Decision Support System: A Bibliometric Review

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Abstract. This paper presents a bibliometric review regarding the evolution of Decision Support Systems (DSS). A search was performed in the Scopus and Web of Science databases with keywords related to the topic from 1977 to 2021 to identify full research articles, book chapters, books, and papers in international conferences and congresses. A total of 5,018 documents were identified for analysis in the VOSviewer® software to identify the trend of publications, the countries with prominent research groups, the institutions with the most publications, collaborations between nations, among others. Findings indicate that DSS is a research area with exponential growth and academic and industrial interest. The leading journals that publish these topics are Decision Support Systems, Lecture Notes in Computer Sciences, and Expert Systems with Applications. The main publishing countries are the United States of America, China, United Kingdom, Italy, Australia, and India. The application areas of DSS are Medicine, Computer Science, Engineering, Mathematics, and Nursing. The principal authors are Haynes, R.B. and Gerrdine, D., and Abrent, A. At the same time, the institutions that receive the most citations are the University of Minnesota and the University of Cincinnati, both in the USA, and McMaster University in Canada.

Keywords: Decision support system, bibliometric review, trends.

1 Introduction

Humans always are making decisions. A decision is the determination to act in a situation that presents several alternatives [1]. From the above, it can be concluded that there must be a decision-maker and alternatives to meet an objective (maximized, minimized, or a nominal value). Often, some criteria and attributes must be analyzed, so it is common to observe multicriteria and multi-attribute decision-making [2].

Even with the above, one decision-maker may classify a decision as good; however, another may classify it as bad, and this is due to their own experience. Decisions may be rational, satisfactory, organizational procedure, and political. However, all decision-making process consists of 5 stages: intelligence, design, selection, implementation,
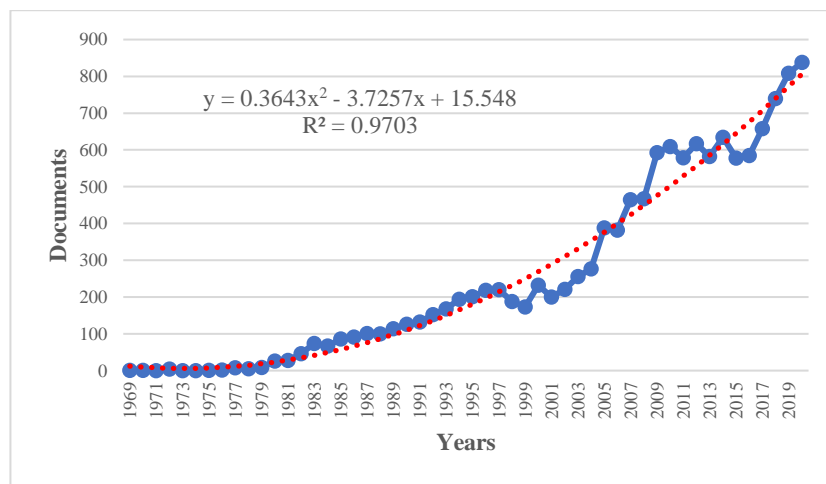
The chart shows the equation $y = 0.3643x^2 - 3.7257x + 15.548$ and $R^2 = 0.9703$.

Fig. 1. Publications by year with the title "decision support system" or "Decision Support System".

and review [3]. According to the method used in a decision-making process, these are classified into programmed and non-programmed, depending on if the problem is structurally well defined. Also, it can be a routinary if the relationships can be predicted, and anyone can execute them; however, it can be complex if relationships are not defined. This is where decision support systems have been developed [4]. A decision support system is a way of modeling data and making quality decisions [5].

A DSS is a computer application that, together with a decision-maker, filters the information and evaluates the alternatives [6]. DSS can be passive or active if it collects and processes the data, is cooperative if it contains the data, analyzes it, and proposes a solution. Finally, driven DSS is when statistical tools, simulations, or financial models offer a solution. Fallon*, et al.* [7] are the first to refer to DSS in the health sector, but two years later, Vienot [8] began to define the main DSS in this sector; however, four years later, he presented a DSS for use in risk analysis by banks and Hansen*, et al.* [9] are the first to report a DSS with an interfaced computer program.

