3,790 journals.

Although Scopus now provides author full name information, not all full names were recorded and only initials were available in some cases. This reflects publisher policies on collecting full names and the widespread use of multiple initials to identify people in some cultures, for instance in South Asia. In our dataset, 6% of author records had only initials available. This is comparable to earlier work using WOS data where 8% of records in 2020 only had initials [9], which was a substantial decline from earlier years, reflecting improvement in the quality of bibliographic databases and journal policies requiring the full name of authors.

For a variety of reasons, such as personal choice, cultural practice and the limitations of these databases, this research approach cannot always accurately determine the gender identification of any individual author, but it can still provide a useful overview of the aggregate landscape of the DSS research area. To identify gender, we matched the author's first name against the World Gender Name Dictionary version 2.0 [15]. Version 2 of this database has enhanced coverage when compared to the first version, with over four million Asian names having been added [16]. In general, we only used the first name of the author, but used a second name if the first name was only an initial. This initial process matched 62,341 names, or 80.7% of the records with full names. This is a higher matching rate than earlier work with WOS [9], reflecting the use of the

extended gender database. While the new database has improved coverage of Asian names, matching was still higher for European originated names compared with Asian ones. Some names remained unmatched owing to features such as hyphens in names, addressing these issues would have required substantial further processing. The aggregate nature of our work means that the absence of an individual name should not adversely affect the research and extran processing would have a very limited effect on the value of the insight from the output.

The process of associating a gender to the first 12 authors of the overall dataset indicated that 64.5% of authors were male and 35.5% were female. This proportion is similar to the proportion in the later years of the previous WOS based analysis [9]. In this dataset, the journals with the highest number of articles are; Sustainability, IEEE Access, Journal Of Cleaner Production, Plos One, Decision Support Systems and Expert Systems With Applications. These reflect DSS in the twenty first century where the traditional areas of applications in business and engineering have been extended by newer environmental and medical applications. These top journals represent traditional sources of DSS output from technical areas, journals set up specifically to publish DSS content, a journal concerned with the environment and a journal substantially concerned with medical applications.

Journal	Articles	Authors	Authors per paper	Male	Female
Sustainability	299	1223	4.1	62.8%	37.2%
IEEE Access	295	1336	4.5	77.2%	22.8%
Journal of Cleaner Production	203	890	4.4	70.7%	29.3%
PLoS ONE	194	1269	6.5	59.0%	41.0%
Decision Support Systems	175	562	3.2	77.8%	22.2%
Expert Systems with Applications	155	602	3.9	77.3%	22.7%

Table 1. Gender proportions in journals with the highest number of DSS papers

Figure 1. presents a graphical representation of authors by co-authorship position during the years 2018 through 2022. It is notable that female authors make up a higher proportion of first authors than their proportion generally.



Fig. 1. Gender proportions by author position in Scopus (2018-2022)

Obviously, a first author may be the only author or may be the first of multiple authors. We can also look at the gender proportion by the number of authors on a paper. Figure 2 shows the gender proportions for articles with a particular number of authors. It is notable here that while male authors predominate in every category, reflecting the overall proportion, there is a higher proportion of male single authored papers than you would expect from the overall ratios. For papers with two authors, there are more papers with two male authors than you would expect from a random process, but about the number of papers that you expect with two female authors or with a female as first author. There are fewer two author papers with a male first author and female second author than you would expect from a random process. These aggregate conclusions needs further investigation by discipline, for instance single author papers may be more common in disciplines with a higher proportion of males. In the case of papers with three authors, the proportion of papers with all authors the same gender is higher than you would expect if this was a random process, and this is broadly true for all discipline groupings. It is likely that there are also more complex patterns for papers with more than three authors which warrant future investigation.

