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Understanding the evolving frontier of DSS: An empirical investigation

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Research-in-Progress

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Abstract

Decision support systems (DSS) have been researched for over half a century. This research-in-progress article aims to explore the DSS research landscape providing insights into this domain regarding publication trends over a 30-year period. This empirical approach considers the academic disciplines in terms of their main categories and by Association for Information Systems (AIS) region. This paper identifies that DSS research has expanded from its original foundations in business and engineering to new areas such as the environment and health, reflecting that these areas have some of the most important decisions to be made in the 21st century. It also identifies the geographical differences in interest in these areas between the AIS regions. However, momentum in the area of Analytics generally has seen growth in the range of systems supporting data-driven decision-making in organisations and a decline in the use of the DSS term. These changes present new opportunities and challenges for DSS at the digital frontier of Information Systems (IS) more broadly. We aim to motivate researchers and practitioners to leverage "traditional" DSS principles to study decision systems across the diverse knowledge domains now exploiting analytics.

Keywords

Decision Support Systems, DSS, Special Interest Group, SIG, Bibliometric analysis, analytics, research frontiers

Introduction

The concept of Decision Support Systems (DSS) has existed in the mainstream academic literature for over 60 years. For decades, academics have drawn on fields such as Economics, Operations Research/Management Science (OR/MS), Information Systems (IS), and Management to identify enhancements to decision-making capabilities for managers in organisations. This article briefly reflects on a historical overview of DSS research milestones against patterns we can observe through a bibliometric analysis of the DSS literature. We aim to leverage future academic decision-making and IS researchers and practitioners to develop new perspectives on DSS and benefit from the "traditional" DSS community. In the Internet age, tools are available that characterise the public's interests through their aggregate use of Internet search. At the same time, other digital bibliographic resources provide insights into publication trends, authors, locations, and areas of DSS research focus. We leverage this data to identify the traditional DSS application areas, reveal new research domains, and map these researchers' locations. This Pre-ICIS SIGDSA symposium 2022 calls on the IS research community to explore the digital frontier of analytics. Our research-in-progress paper aims to trace DSS research trends to understand the structure and publication patterns in the field and to highlight new opportunities for DSS researchers in this era of Analytics.

Before the technology and processing capability was even available, academics such as Herbert Simon conceptualised the possibilities of supporting managerial decision-making through the use of technology "simulation has enabled an airline to determine how many reserve aircraft it should keep on hand, has been used to study highway congestion, has led to improvement in inventory control procedures for a

huge warehousing operation, and has accomplished many other difficult tasks. (p. 19) … The revolution in programmed decision-making has by no means reached its limits, but we can now see its shape. The rapidity of change stems partly from the fact that there has been not a single innovation but several related innovations, all of which contribute to it (p.20)" (Simon, 1960). This changed in the mid-1960s when computer-based DSS became practical with further advances in IT processing capability and the availability of increased computer storage. By around 1970, international business journals began to publish articles on management decision systems, strategic planning systems and DSS (Sprague Jr & Watson, 1979). In 1980, Alter published the results of his MIT doctoral dissertation findings in a book entitled 'Decision Support Systems: Current Practice and Continuing Challenge', which aimed to expand the community's thinking about management decision systems (Alter, 1980).

A decade and a half later, researchers recognised the value of new Internet and World Wide Web based systems, and Power noted that "the term decision support system and its acronym DSS remains a useful and inclusive term for many types of information systems that support decision making" (Power, 1997). The AIS was founded in 1994 to advance IS research, and the association and the conferences it supported became important channels for research discussion. At the Americas Conference on Information Systems (AMCIS) in 2001, Detmar Straub and Diane Strong identified nine new tracks for the conference, including data management and decision support. In his online DSS newsletter, (Power, 2001) commented on the importance of identifying a Special Interest Group (SIG) related to information systems intended to support decision-makers. He noted that "creating SIGs is an important step in advancing the field of Information Systems. The identification of specific interest groups should not however be a popularity contest or a function of serenity in terms of the proposals submitted. The AIS Board needs to choose SIGs that are related to core concepts" (Power, 2001). In mid-December 2001, SIG Decision Support Systems (DSS) was formed. It was established as a forum for AIS members "to discuss, develop, and promote issues, ideas and research related to using Information Technologies to support decision-makers and improve decision processes in businesses and organizations"(Power, 2002). Seven AIS members, S. Alter, J. Courtney, D. Power, R. Sharda, V. Sugumaran, M. Turoff, and H. Watson, joined in submitting the revised proposal for SIG DSS. Following a panel discussion at the 30th Decision Sciences Institute Annual Meeting in New Orleans in 2002, an important article was published in Decision Support Systems entitled "Past, present, and future of decision support technology", in which DSS academics characterised DSS as a type of IS, i.e., computer technology solutions, that can be used to support complex decision making and problem-solving (Shim et al., 2002). Shim and colleagues echoed earlier definitions of a typical DSS as including (i) database management capabilities, (ii) modelling functions, and (iii) simple user interfaces that enable engagement by an end user (Shim et al., 2002). A decade later, researchers argued that DSS research was alive and well in the IS domain (Hosack et al., 2012). They noted the growth of DSS in new disciplines and highlighted that the Shim paper had been widely cited in multiple domains. They also remarked on the inconsistent use of terms such as DSS, Business Intelligence and Business Analytics (Hosack et al., 2012). However, since this paper there has not been a widely cited contribution central to the DSS discipline.