A search in Scopus indicates that there are a total of 13,796 papers with the title the word (TITLE ("decision support system") OR TITLE ("Decision support system") OR TITLE ("Decision Support System") OR TITLE ("DECISION SUPPORT SYSTEMS")), indicating academic interest (consultation conducted on September 08, 2021). Figure 1 illustrates the distribution of these 13,796 published papers included in Scopus, where 563 documents from 2021 and 8 from 2022 have already been omitted. The red dotted line indicates a quadratic trend and can be observed that from 1983 onwards, the DSS began to boom.

The applications of DSS are multidisciplinary, and Figure 2 illustrates the top ten academic areas that develop DSS. The main areas refer to computational sciences, engineering, medicine, and social sciences. There are 13,237 documents in English, 260 in Chinese, 60 in German, 41 in French, 37 in Portuguese, 34 in Spanish, among others. The documents refer to 7,149 scientific articles, 5,548 conference papers, 401

Table 1. Main areas of literature reviews.

Review area	Number	References
Medicine	178	[10,13]
Computer Science	60	[12,13]
Engineering	50	[14,15]
Agricultural and Biological Sciences	48	[16,17]
Environmental Science	47	[18,19]
Business, Management and Accounting	33	[20,21]
Nursing	31	[22,23]

book chapters, 397 reviews, 88 editorial releases, 45 errata, 41 notes, 38 letters to the editor, 33 books, 19 small surveys, among others. Nowadays, there are reviews on DSS, and Table 1 shows a summary. Observe that a large percentage of them are focused on medicine and computer science. In medicine, Harada*, et al.* [10] present a literature review focused on DSSs used by physicians in early diagnosis to decrease risks of future diseases, while Abdellatif*, et al.* [11] report a review of DSSs applied to nurses who support older people in their own homes, allowing them to streamline decision making. Likewise, Aktürk [12] reports a bibliometric review of DSS used in clinical analysis.

The number of specialized reviews reported about DSS is justified, given the number of existing papers in each research area. However, some of these reviews almost always include theoretical documents that lack real applications, even if they are thematic. Sometimes, they are improvements made to another DSS, focusing only on proposing a new modification. Given the above situation, revisions are required to address DSS applied to some sectors, not only theoretical concepts that provide new proposals.

Given this situation and intending to contribute to this area of research and take advantage of specialized software to carry out this activity, the objective of this chapter is to present a bibliometric review of DSS applied to any sector. This work will allow DSS scholars to identify the leading research groups, the universities that publish, the most cited authors, and the journals that focus on this topic. After this brief introduction, section two presents the methodology used to achieve the proposed objective, section three presents the results found, and finally, the conclusions are offered.

2 Methodology

2.1 PRISMA Method

To identify the articles to be analyzed, the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) methodology was used [24] since it has been used in similar studies in the health area by Li*, et al.* [25]. The identification of the documents is performed in the Scopus and Web of Science (WOS) databases, although Lens and Dimensions are used alternatively. The search equation was as follows: (TITLE ("decision support system") OR TITLE ("Decision support system") AND TITLE-ABS-KEY ("decision making") AND TITLE-ABS-KEY ("decision-making"))

AND (LIMIT-TO (PUBSTAGE, "final")) AND (LIMIT-TO (DOCTYPE, "ar") OR LIMIT-TO (DOCTYPE, "cp") OR LIMIT-TO (DOCTYPE, "ch")) AND (LIMIT-TO (LANGUAGE, "English")). The above indicates that only documents containing the word "decision support system," or "Decision support systems," or "Decision Support System" in the title are considered.