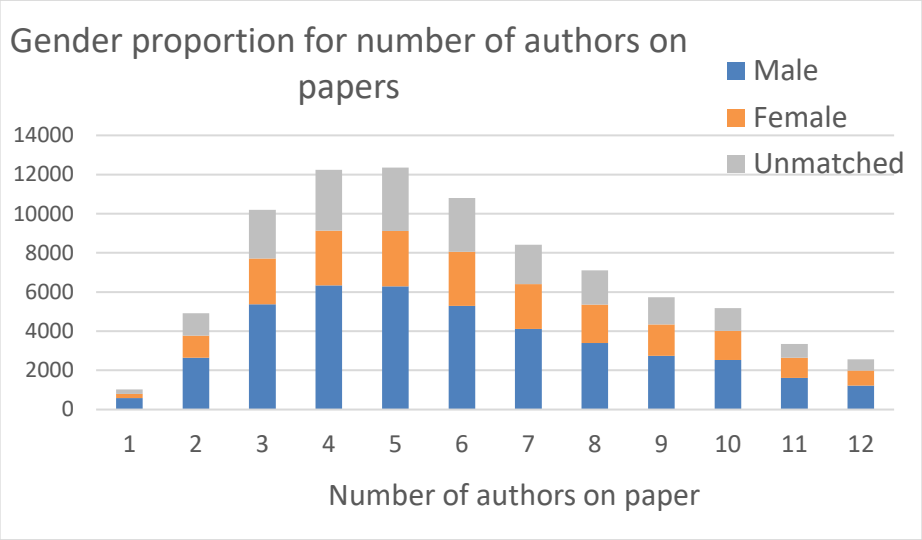


Fig. 2. Gender proportion and number of authors per paper

The full name of the corresponding author was not given, so we associated the name of the corresponding author with the full name in the author list, where that full name was present. This allows us to determine the author position and gender of the corresponding author. Usually, the corresponding author was the first author, which is a requirement of some journals, otherwise the corresponding author was generally the second or third author. When the corresponding author was the first author, the proportion of females was notably higher and marginally higher than the overall average for the dataset (Fig 3.)

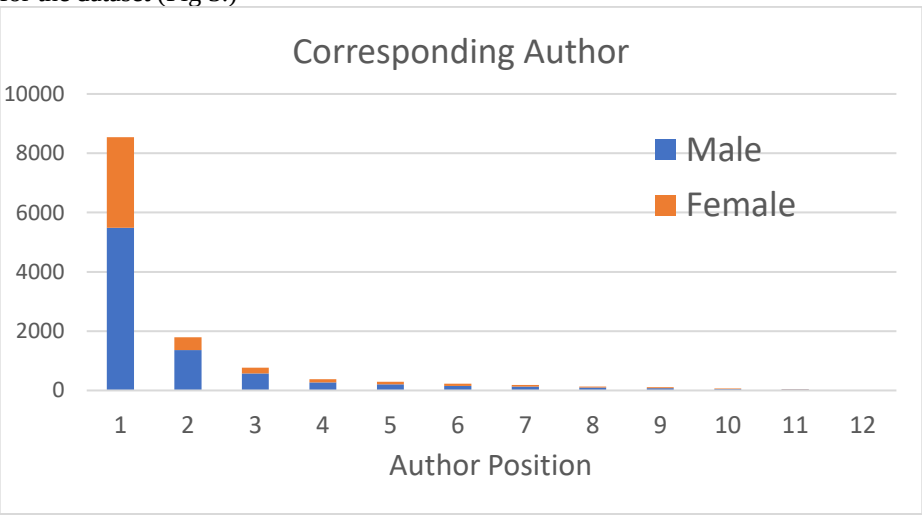


Fig. 3. the gender proportion and number of papers for corresponding authors.

Exploring DSS in the wider Scientific Research Landscape

Scopus has its own groupings of disciplines, namely the All-Science Journal Classification Codes (ASJC) schema. This is grouped into 31 subject areas, which are organised by Scopus into four major areas: Life Sciences, Social Sciences, Physical Sciences, and Health Sciences. Analysis using these research areas creates complexity because a given publication may be included in one or more classifications and in up to three top-level groupings. Frequently, a DSS publication can be in two top-level groupings, typically combining a computer science classification with an application area. For instance, the journal Decision Support Systems is in both the Social Sciences and Physical Sciences categories, and the journal International Journal of Environmental Research and Public Health is categorised both in Physical Sciences and Health Sciences. While these overlaps complicate the analysis, this research is interested in the patterns of gender and co-authorship in different disciplines; these comparisons are possible notwithstanding these challenge [9].

