A Survey of Eight Key Issues for the Decision Support Systems Discipline

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ABSTRACT

Decision Support Systems (DSS) is a specific class of computerized information system that support business and organizational decision making activities.

To examine the development pattern of a specific DSS over time, we analyzed and summarized the survey results, according to (1) the area of application, and (2) the management level (operational, tactical, or strategic) for which the DSS was designed.

This paper integrates a number of strands of a long-term project that is critically analyzing the academic field of decision support systems (DSS). The project is based on the content analysis of 1093 DSS articles published in 14 major journals from 1990 to 2004. An examination of the findings of each part of the project yields eight key issues that the DSS field should address for it to continue to play an important part in information systems scholarship.

These eight issues are:

The relevance of DSS research, DSS research methods and paradigms, the judgment and decision-making theoretical foundations of DSS research the role of the IT artifact in DSS research, the funding of DSS research, inertia and conservatism of DSS research agendas, DSS exposure in general "A" journals, and discipline coherence.

The discussion of each issue is based on the data derived from the article content analysis. A number of suggestions are made for the improvement of DSS research. These relate to case study research, design science, professional relevance, industry funding, theoretical foundations, data warehousing, and business intelligence.

Keywords
Decision Support Systems

1. INTRODUCTION
The primary and main objective of the decision support system is to provide and find solutions to very complex and unique problems. Decision support systems use mathematical models to be able to provide solutions and be effective to solve complex problems. There is difficulty in finding solutions to this type of problem. Decision support systems help in the decision-making process.

Decision support systems (DSS) are the area of the information systems (IS) discipline that is focused on supporting and improving managerial decision-making. Essentially, DSS is about developing and deploying IT based systems to support decision processes. The current DSS industry movement of business intelligence (BI) is one of the most buoyant areas of investment despite the IT downturn of the early to mid2000s.The market in new BI software licenses grew 12% from 2003 to 2004 .The history of DSS reveals the evolution of a number of sub groupings of research and practice.

The major DSS sub-fields are:
•Personal Decision Support Systems (PDSS): usually small-scale systems that are developed for one manager, or a small number of independent managers, to support a decision task.
•Group Support Systems (GSS): the use of a combination of communication and DSS technologies to facilitate the effective working of groups.
•Intelligent Decision Support Systems (IDSS): the application of artificial intelligence techniques to decision support.
•Knowledge Management-Based DSS (KMDSS): systems that support decision making by aiding knowledge storage, retrieval, transfer and application by supporting individual and organizational memory and inter-group knowledge access.
•Data Warehousing (DW): systems that provide the large-scale data; infrastructure for decision support.
•Enterprise Reporting and Analysis Systems: enterprise focused DSS including executive information systems (EIS), business intelligence (BI), and more recently, corporate performance management systems (CPM). BI tools access and analyze data warehouse information using predefined reporting software, query tools, and analysis tools. Of these sub-fields, PDSS, Enterprise Reporting and Analysis Systems, and DW have had the most presence in practice.

2. RESEARCH PROBLEM
Sean Eom and colleagues' series of analyses have used bibliometric approaches, including co-citation analysis, to analyses the intellectual structure of the field. Other reviews have examined the content of articles but have usually concentrated on one aspect of the field; for example, Benbasat and Ault examined empirical DSS research, while Pervan analyzed group support systems.
The literature analysis at the heart of this project included all DSS types. It involved the content analysis of each paper in the sample.

The time period of published research chosen for this project is 1990 to 2004. For this paper, their data sets have been updated with 2003 and 2004 data.
The start of the analysis period is marked by two much-cited

reviews: Both of these reviews covered the DSS field from its inception to the late 1980's.

The period 1990 to 2004 also marks an interesting period in the development of the information systems discipline as it witnessed a significant growth in the use of no positivist research methods. In industry, the analysis period saw the deployment of several new generations of DSS, especially the large-scale approaches of executive information systems, data warehousing, and business intelligence. To help identify trends in DSS research, the sample was divided into three five-year eras: 1990–1994, 1995–1999, and 2000–2004. The sample of articles for the project is DSS research published between 1990 and 2004 in the 14 journals.