This terminological variation has also been reflected in the AIS SIG. In 2007, while AIS continued to promote the growth of sub-communities, M. Goul proposed a SIG Knowledge Management (KM) and following some discussion, SIGDSS briefly became SIGDSSKM. To be renamed once more as SIGDSS, when it was agreed that this adequately captured the KM research agenda at that time. Following a meeting of the SIG at the annual pre-ICIS symposium in December 2013, the SIGDSS board approved the renaming of the organisation to SIGDSA (Special Interest Group on Decision Support and Analytics) to reflect the growth of analytics for decision-making. The SIG renaming in 2014 marked a significant transition to what we now consider the modern era of analytics. However, the renaming did not fully clarify the relationship of the large field of analytics to the decision-maker driven systems, encompassing data, a model and UI, forming the core of DSS.

The historical account of the DSS field and supporting SIG activity is not well documented. It is useful to triangulate this evidence and patterns observed in published journal articles and books. The remaining sections 1) characterise the DSS landscape, 2) leverage Scopus to present a bibliometric analysis of DSS research, and 3) examine the geographical distribution of DSS research output across the three AIS regions. The final section offers some conclusions and considers the next steps in this study.

Understanding the DSS Landscape

Google Trends can be used to measure the popularity of keyword searches from 2004, when the search data time series began. Our empirical approach uses Google Trends to present a sense of the DSS landscape, interrogating the frequency of the search terms. Figure 1. shows the frequency of searches for the term "Decision Support Systems" from 2004 to Sept 2022.

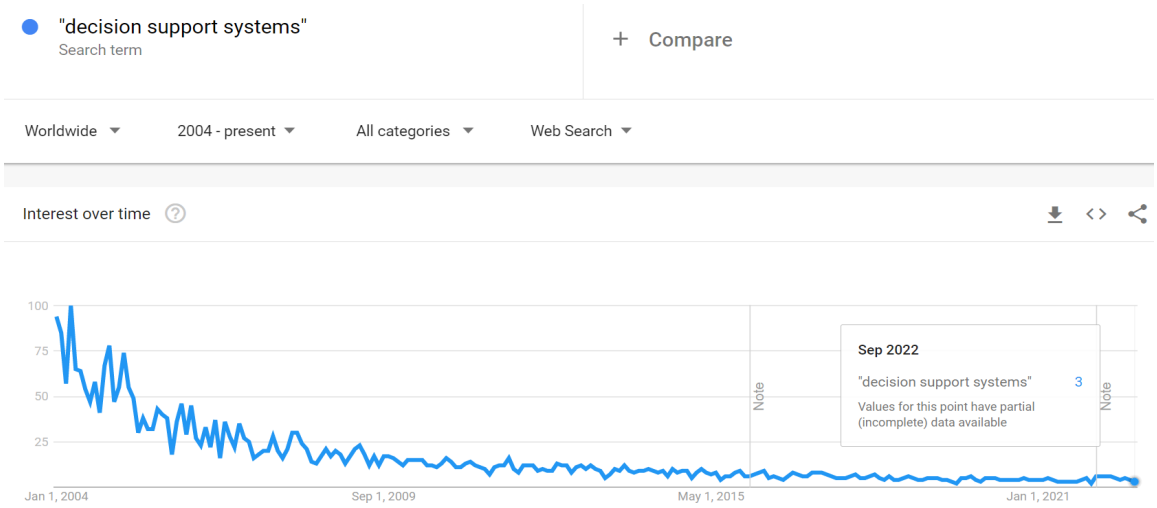

Figure 1. Relative interest in key search term "Decision support system" Google Trends (2004-2022)

This graphic shows a marked decline in the popularity of this term during that period. Figure 2 compares the terms "Decision Support Systems" and DSS, the most popular acronym used to describe such systems.