However, given that many DSS focused on computer systems, it was requested that the documents also contain the word "decision making" or "decision-making" in the abstract, which guaranteed their application. However, the following inclusion criteria were established: The search equation was as follows:

1. Papers must be final and not in print.

2. Only research articles, conference papers, and chapters are included to guarantee a scientific evaluation of them.

3. Finally, all papers must be written in English.

2.2 Analysis with VOSviewer

VOSviewer® 1.6.17 software is used for the analysis of the 779 documents that are identified by the PRISMA methodology, as it has been used in DSS applied to supply chain [21] and DSS in sustainable logistics [26]. The primary analyses focus on the following:

1. The trend of publications per year of applied DSS.

2. Authors, institutions, and countries that generate more scientific production in applied DSS.

3. Main keywords used by authors and publishers when indexing applied SSD papers.

4. Most cited articles, journals, authors, organizations, and countries in applied SSD.

3 Results

3.1 General Data of the DSS Applied

A total of 4,234 documents were identified in the Scopus and WOS databases, but also 1,385 in Dimensions and Lens. The results of both searches were downloaded in RIS extension to be read in Endnote 20® software, which made it possible to identify a total of 421 duplicate documents and obtain 5,198.

However, it has been established as an inclusion rule that all documents must be full text, which allowed the elimination of 18 more documents, leaving 5,180. In addition, it was established that only research articles, conference articles, book chapters, and books, written in English and published and not in press, are analyzed. This procedure made it possible to eliminate 162 more documents, leaving 5,018 documents to be analyzed. Figure 2illustrates the PRISMA method graphically, indicating the corresponding quantities in each of the stages.
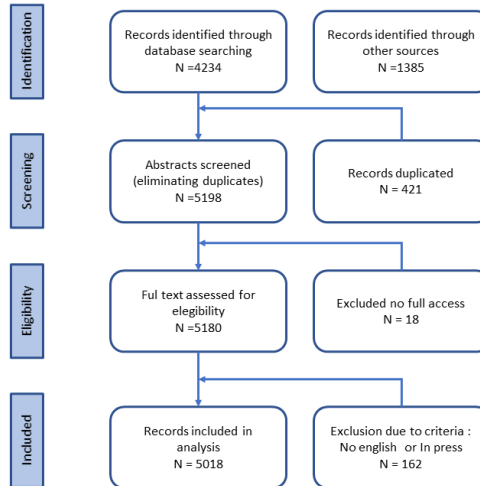
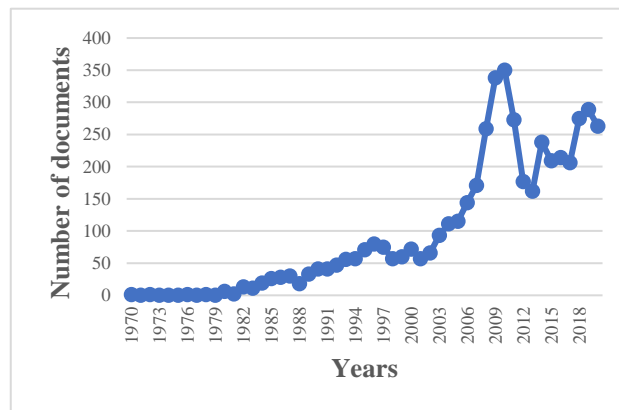**Fig. 2.** Methodology for select documents.

Fig. 3. Papers published.

Figure 3 shows the annual production that has existed about DSS applied up to 2020 since, in this case, 152 publications that already exist in 2021 and three in 2022 have not been included. In general, it is observed that it was from 1988 when the DSS began to have their peak, having their highest value in 2010 with 350 publications, and from that date, there was a decline until 2013, reaching only 162 publications in the same year. However, there is again an increase in the number of publications per year from that year onwards, although it is far from reaching the paper's production of a decade ago.

