Available online at www.sciencedirect.com
ScienceDirect
Decision Support Systems 44 (2008) 657–672
Decision Support Systems
www.elsevier.com/locate/dss

Eight key issues for the decision support systems discipline ☆

David Arnott [a,*], Graham Pervan [b]

[a] Centre for Decision Support and Enterprise Systems Research, Monash University, Melbourne, Australia
[b] Curtin Business School, Curtin University of Technology, Perth, Australia

Received 2 May 2006; received in revised form 26 August 2007; accepted 23 September 2007
Available online 29 September 2007

Abstract

This paper integrates a number of strands of a long-term project that is critically analysing 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 judgement 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. The suggestions should help DSS researchers construct high quality research agendas that are relevant and rigorous.

Keywords: Decision support systems; Group support systems; Executive information systems; Data warehousing; Business intelligence; Review

1. Introduction

Decision support systems (DSS) is 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. DSS has been an important area of IS scholarship since it emerged in the 1970s. It has also been a major area of IT practice and the decisions made using IT-based decision support can have a significant effect on the nature and performance of an organization. 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 mid 2000s. The market in new BI software licences grew 12% from 2003 to 2004 and is expected to have compound growth of 7.4% to 2009 [34]. DSS is not a homogenous field and over its 35-year history a number of distinct sub-fields have emerged. The history of DSS reveals the evolution of a number of sub-groupings of research and practice [6]. 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;

☆ An earlier version of this paper was presented at the IFIP Working Group 8.3 Conference, London School of Economics and Political Science, United Kingdom, July 2006.

* Corresponding author. Tel.: +61 3 9903 2693.
E-mail address: david.arnott@infotech.monash.edu.au (D. Arnott).

0167-9236/$ - see front matter © 2007 Elsevier B.V. All rights reserved.
doi:10.1016/j.dss.2007.09.003

- *Group Support Systems* (*GSS*): the use of a combination of communication and DSS technologies to facilitate the effective working of groups;
- *Negotiation Support Systems* (*NSS*): DSS where the primary focus of the group work is negotiation between opposing parties;
- *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 focussed 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 [63].

Of these sub-fields, PDSS, Enterprise Reporting and Analysis Systems, and DW have had the most presence in practice.

This paper integrates a number of strands of a long-term project that is critically analysing the academic field of DSS. The foundation of the project is the content analysis of 1093 DSS articles published in 14 major journals from 1990 to 2004. The first, descriptive, results were presented in Arnott, Pervan and Dodson [8]. Pervan, Arnott, and Dodson [72] presented a critical analysis of group support research from 1990 to 2003, while Arnott, Pervan and Dodson [7] analysed the funding of all types of DSS research. Pervan and Arnott [71] examined data warehousing and business intelligence research and Dodson, Arnott and Pervan [22] analysed the role of the system's client and user in DSS research. The major publication from the project to date, Arnott and Pervan [6], analysed published research in a number of dimensions including journal publishing patterns, research paradigms and methods, decision support focuses, professional relevance, and judgement and decision-making foundations. The aim of this paper is to integrate the findings of the strands of the project into a set of key issues that can assist DSS researchers in the development of research agendas that are important for both theory and practice.

This paper is structured as follows: first, the project's research method and design is described. This is followed by the identification of the key issues that have emerged from the various strands of the project. Each key issue is discussed in turn, following which suggestions for the improvement of DSS research are made, the limitations of the research outlined, and the future directions of the project are discussed.

2. Research method

The overall project is attempting to understand the nature of the DSS discipline using literature analysis. There have been a number of other critical reviews of DSS publication. Sean Eom and colleagues' series of analyses have used bibliometric approaches, including co-citation analysis, to analyse the intellectual structure of the field [24–28]. Other reviews have examined the content of articles but have usually concentrated on one aspect of the field; for example, Benbasat and Nault [9] examined empirical DSS research, while Pervan [70] analysed 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. This form of data capture has the disadvantage that it is a very labour intensive process but, importantly, it has the advantage that it can illuminate the deep structure of the field in a way that is difficult with citation studies.