While it seems that DSS as a term is used to search more frequently, we have no way of knowing if the use of the term refers explicitly to decision support. This search behaviour provides a sense of the popularity of a search term at a particular time, and the frequency of term usage may be one indicator of this. While Google Trends captures aggregate public interest, it lacks detail. Consequently, the following section leverages bibliometric techniques offering greater insight into research activity in the DSS area.

Figure 2. Relative interest in key search term "Decision support system" v "DSS" Google Trends (2004-2022)

Disciplinary breakdown of DSS research

Scientometric techniques support the examination of aggregate trends in academic publications using bibliographic databases. These techniques allow the identification of the trends in the subjects researched, trends in authorship and collaboration and the identification of important research outlets. Scientometric investigation has dramatically increased owing to the increased availability of bibliographic databases, new software to visualise and analyse bibliographic data, and the improved capacity to analyse large datasets. The most widely used bibliographic databases are the Web of Science (WOS), maintained by Clarivate Analytics (previously Thomson Reuters) and Scopus, owned by Elsevier. Google Scholar (http://scholar.google.com) and the relatively new Dimensions database (https://www.dimensions.ai) have a less well-established role in scientometric research, while the Microsoft Academic database was a potentially valuable resource but has been discontinued (Visser et al., 2021).

Scopus (http://www.elsevier.com/scopus) contains 55 million records from over 22,000 titles from more than 5,000 publishers. While Scopus has more records than WOS and records dating back to 1823, it is perceived to be less comprehensive before the 1990s than WOS. Consequently, in this research, we used a 30-year period from 1992 to 2021. Scopus allows keyword search on the title and abstract and has keywords provided by the author and added by Scopus. In this research, we required the term "decision support" AND (systems OR system) in the title or abstract and also a keyword “Decision Support System” or “Decision Support Tool” or “Decision Support Aid”. We limited the search to journal articles, as these are more consistently recorded in the database. This research produced 58,156 records for the 30-year period 1992-2021. The search term choice is a balance between excluding relevant papers and a wider search which includes papers outside the core area being examined. The object of this work is to form an aggregate picture of the field, and how it has changed over time; while individual papers may be excluded or included inappropriately, the aggregate picture can still be valid if most papers are appropriate.

Scopus allows the analysis of results and breaks down publications by year, country, and author. In this research, we grouped the countries of authorship into the three AIS regions. A small proportion of records were not correctly matched in this process owing to variations in the names of countries, but this is not material in comparing the aggregate proportions of papers in the AIS regions.

Leydesdorff, de Moya-Anegón and de Nooy (Leydesdorff et al., 2016) performed an analysis of the aggregated citation relations among 19,600 journals in Scopus for publications between 1996 and 2012. This work produced a visualisation in the Vosviewer software (Van Eck & Waltman, 2010) of all academic research in Scopus; in this visualisation the journals are positioned close to those with similar citing patterns. The visualisation also clustered related publications together into 16 major communities. The overall shape of the visualisation groups related fields so that mathematical disciplines are on the top left, social science on the bottom left, and medical disciplines are on the right. Journals which appear in the sparsely populated centre of the visualisation often bridge disciplines. In the case of DSS, medical informatics journals are found on the graphic between the DSS publications on the left and the medical ones on the right of the visualisation.

Figure 3 visualises DSS research in 1992. At this time, DSS papers were mainly found in journals representing Computer Science, OR/MS, Information Systems (IS) and Decision Sciences. These related fields are located on the visualisation on the left-hand side, and the largest bubbles are OR/MS journals such as the European Journal of Operational Research and Computers and Operations Research. In 1992, a smaller number of papers relating to medical applications are also on the bottom right of the visualisation.