Across the dataset 15% of the papers are in Life Sciences, 17% are in Social Sciences, 50% in Physical Sciences and 40% in Health Sciences, note that the overlapping categorisation means that this totals more than 100%. However, if we look at authors then we see that the number of authors differs by generic discipline, with health sciences dominating papers with a larger number of authors. Note that a journal may be in two categories, so the total number of papers is increased and the effect of different authorship norms may be less clear as some journals are counted as both Health Sciences and another disciplinary grouping.

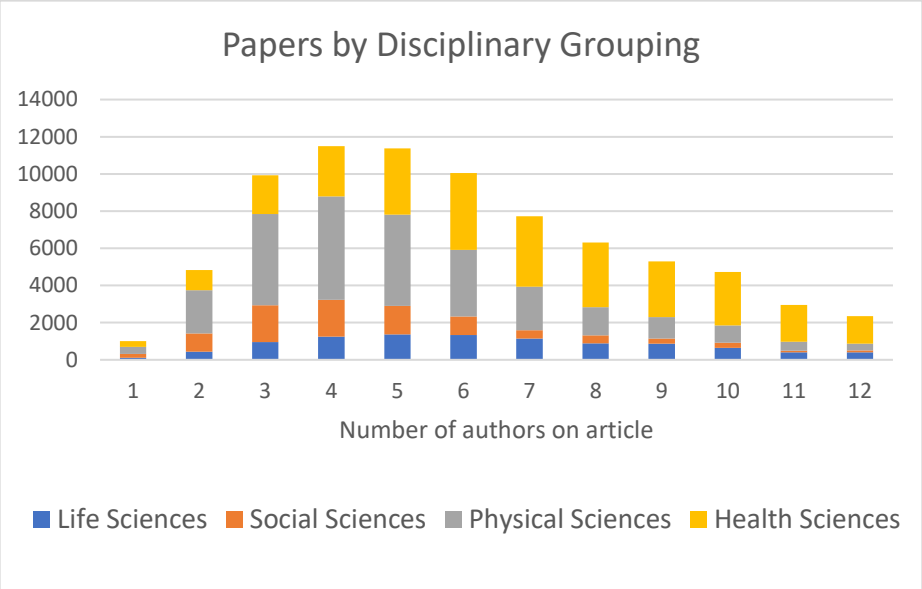


Fig. 4. Disciplinary grouping for papers with different numbers of authors.

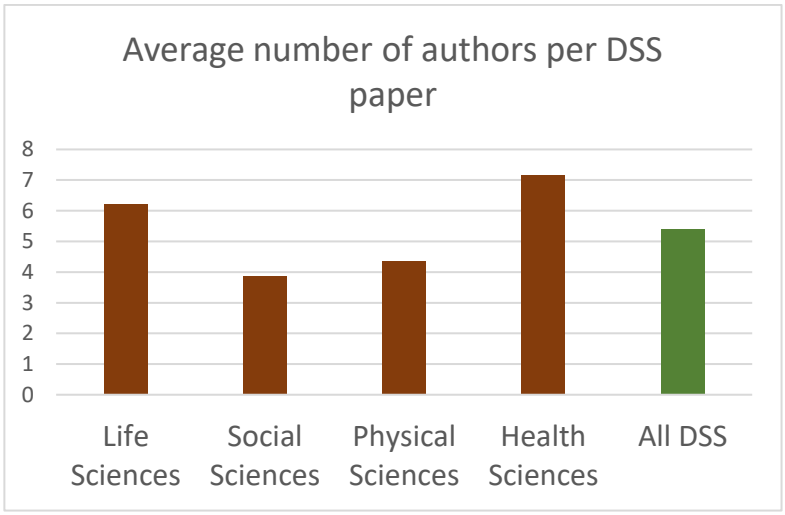
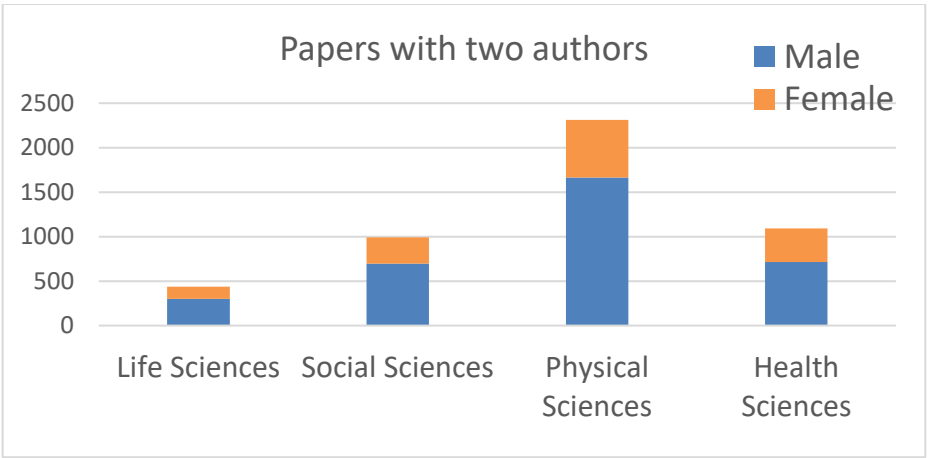