An essential aspect of the DSS is to know the entities or sources of funding since it is a metric of the levels of importance given to this topic, and Figure 4 illustrates the top ten. It is essential to mention two aspects. The first is that there are three offices
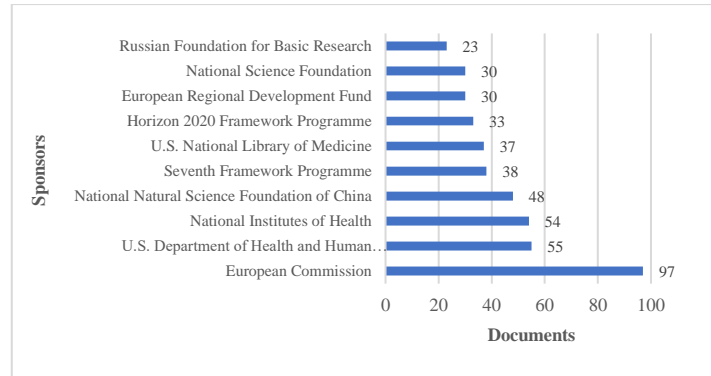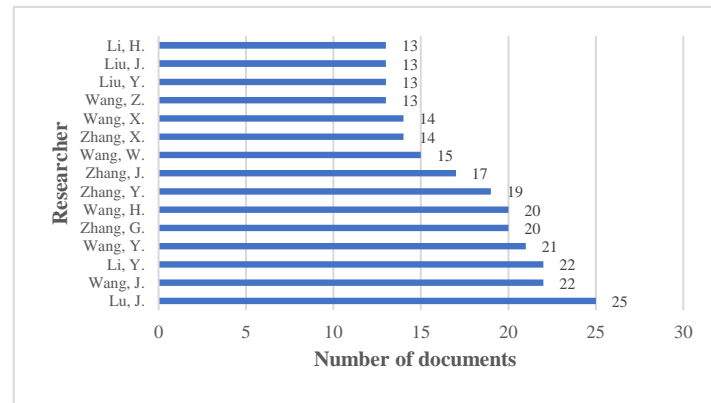
Fig. 4. Main sponsors in DSS applied.

Fig. 5. Most productive authors.

focused on health sciences, and the second is that there are two European offices, which indicates that geographically in Europe, much emphasis is being given to this type of research applied to DSS and that health is a science in which it has been very well accepted. On this occasion, it can be seen that the European Commission is one of the primary sources of funding, sponsoring 97 investigations. At the same time, the U.S. Department of Health and Human Services, which is an office focused on health, is in second place with 55 investigations.

3.2 Authors, Organizations, and Countries that Publish the Most

Figure 5 illustrates the 15 most productive authors in the field of applied DSS. It can be seen that the most productive author is Lu, who starts by presenting a paper at a conference [27], and his most recent article is in 2018 [28]. The next author is Wang, J. started his production in 2004 [29], and his most recent publication was in the year
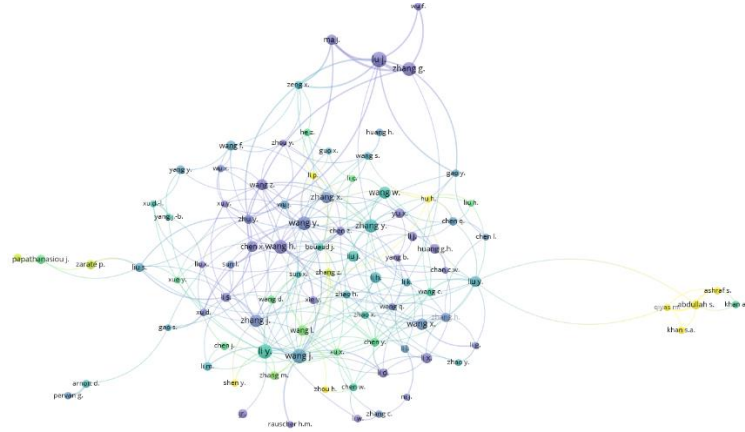
Fig. 6. Relationships and consolidation of authors.

2021 [30]; being more productive concerning time refers to a co-authorship with the first-place author.