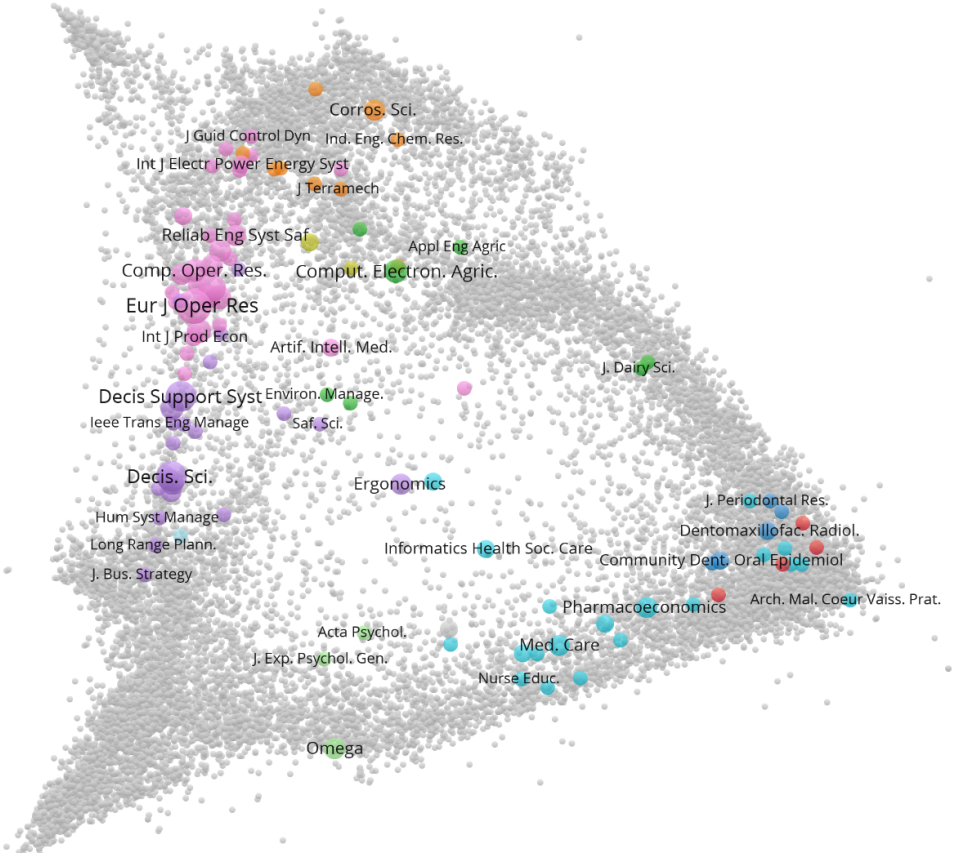

Figure 3. visualisation of DSS research in 1992 in Vosviewer overlaid on a representation of all research in Scopus (Leydesdorff et al., 2016)

In 2021 (Figure 4), there are many more papers; while the traditional areas have increased to some extent, there are more papers in the environmental area (appropriately coloured green in the figure), and there are also more papers in the medical/healthcare area. The growth in environmental and medical disciplines shown here in Scopus has also been seen in earlier analyses using WOS (Keenan, 2016). The journal Decision Support Systems was relatively new in 1992 and was not yet as important as it subsequently became. Even in 1992, mainstream IS journals were not prominent in the visualisation, which is also reflected in earlier research using the WOS database. However, earlier research using WOS suggested that 1990s papers often cited earlier seminal articles in IS journals (Keenan, 2016). As well as IS-related publications, these influential seminal papers were also cited in the early work concerning DSS in non-business disciplines.

Scopus has its own groupings of disciplines, the All Science Journal Classification Codes (ASJC) schema. This is grouped into 31 subject areas, which in turn are grouped in Scopus into four major areas: Life Sciences, Social Sciences, Physical Sciences, and Health Sciences. The use of these areas for analysis is complicated because a given publication may be in several classifications and be included in up to three top-level groupings. More commonly, 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 Computers in Biology and Medicine is categorised both in Physical Sciences and Health Sciences.