Fig. 5. Average number of authors for different disciplinary groupings.

To illustrate the difference, the figures below show the distribution of discipline groupings for papers with two authors and papers with ten authors.



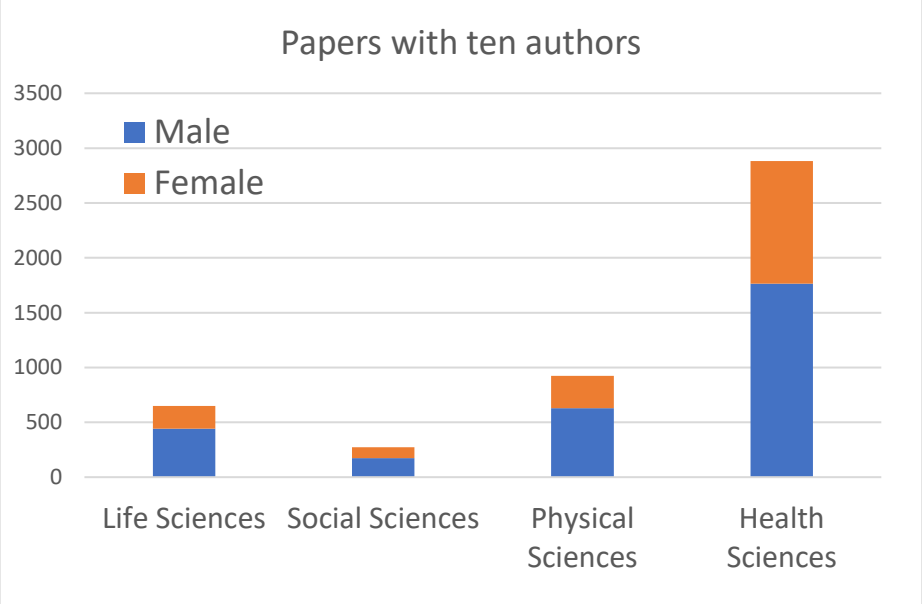


Fig. 6. Disciplinary groups for papers with two and ten authors.

Geographic structure of DSS Research

In this research, we attempted to examine the geographic location of authors. Initially, we attempted to geolocate the author addresses using the ArcGIS geocoding service. While this is a very comprehensive geocoding database, this process was only partly successful as recorded author affiliations often did not give a precise location. Even the address of the corresponding author was ambivalent in many cases, listing the institution but not providing a usable address. However, even with an ability to accurately geolocate only half the author locations, it is clear that DSS research is conducted in a wide variety of locations. Figure 7. presents a visualisation of research publications by European location, as indicated by the green dots on the map.