Figure 6 illustrates a diagram of relationships among the most active authors. Ten clusters were identified. In this case, the size of the circles is associated with the number of published articles, while the color is related to the years of consolidation. Among the most consolidated authors are Wang, Y., Wang, H., Zhang, X. The green colors are authors in consolidation, such as Li, Y., Li, M., Zhang, Y., among others. Finally, the authors beginning their scientific production process are Zaraté, P., Zhang, Z., Hu, H., among others.

Table 2 illustrates the leading institutions and research institutes that have published the most on the topic of applied DSS. In this case, it is observed that the IEEE is the organization that has published the most with 10 in total; however, it is not the one with the most citations. It is essential to mention that the IEEE appears without an associated country, given that it has different research centers around the world. The second place is occupied by the Algoritmi Centre of Portugal and the Systems Research Institute of Poland, with five publications each. They have more citations than the works reported by the IEE. Please note that two institutions from Portugal appear in Table 2, which indicates the importance of DSS research for that country.

Although a total of 9,579 different author affiliations have been identified, many of these institutions have only one document, and it has often not been cited. Figure 7 illustrates the relationships between the different institutions and clearly shows that the IEEE is the institution that has published the most and that has academic relationships with many other institutions.

In this case, the consolidated institutions researching DSS are the Advanced Technology R&D Center of the Mitsubishi Electric Corporation of Japan. Although a total of 9,579 different author affiliations have been identified, many of these institutions have only one document, and it has often not been cited. However, there is a large grouping of institutions, so Figure 7 illustrates an approach to this group of

Table 2. Institutes and research centers in DSS.

Organization	Documents	Citations
IEEE	10	19
Algoritmi Centre, University of Minho, Portugal	5	36
Systems Research Institute, Polish Academy of Sciences, Poland	5	100
Department of Industrial Engineering, Stellenbosch University, South Africa	4	1
Department of Information Systems, Stmik Pringsewu, Indonesia	4	24
GECAD –Institute of Engineering, Polytechnic of Porto, Portugal	4	34
Institute of Informatics and Computing Energy, Universiti Tenaga Nasional, Malaysia	4	42
University of Southampton, United Kingdom	4	88
Business Information Systems, University College Cork, Ireland	3	18
Delft University of Technology, Netherlands	3	21
James Madison University, United States of America	3	14
PBS & J, United States of America	3	1

Table 3. Production by country.

Country	Documents	Citations
United States of America	1043	19233
China	596	3631
United Kingdom	337	5701
Italy	223	3275
Australia	220	3511
India	209	1473
Germany	206	2749
Canada	189	4612
Spain	177	3620
France	159	1706
Netherlands	152	2844
Indonesia	140	393
Greece	127	2302
Russian Federation	121	419
Taiwan	118	2371

institutions, where it can be seen that there are many more, all of which are established in Japan.

Table 3 shows the production of documents by country and their citations. It can be seen that the USA is the country that has published the most papers, with a total of 1,043, and of this group, it is the most cited. China's second place is occupied with 596 documents and 3,631 citations, while the United Kingdom occupies third place with 337, but with 5,701 citations, a higher value than that of China.

From this list, the United States of America and Canada represent the Americas. In contrast, countries such as the United Kingdom, Italy, Germany, Spain, France, Holland, and Greece represent Europe, and Asia is represented by China, India, Russia, and Taiwan. Unfortunately, there are no Latin American countries in this list of countries with the most publications.

Figure 7 illustrates the top fifteen journals that publish on DSS. However, there is a list of 843 sources (journals or conferences), of which only 153 have published at least
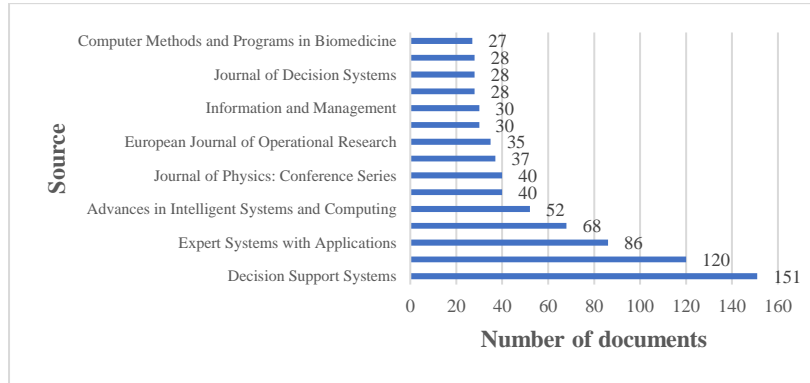
Fig. 7. Papers published on DSS by journal.