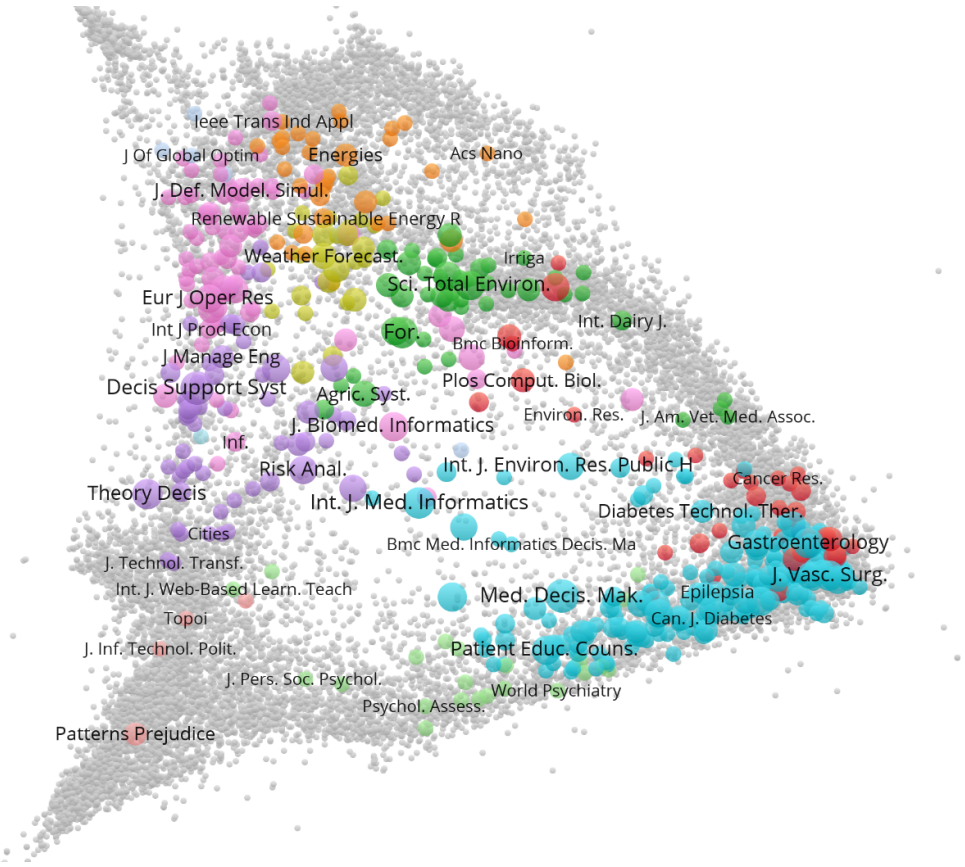

Figure 4. visualisation of DSS research in 2021 in Vosviewer overlaid on a representation of all research in Scopus (Leydesdorff et al., 2016)

While these overlaps complicate the analysis, this research is interested in the patterns of change over time and the different interests in different geographic areas; these comparisons are possible notwithstanding the overlaps.

Regional distribution of DSS Research

The AIS has three regions:

Region 1: North, South, and Central America
Region 2: Europe, the Middle East, and Africa
Region 3: Asia and the Pacific

Figure 5 shows the growth in DSS papers in these regions. These totals largely reflect English language papers, as Scopus contains fewer publications in other languages. There is a small element of double counting in these totals, as a paper with authors from two regions will be counted in both. All areas showed rapid growth for the first 25 years, with the fastest growth being Region 3, which has grown to a similar number of papers as Region 1 over this period.

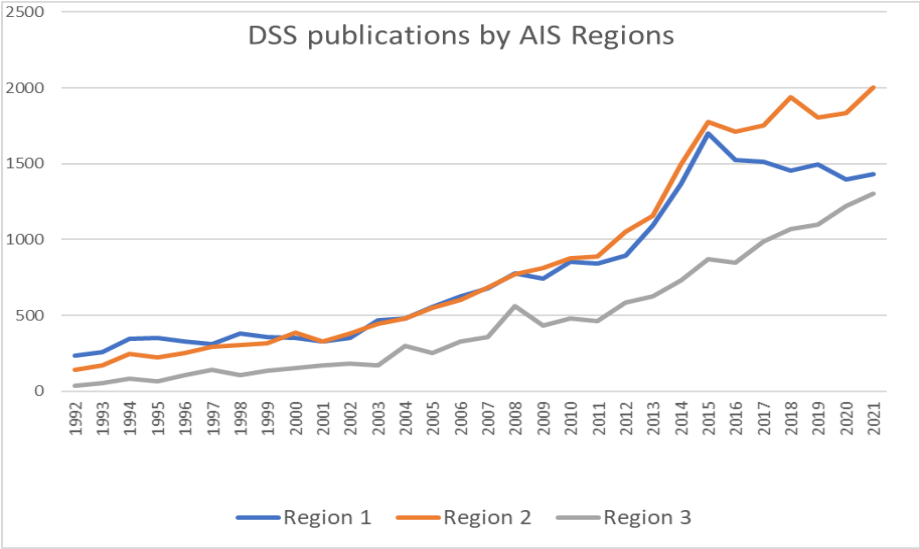

Figure 5. number of papers in AIS regions

Within the regions, there is some variation in the proportions of papers in the areas of application of DSS (Figure 6).