The time period of published research chosen for this project is 1990 to 2004. Some of the earlier papers that reported on parts of the project ended their analysis in 2002 or 2003. 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: Eom and Lee [27] and Benbasat and Nault [9]. Both of these reviews covered the DSS field from its inception to the late 1980's. A third review paper focusing on DSS implementation, Alavi and Joachimsthaler [2], provides a further anchor for the starting date of our analysis, as does the TIMS/ORSA and National Science Foundation sponsored discipline assessment [83]. 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 non-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

shown in Table 1. We adopted a large set of quality journals as a basis of the sample because we believe that this best represents the invisible college of DSS research. Previous analyses of information systems research have used a similar sampling approach [1,9,70]. Alavi and Carlson [1] used eight North American journals for their sample. However, Webster and Watson [88] have criticised the over emphasis on North American journals in review papers. In response we included five European information systems journals (*ISJ*, *EJIS*, *I&O*, *JIT*, and *JSIS*) in our sample. Following Chen and Hirschheim [15], the classification of a journal as US or European is largely based on the location of the publisher. Galliers and Meadows [30] used a similar approach, making their journal origin decision on the basis of the location of the publisher and the nationality of the editor. Analyses of IS publishing have found significant differences between the nature of research published in North American and European journals [15,30,39]. The quality of journals was classified as 'A' level or 'Other'. This classification was based on publications that address journal ranking [33,36,42,49,61,87,89] and on discussions with journal editors and senior IS academics.

The DSS articles were selected electronically by examining key words and titles. A manual check was performed of the table of contents of each issue of each journal. In addition, the text of each potential article for analysis was examined to verify its decision support content. This procedure identified 1093 DSS papers. The protocol used to code each paper appears in the Appendix. The protocol was based on that used by Pervan [70], modified and augmented to reflect known issues in broader DSS scholarship. Some papers, termed 'example articles', were selected as being representative of the various article types. These articles, such as [12,18,73,79], were well known to the researchers and were clear examples of each DSS type. To calibrate the coding process, the example articles were coded independently and compared. A small number of changes to the initial assessments were made. Each article in the sample was then coded by one of the two authors or a research assistant. The coding was performed in intensive week-long retreats where the three coders were able to challenge or confirm any question or issue as they arose. The ability to easily discuss interpretations improved the consistency of the coding. The time taken to code each article varied considerably, ranging from over an hour for large, complex papers, to 15 min for the straightforward coding of a known paper. In coding each paper the emphasis was on the dominant attribute of each factor for each paper. For consistency, the coding of articles by the research assistant was also reviewed by the first author. Papers on organizational DSS (ODSS), for example [77], were a difficult coding issue. Because the number of papers in this area is very low, it was not included as a major DSS type. Further, the ODSS papers were divided in focus; some were coded as PDSS, some GSS, and some as Enterprise Reporting and Analysis Systems. Corporate planning systems, one of the earliest forms of DSS, were coded as Enterprise Reporting and Analysis Systems. The coded protocols were entered into an SPSS database for

Table 1
Article sample by journal

Journal	Origin	Ranking	Journal orientation	No of DSS articles published	Total no of articles published	DSS articles as a percentage of published articles
Decision Sciences (*DS*)	US	A	Multi-discipline	64	665	9.6
Decision Support Systems (*DSS*)	US	A	General IS	466	857	54.4
European Journal of Information Systems (*EJIS*)	Europe	A	General IS	24	348	6.9
Group Decision and Negotiation (*GD&N*)	US	Other	Specialist IS	122	321	38.0
Information and Management (*I&M*)	US	Other	General IS	98	818	12.0
Information and Organization (*I&O*)	Europe	Other	General IS	16	169	9.4
Information Systems Journal (*ISJ*)	Europe	A	General IS	15	183	8.2
Information Systems Research (*ISR*)	US	A	General IS	34	303	11.2
Journal of Information Technology (*JIT*)	Europe	Other	General IS	22	378	5.8
Journal of Management Information Systems (*JMIS*)	US	A	General IS	80	523	15.3
Journal of Organizational Computing and Electronic Commerce (*JOC&EC*)	US	Other	Specialist IS	71	225	31.5
Journal of Strategic Information Systems (*JSIS*)	Europe	Other	General IS	8	240	3.3
Management Science (*MS*)	US	A	Multi-discipline	39	1807	2.1
MIS Quarterly (*MISQ*)	US	A	General IS	34	347	9.8
Total				1093	7184	15.2

analysis by the second author, who also performed data validity checks on the coding.