3. KEY ISSUES

3.1 Key Issue 1- the relevance of DSS research

A number of information systems researchers are concerned that there is a widening gap between research and practice, particularly in the systems development area. Hirschheim and Klein, in a critical assessment of the IS discipline, identified major disconnects between information systems researchers and executives, and between information systems researchers and information systems practitioners.

Benbasat and Zmud identified five reasons why information systems research lacks relevance:

The first is an emphasis of rigor over relevance in order to gain the respect of other academic disciplines; the second is the lack of a cumulative tradition that yields strong theoretical models that act as a foundation for practical prescription; the third is the dynamism of information technology, which means that practice inevitably leads theory; the fourth is a lack of exposure of IS academics to professional practice and the fifth is the institutional and political structure of universities which limits the scope of action of information systems academics.

Though the relevance scores of DSS have improved, the relevance levels are so low as to constitute a major problem for the DSS discipline. We believe that all of the factors identified by Benbasat and Zmud are likely to be in play in DSS research. The relative lack of exposure of academics to contemporary professional practice is a particular problem for DSS.

The concentration on natural science style research in order to gain institutional acceptance is evident in DSS publication. Only two DSS types have combined high and very high relevance scores in greater than 10% of papers:

Enterprise Reporting and Analysis Systems (34.2%) and DW (56.3%).These areas are overwhelmingly dominant in contemporary practice and as a result their high relevance scores are understandable. However, only 8.6% of DSS papers are in these areas. In terms of decision support focus there is no significant difference in relevance scores between papers that focus on systems development, technology, decision outcomes and impacts, or decision-making processes. A factor that is not included in Benbasat and Zmud's list but which may be operating in DSS research is the lag time in journal publishing. A long time lag between data collection and publication can make the published results less relevant to professionals. Some journals in our sample have a two-year period between typesetting and publication. Combined with time to develop a research plan, collect and analyse data, write a paper and go through the refereeing process, there can easily be a five-year gap between project initiation and publication. In particular, the publishing lag can discourage rigorous surveys of current practice, research that is highly relevant to professionals.

3.2 Key Issue 2 -DSS research methods and paradigms

There are many classification schemes for research paradigms. Neuman's approach of separating inquiry into positivist, interpretivist, and critical social science paradigms is well accepted in information systems research. The period of analysis, 1990 to 2004, saw a significant move in information systems research from positivism towards interpretivism, and to a lesser extent, critical theory. DSS research is overwhelmingly dominated by the positivist paradigm with 92.3% of empirical studies following that approach. Chen and Hirschheim's study of general information systems research from 1991 to 2001 reported that 81% of papers had a positivist orientation with 19% using an interpretivist approach. We found no paper that used a critical theory approach. DSS research is more dominated by positivism than general information systems research. Data Warehousing and Enterprise Reporting and Analysis Systems have the highest proportion of interpretivist studies, while Intelligent DSS and Personal DSS have almost ignored non-positivist paradigms. It is not surprising that the more modern types of DSS are being researched with a more contemporary mix of paradigms than older types of DSS. This may be due to practice leading research in this area; thus providing opportunities for research in the field from which researchers can inductively build theory using interpretivist approaches In US journals 95.7% of empirical papers were positivist and 4.3% interpretivist. For European journals the position is dramatically different with 56.5% positivist, 41.9% interpretivist and 1.6% both. Compared with Chen and Hirschheim's analysis of general information systems research, US DSS research is more positivist than US information systems research and European DSS research is more interpretivist than European information systems research. Chen and Hirschheim's analysis of overall information systems research (in a literature review of 1893 information systems papers) reported a different split between non-empirical (40%) and empirical (60%) research. This means that DSS research has significantly more empirical research than general information systems.

DSS was founded on the development of experimental systems for managers and has a long history of the publication of descriptions of DSS applications that are novel or important. This is part of what is now called design science. Design science is an alternative, or complement, to the natural science approach that is dominant in information systems research. In design science the researcher "creates and evaluates IT artifacts intended to solve identified organizational problems. March and Smith clearly draws the distinction between natural and design science:

Whereas natural science tries to understand reality, design science attempts to create things that serve human purposes". Because of the significant design science research experience, DSS researchers have much to offer the current debate on information systems design science methodologies; it may be one of the most significant contributions that DSS can make to its parent discipline.