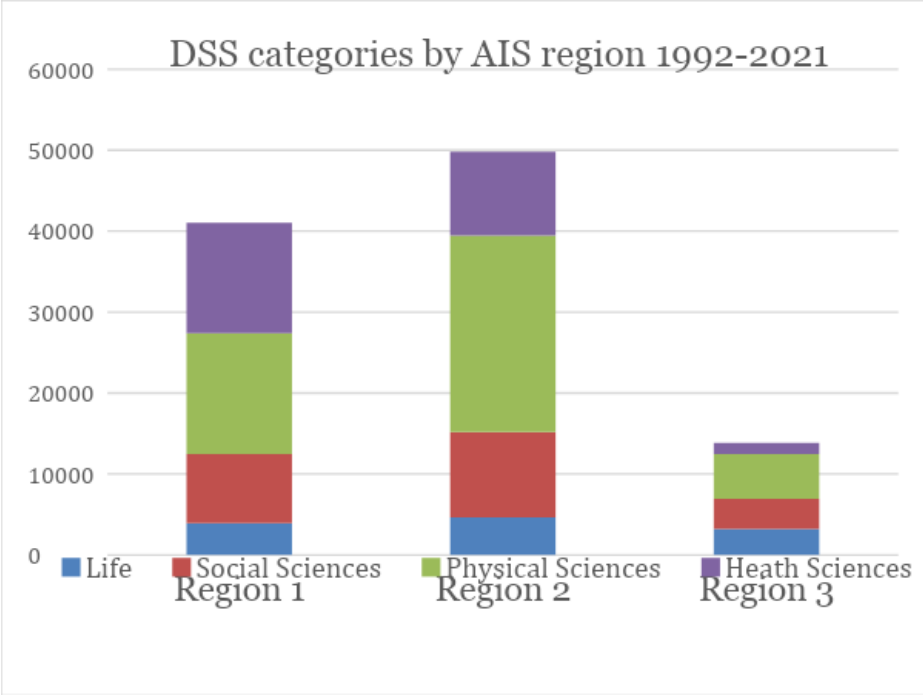

Figure 6. Relative interest in Scopus research areas in AIS regions

In Region 1, there are more papers in Health Science publications. In Region 2, the Physical Science category is relatively larger, mainly comprising the Computer Science and Engineering categories. In Region 3, there have been more papers in the Life Science category, reflecting recent papers in the

Agriculture and Environmental areas. What is clear is that the majority of DSS-related research is not in Business School journals and that a large part of DSS relates to areas like the environment and medicine, which are not fully represented in academic discussion among DSS researchers.

Conclusion and Next Steps

This research-in-progress article examines the subject and geographical structure of research in the DSS field to understand better how DSS has changed during the life of the AIS SIG. Using Google Trends, we visualise the popularity of the DSS concept globally with the public, and we use bibliographic analysis in Scopus to examine changes in the themes and locations of DSS research. The DSS field is now over half a century old. By the beginning of the present century, the DSS field was a developed one with a clear sense of its own value and purpose and the changing contribution of new technologies. This led to the creation of the AIS SIG to drive a cohesive research. After two decades, it is appropriate to look at how the DSS field has evolved and ask whether the DSS research community has developed with it. The SIG originates in a discussion panel entirely composed of US-based researchers, and AIS is a US-centric organisation. Yet, this research shows that DSS has grown more quickly since then outside AIS Region 1. That panel was entirely male, yet other research shows that one-third of DSS researchers are female (Keenan & Heavin, 2022). AIS is mainly an organisation based in Business Schools, yet this research reveals that most DSS applications are in other domains. In general, it seems that DSS researchers have not offered much recent insight on DSS to these fields nor sought to learn from them. In recent years, the use of the term "decision support system" has declined both in general use and in academic papers in some parts of the world. Further research requires a more detailed examination of the evolution of the research themes in the different regions, including a study of their citations and their geographic distribution. Additional empirical studies are needed to investigate the recent decline in the number of papers describing themselves as DSS in the countries which initially led this research. The decrease in the number of studies explicitly referring to "Decision Support Systems" and "DSS" may reflect a change of terminology and a move towards using other popular Analytics related terms to characterise this field of research. Future studies should focus on establishing a better understanding of how research relating to novel decision systems is described in this era of Analytics. Given the observations presented here and the diversity of domains involved, it is difficult to believe that we have entirely solved the problem of how best to use information technology to support decisions!

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