Table 4. Most used keywords.

Keyword	Occurrences
decision support system	1696
decision making	287
decision support	180
data mining	87
gis	79
artificial intelligence	71
clinical decision support system	71
ontology	71
fuzzy logic	70
decision support system (DSS)	69
clinical decision support systems	57
optimization	56
simulation	54
multicriteria decision making	50
data warehouse	48

five papers. It is observed that, given the level of importance of DSS, there is a journal specialized in this topic called Decision Support Systems that has 151 publications and ranks first in publications, followed by Lecture Notes in Computer Sciences that has 120 and Expert Systems with Applications that has 86.

Other journals are Computers and Industrial Engineering, Information and Management, and Decision Sciences, Lecture Notes in Computer Science, Expert Systems with Applications and Computers, and Electronics in Agriculture. Table 4 illustrates the main keywords used by the authors. It can be seen that the "decision support system" is the most used with 1696 occurrences. The second place is occupied by decision-making with 287 occurrences. A total of 9,721 keywords and some associated industrial sectors and techniques appears, such as AHP, promethee, heuristics, among others.

It is not precisely the Journals that publish the most that are the most cited. Figure 8 illustrates the most cited sources, where the journal Decision Support Systems
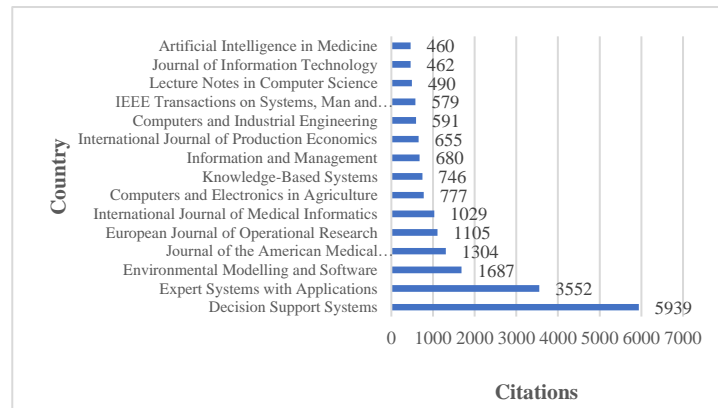
Fig. 8. Most cited sources per country.

(Elsevier) occupies the first place in citations, with 5,939 for its 1,351 published documents. On this occasion, it is consistent with the journal that has published the most on DSS. However, the journal Expert Systems with Applications (Elsevier) is in second place with 3,552 citations to its 86 papers, displacing Lecture Notes in Computer Science (Springer).

4 Conclusions

From the analysis of 5,018 published papers on DSS applications, the following conclusions can be drawn:

- The application of DSS has exponential growth.

- The United States of America is the country that has generated the most documents and has received the most citations.

- The main applications of DSS are in Computer Science, Engineering, Decision Science, and Medicine.

- The main sponsor or source of funding for this line of research that generates DSS is the European Commission.

- The most cited institutions are the University of Minnesota and the University of Cincinnati.

- The most cited organizations are the IEEE, the Algoritmi Centre in Portugal, and the Systems Research Institute in Poland.

- The journals that publish the most on DSS topic are Decision Support Systems and Lecture Notes in Computer Science.

- The three most used keywords in papers related to DSS are decision support system, decision making, and decision support.

- The most cited authors are Haynes R.B. and DeSanctis and Gallupe.

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