3.3 Key Issue 3 - the theoretical foundations of DSS research

Because DSS research has the mission of improving managerial decision-making, DSS articles should be grounded in quality judgement and decision-making research. In analysing DSS papers, special care was taken to distinguish between merely citing reference theory in introductory passages or focusing discussion and explicitly using reference theory in the design of the research and interpretation of results. Only the second, integral, use of reference theory was coded in this project. Surprisingly, 47.8% of papers did not cite any reference research in judgement and decision-making in this fashion. Further, the percentage of papers that explicitly used judgement and decision-making reference research is relatively stable over time.

The mean number of citations to judgement and decision-making reference research per paper for each type of DSS. Group and Negotiation Support, and Personal DSS have the most reference citations, with the current professional mainstream of Data Warehousing having the poorest grounding. One reason for this could be that GSS, NSS, and PDSS largely involve the application of technology to tasks that have been researched by other disciplines. As such it is relatively easy to select a foundation theory lens for DSS research.   DW and BI are less mature DSS types and current research is largely focussed on technology and getting the data right. It may be more difficult to find models of behaviour to inform research in these DSS types.

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3.4 Key Issue 4 - the role of the IT artifact in DSS research

One of the key contemporary debates in the Information System discipline is the role of the Information Technology artifact in Information System research. How close should the research constructs that we use be to an IT-based system? Orlikowski and Iacono argued that theorizing about IT artifacts should be at the core of Information System research projects. Benbasat and Zmud supported this view and argued that Information System research constructs should be intimately related to the IT artifact. Benbasat and Zmud's paper spurred considerable debate within the IS community.

Argarwal and Lucas, while subscribing to many of Benbasat and Zmud's recommendations, argue that Information System research should also focus on the transformational aspects of IT in organizations. Essentially, Benbasat and Zmud present a micro view of Information System research and Argarwal and Lucas, a macro focus .That DSS research has embraced both micro and macro Information System research traditions.

Research that focuses on the IT artifact ("systems development" and "information technology") comprises 44.4% of DSS research and a further 19.1% focuses on the macro transformational issues of decision outcomes and organizational impact. also shows that the two micro focuses on the IT artifact have declined in article numbers significantly

in the last five years. This is partly at odds with the design science heritage of the field.

3.5 Key Issue 5 - the funding of DSS research

The analysis identifies those papers supported by major competitive grants from national agencies (for example, US National Science Foundation, Australian Research Council, Research Councils UK, and the Canadian National Research Council), cash funding by industry, and internal university grant schemes. As a field, DSS research is poorly grant-funded. Only 24.1% of DSS papers in the sample received any grant funding; only 20% received any external funding. The 1093 papers in the sample from 14 major DSS and Information System journals should represent the best of DSS research. However, 75.9% of papers do not acknowledge any specific funding. This is a reasonably reliable statistic as a condition of most grant funding is the acknowledgement of the funding body in any publications. Further, only 15% of these 'best' DSS papers attract the prestigious competitive grant funding which enhances a department or school's reputation and attracts further infrastructure funding from governments. The low level of grant funding of DSS research may have national differences. In some Asian countries virtually all research is grant funded, while in some US universities researchers can pursue large projects with internal funds. However, discussions with department chairs and deans in Europe, UK, and USA indicate that most IS schools currently have significant funding problems and that they need increasing levels of external grant income to support normal research programs. It is apparent that most DSS research is implicitly funded, that is, funded as an integral part of the standard work of an academic and the recurrent budget of the academic's department. However, in the current global academic environment, any discipline that relies on implicit funding of research is unlikely to prosper, simply because implicit funding no longer provides adequate support for an academic's research career. As a result, the relatively low level of grant funding represents a major problem for the DSS field. To add to the competitive grant-funding problem, DSS has also been relatively unsuccessful with industry funding, with only 5% of papers reporting industry support. Further, industry support has appreciably declined since 1990. This amplifies the concern about research relevance discussed under Key Issue 1.

3.6 Key Issue 6 — inertia and conservatism of DSS

Research agendas An important issue in an applied field like DSS is the extent to which the academic field leads or follows industry practice. One way of identifying where DSS lies on this continuum is to examine the publishing of different DSS types over time. Despite the lags in journal publishing, this analysis gives an indication of the level of conservatism of research agendas. At the start of our analysis period PDSS and GSS were the most important DSS types; by the end of the period DW and Enterprise Reporting and Analysis Systems were overwhelming dominant in practice. Around 35 years after the birth of the field, Personal DSS, one of the oldest types of DSS, still dominates the agenda of researchers. PDSS research has evolved significantly over this time, driven by sustained improvement in information technologies and greater managerial knowledge and experience. It has however; waned considerably in perceived importance to industry.That every type of DSS, regardless of its age and contemporary professional relevance is represented in journal publication.