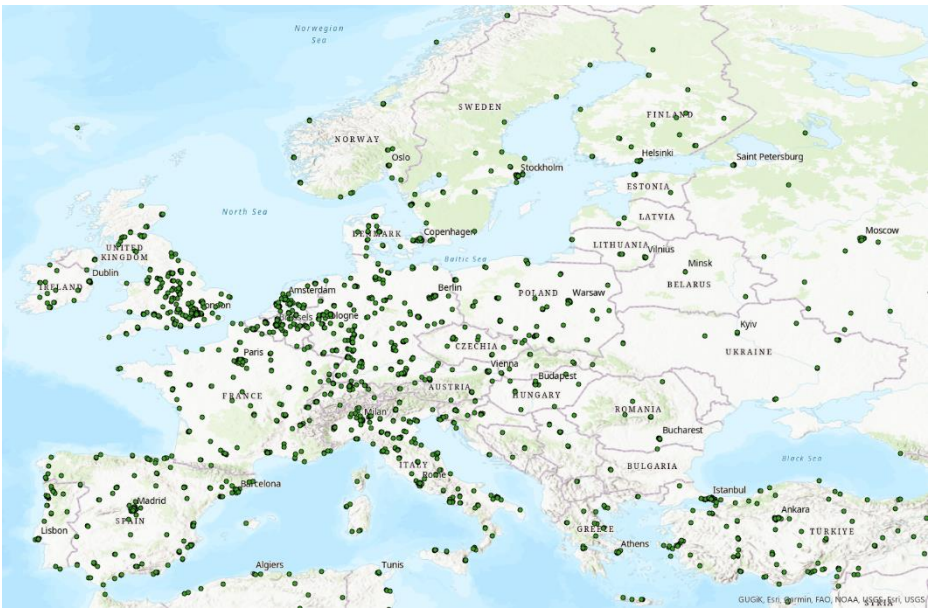


Fig. 7. Detailed geographic map of European DSS authors in Scopus (2018-2022)

This illustration highlights the dispersion of DSS research activity right across Europe. This high-level view of the DSS activity points to a concentration of DSS research in central Europe from the Netherlands to Italy. It seems that the further east we travel here, the more dispersed and decentralised the DSS community. Further in the Irish context, we noted that the smaller regional technical universities also had DSS output in the dataset, research output was not limited to the larger institutions.

While precise geolocation proved challenging, we sought to identify the countries from the text affiliation data provided by Scopus. This was successful in most cases, although variations in the naming of countries meant that some records were not matched. There was a particular problem identifying the country of authors with two affiliations, as Scopus does not distinguish these two affiliations clearly in its records.

At a country level, the gender ratio can differ significantly owing to the relatively small number of papers in some countries [8]. Therefore, it is more useful to look at world regions (Table 1). We grouped countries into regions and continents and matched corresponding author information with the gender of those authors. Table 2 presents this analysis, it confirms a pattern in [8] of female authorship being high in Oceania and Africa, although these regions together represent only 6% of DSS papers.

Location	**M**	**F**
Western Europe	66.7%	33.3%
Southern Europe	67.1%	32.9%
Eastern Europe	75.2%	24.8%

Northern Europe	65.1%	34.9%
Europe	**67.0%**	**33.0%**
Western Asia	77.3%	22.7%
Southern Asia	75.7%	24.3%
South-eastern Asia	71.7%	28.3%
Eastern Asia	69.6%	30.4%
Àsia	**72.2%**	**27.8%**
Northern America	65.0%	35.0%
Central America	86.0%	14.0%
South America	73.2%	26.8%
Caribbean	66.7%	33.3%
Americas	**66.0%**	**34.0%**
Africa	**60.6%**	**39.4%**
Oceania	**60.4%**	**39.6%**

Table 2. Corresponding authors of DSS papers by location by Gender in Scopus (2018-2022)

While a useful guide in aggregate, these proportions may vary slightly owing to data quality and challenges in determining gender in author first names. Additional exploration shows further nuances in DSS authors by gender breakdown. In the subset of larger countries in each continent presented in Table 2, we highlight that Australia has the most representative balance of publishing authors with 60.1% men and 39.9% women while India presents a less representative landscape by gender.

Country	**M**	**F**
Australia	60.1%	39.9%
China	68.5%	31.5%
Germany	73.0%	27.0%
India	74.8%	25.2%
United Kingdom	66.3%	33.7%
United States	65.7%	34.3%

Table 3. Author gender for countries in different regions for DSS papers in Scopus (2018-2022)

The pattern represented in Table 3 broadly translates to two male authors to every one female for articles in a DSS-related area during this period of analysis. Following, Table 4. presents a high-level view of the extent of international co-authorship considering

the number of co-authors on a single published article. The matching column reflects whether the country was determined for each author, the more authors there are on a paper then the more likely it is that one author country could not be assigned. Notably, the lower the number of co-authors the more likely authors are to be in the same country.