As each new approach to managerial decision support is added to the IS research and practice portfolio, each older DSS approach remains in play. Aserious concern that stands out is the low proportion of DW and Enterprise Reporting and Analysis papers at 8.5%. The situation is slowly improving and in the 2000–2004 period the proportion was 10.8%. The low relative frequency of DW and Enterprise Reporting and Analysis Systems in the distribution cannot be explained by novelty as they have been mainstream in practice for some time , well outside the lag effect of journal review and publication. DW and BI systems are large-scale and complex. It takes considerable effort for a researcher to learn the technologies and to engage professionals at the level required for quality research. This may be acting as a barrier to entry to DW and BI research. There are no academically rigorous market statistics for DW and Enterprise Reporting and Analysis Systems but conversations with senior chief information officers (CIOs) indicate that almost all major commercial expenditure in decision support involves these DSS types. The industry research firm, Meta Group, estimates that the DW market is currently worth US$25 billion.   IDC, another commercial research firm, believes that DW and BI are central to contemporary IT investment and will remain so for some time. Even allowing for serious overestimation by the CIOs and the commercial researchers, there is a marked disconnect between the agendas of DSS researchers and senior IT professionals.

This reinforces the concern expressed in the discussion of research relevance under Key Issue 1 and the low level of industry funding under Key Issue 5. That DSS publication has fallen in the last era (2000–2004). Within the last era, 2002 had the lowest publication total, 45 papers, but publication increased to 74 in 2004. The general drop in DSS publishing could be the result of agenda shifting by Information System researchers, perhaps into e-commerce and enterprise systems.

3.7 Key Issue 7 — DSS exposure in "A" journals

In Table 1 the journals in the sample were classified by origin (US or Europe) and ranking ('A' or "other'). They were also classified by their orientation: general Information System, specialist Information System, or multi-discipline. All researchers strive to publish in the highest quality journals and a field's performance and influence can be judged by its researchers' relative success in publishing at the highest levels. Table 9 presents a reorganization of the statistics from Table 1 into a number of origin and ranking categories. In all 'A' journals, DSS research occupies 15.0%, around the same percentage it occupies in all 'Other' journals. This shows that DSS academics have a good overall publishing record. However, this performance may be inflated by the influence of the journal DSS in the analysis. We classified DSS as a general Information System journal because over time it has broadened its scope to much more than DSS. An indication of this generalization is that changed its title to Decision Support Systems and Electronic Commerce in February 1999. Further, only 54.4% of papers in DSS meet the definition of decision support systems used in this paper. When DSS is removed from the analysis, the percentage of DSS papers in general IS 'A' journals drops from 25.5% to 11%. This is a poor result for the field as, with the exception of one European journal, the readership and impact of the other general IS 'A' journals is much larger. We believe that it is important for the discipline to increase its presence in all general Information System 'A' journals. Further splitting the general IS category into US and European categories shows that DSS researchers publishing in European journals have a better proportional publication record

in 'A' journals than 'Other' journals, a sign of very high quality research. However, at 7.3% for 'A' and 5.8% for 'Other' European journals the presence of DSS in European Information System scholarship is much less, both absolutely and relatively, than in US scholarship.

3.8 Key Issue 8 — discipline coherence
Hirschheim and Klein , in a critical analysis of the state of the Information System, argue that fragmentation is "the root cause of the field's potential crisis" Arnott and Pervan ,using an historical analysis, characterized DSS as a set of sub-fields partially connected by their desire to provide ways of supporting decision makers.