Number of Authors	Same Country %	Matched %
2	86.7%	80.4%
3	84.4%	69.6%
4	83.0%	61.9%
5	77.1%	57.0%
6	74.0%	56.6%
7	72.1%	53.9%
8	67.7%	53.4%
9	68.5%	49.3%
10	67.7%	54.4%
11	63.8%	49.0%
12	64.9%	53.5%

Table 4. Corresponding authors of DSS papers located in the same country in Scopus (2018-2022)

As highlighted in Table 4., some of the records remain unmatched. For example, any author with two affiliations is not matched, plus some countries might have variations in their names that are more complex to process. The more authors collaborating on a paper, the increased likelihood that one country could not be determined using our analysis techniques. The "same country" column is therefore conservative. If you had 7 authors and one country was not determined then they would not be regarded as the same country in this percentage, even though the those that were determined were in the same country. Noteworthy, the greater the number of authors on an authorship team, the more likely it is that one or more authors are located in another country.

Discussion and Conclusion

This research uses a bibliometric analysis of articles published during a five-year period from 2018 to 2022 through Scopus papers. Our aim is to investigate current trends in DSS publishing with particular focus on co-authorship by gender by geographic location. Our findings suggest that in DSS-related papers approximately one-third of authors are female, two-thirds are male with male authors leading on the majority of published papers. However, we have shown that this proportion varies by discipline and that expanding areas of DSS application have a somewhat more balanced ratio. This analysis is just a starting point, and we recognise that there is still a great deal of work to be done to defeat gender disparity in scientific publishing in the DSS domain. Through our analysis of this recent Scopus dataset, we highlight the volume and diversity of DSS research and collaboration opportunities that currently exist, and the potential opportunities given the trends identified.

It is important to acknowledge the limitations in the analysis presented. The sample of papers could be expanded to include a more extensive range of years and by improving our techniques for matching names. In our analysis, 97.3% of the articles are in English; the inclusion of additional languages may have altered the DSS authorship by location presented in Figure 1. Further, the map focuses on DSS research in Europe, additional work might include a more in-depth analysis of DSS in other continents. Our analysis includes a period of global pandemic our initial rudimentary analysis does not account for the likely "Covid effect" on DSS research output from 2020 to 2022.

Following our bibliometric analysis, we feel that it is useful to revisit the Hosack et al. [7] question "Is Decision Support Research alive and well". This research investigating academic publication patterns during the most recent five-year period reveals that scholars continue to publish scientific research in DSS. More than ten years later we continue to highlight "the plethora of DSS research and collaboration opportunities that currently exist or are within our reach in the near future given the trends" [7]. Indeed, Hosack and colleagues acknowledged the variety of decisions that confront users daily presenting the "limitless" new research opportunities to understand human-technical interaction. These possibilities have brought DSS research into areas of environmental science and medical applications which have different academic traditions than the business and engineering disciplines that provided the bulk of DSS research in its earlier years [8]. In this research these traditions are reflected in the number of authors per paper, but there may also be less obvious differences.

However, the pervasiveness of DSS in modern organisations, emphasises the need for researchers, designers, and builders of DSS technologies to reflect the underlying characteristics and diversity of their users [9]. Given this diversity, there is also a need for the traditional DSS research community to interact with DSS researchers in newer areas of application, to avoid a fragmented field.

It is important to note that the period 2018 to 2022 was not a "typical" period in scientific publishing. Future research could consider how this period and the subsequent opportunities and challenges for scientific researchers has impacted the scientific publications in terms of gender imbalance and geographic jurisdiction considering lockdowns, school closures etc. in DSS research output. A new phase of this research might be to further explore opportunities for academic collaborations across these diverse locations. Further research considering various contributing factors that may affect scientific productivity is necessary, particularly in terms of co-authorship relationships (e.g., childcare resources, caring responsibilities, type of authorship). Novel research is required to better understand the intrinsic and extrinsic factors that influence this phenomenon in the DSS research domain.

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