The top five judgment and decision making reference articles for each DSS type (using the selection logic outlined under Key Issue3).The total number of references per type is shown in the left column and the right column shows the reference ranking and reference frequency for each type. This analysis of the foundation citations does provide an indication of the level of coherence of the field. Immediately standing out in the table is the disconnect between group and negotiation support systems on the one hand, and the remaining DSS types on the other — there are no common key references between these two groupings. This suggests that they may even be considered as separate academic fields, a notion that is supported by the conduct of separate specialist conferences and the publishing of separate high-quality specialist journals. The lack of judgement and decision-making references in data warehousing research indicates that it could also be regarded as a separate academic area. The foundation of data warehousing appears to be in data modeling and database design rather than in judgement and decision-making. Another interesting observation is the integrating nature of Simon's behavioral theory of decision-making across personal DSS, Enterprise Reporting and Analysis Systems, Intelligent DSS, and KM-based DSS. The strength of this referencing does indicate intellectual coherence across these DSS types. To summarize, the analysis of Table 10 indicates that DSS has marked disconnects between important sub-fields. In terms of judgement and decision-making reference theory, there appears to be three disjoint sub-fields of DSS   (1) Personal DSS, Enterprise Reporting and Analysis Systems, Intelligent DSS, and KM-based DSS; (2)Group and Negotiation Support Systems (3)Data Warehouse. The first grouping reveals that there is substantial coherence among the majority of the DSS sub-fields. The second grouping reflects the evolution of GSS and NSS from different theoretical branches and different technological focuses. GSS research, for example, has long been dominated by a focus on enhancing communication and information sharing using computer networked electronic meeting systems (such as the University of Arizona's Group Systems software).   However, this may represent an opportunity to further integrate these products with appropriate decision making methods and tools.

4. CONCLUSION, LIMITATIONS AND FUTURE RESERSH
The analysis of the eight key issues constitutes a cause for reflection, revision, and evolution of DSS research agendas. Before suggesting some directions for DSS research, a word of caution about the findings is warranted as the eight key issues can be viewed in a slightly negative way this is because the intention of the analysis was to illuminate problems in the field so that we may change our research behaviour in a way that significantly improves our work. As Tversky and Kahneman

have found, a negative frame can bias the perception of a decision or task. It should be remembered that despite its current problems, DSS has a long history of success in scholarship and practice. BI and PDSS systems are now an integral part of most managers' work. The idea that computers can be used to support rather than replace humans is as important today as it was in the 1970s. DSS scholars have contributed significantly to IS theory in areas such as evolutionary systems development, the incorporation of AI into business systems, multi-dimensional data structures, critical success factors, group processes, and managerial information behaviours. Nevertheless, the eight issues identified in this paper should be given careful attention. The key issues are summarized in Table 1.

Table 1 Key issues for the DSS discipline

Key issue	Comments
1. Professional relevance	**Most DSS research is disconnected from practice. Only Enterprise Reporting & Analysis and DW have reasonable relevance scores.**
2. Research methods and paradigms	**DSS is more dominated by positivism than general IS. Case study research is under represented. A long history of design science research could contribute methodologically to IS research**
3. Theoretical foundations	**Around half of the papers have no explicit foundation in judgment and decision-making. Much DSS research is based on a relatively old theoretical foundation. Enterprise Reporting & Analysis and DW research has the poorest theoretical grounding in judgment and decision making**
4. Role of the IT artifact	**DSS research had a strong focus on the IT artifact early in the analysis period but this focus is declining.**
5. Funding	**DSS has relatively low competitive grant success and even lower industry support. Industry support is declining. Most research relies on implicit funding through university departments**
6. Inertia and conservatism	**e relatively older types of PDSS and GSS still dominate research agendas**
7. Exposure in 'A' journals	**DSS needs to increase its presence in IS 'A' journals other than DSS. DSS researchers are under-represented in European IS scholarship.**
8. Discipline coherence	**DSS comprises three relatively isolated subfields.**

5. LIMITATIONS

No research study is free of limitations and this project has at least three areas of possible concern. **First,** this study reviewed a finite set of DSS articles (1093) but it could be argued that this number is large enough to support the validity of our conclusions.

Second, conducting a literature review and coding the content on various dimensions is, of necessity, rather subjective. However, the rigor of the coding and analysis procedures used and the research experience of the researchers ensured that the data was fairly reliable. We believe that other researchers using our protocol would produce similar results.

Finally, any large study of journal papers is dependent on the set of journals chosen. We chose a mix of general management science, information systems, and decision support systems journals. This set should be sufficiently representative of the field. We also included five European journals to provide an international mix that is generally absent from other studies. We did not include professional journals as our focus was on DSS research.

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