Table 1 shows the distribution of these papers by journal as well as identifying the percentage of papers in each journal that were classified as DSS according to our definition. Overall, 15.2% of published papers between 1990 and 2004 were in the DSS field. When only the general IS journals in the sample are examined, the proportion of DSS articles is a very healthy 19.1%. Each of these measures indicate that DSS is an important part of the IS discipline.

3. Key issues

The key issues presented in this section aggregate the various strands of the project. Issues 1 through 7 come directly from the analysis and discussion in previous papers; Issue 8 is new to this paper. The sequence of presentation does not imply any hierarchy of importance among the issues. It is also important to note that there is considerable overlap and interaction between the nature and impact of a number of the 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 [4,11,29]. Hirschheim and Klein [40], in a critical assessment of the IS discipline, identified major disconnects between IS researchers and executives, and between IS researchers and IS practitioners. Fundamental to these disconnects is the perception that much IS research is of little relevance to the practice of these two vital constituencies. Benbasat and Zmud [10] 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 IS academics.

An assessment of the practical relevance of DSS articles is shown in Table 2. The assessment of the practical relevance of a journal paper is a subjective judgement. In judging relevance we were informed by the aims and objectives of the paper, the nature of the discussion, and in particular, the content of the concluding comments of each paper. The researchers spent considerable time in discussing and reviewing their coding of this factor to assist in calibrating the independent coding processes. Both authors have many years of DSS research experience and both have been DSS practitioners; both maintain close links with industry and organizations and the judgement of relevance is based on this academic and professional experience.

Table 2 shows that overall, only 10.1% of research is regarded as having high or very high practical relevance. On the other hand, 49.2% of research was regarded as either having low practical relevance or none at all. Over time the relevance of DSS research has been improving. A one-way ANOVA of mean relevance scores over the three analysis eras shows significant improvement ($p<0.01$). Similar ANOVAs at the DSS type level shows that only two types have had significant improvement in relevance: PDSS ($p<0.05$) and IDSS ($p<0.01$). The improvement of relevance is driven by the large proportion of the sample that is PDSS. Even

Table 2
The practical relevance of DSS types

	Very high		High		Medium		Low		None	
	No of articles	% of type	No of articles	% of type	No of articles	% of type	No of articles	% of type	No of articles	% of type
Personal DSS	5	1.3	30	7.7	179	46.0	154	39.6	21	5.4
Group SS	1	0.3	20	6.3	120	37.6	142	44.5	36	11.3
Enterprise Reporting & Analysis	3	3.9	23	30.3	31	40.8	18	23.7	1	1.3
Data Warehouse	2	12.5	7	43.8	5	31.3	2	12.5	0	0.0
Intelligent DSS	0	0.0	13	8.1	55	34.4	84	52.5	8	5.0
KM-based DSS	0	0.0	2	9.1	11	50.0	8	36.4	1	4.5
Negotiation SS	0	0.0	0	0.0	14	32.6	18	41.9	11	25.6
Many	0	0.0	5	7.4	29	42.6	30	44.1	4	5.9
Total	11	1.0	100	9.1	444	40.6	456	41.7	82	7.5

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 [10] 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%). As will be discussed below, 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 [64] approach of separating inquiry into positivist, interpretivist, and critical social science paradigms is well accepted in IS research. Consistent with other literature analyses [15,35], Table 3 shows the empirical papers in the sample coded for research paradigm. 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 [13,39,67]. 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 IS research from 1991 to 2001 reported that 81% of papers had a positivist orientation with 19% using an interpretivist approach [15]. We found no paper that used a critical theory approach. DSS research is more dominated by positivism than general IS research. Table 3 shows that 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.

Not shown in Table 3 is the relationship between journal origin and research paradigm. 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 IS research, US DSS research is more positivist than US IS research and European DSS research is more interpretivist than European IS research.

Table 4 shows that around one-third (33.6%) of DSS research is non-empirical, with two-thirds (66.4%)

Table 3
DSS types by research paradigm

DSS Type	Positivist		Interpretivist		Mixed		Total No of articles
	No of articles	% of type	No of articles	% of type	No of articles	% of type	
Personal DSS	250	96.5	8	3.1	1	0.4	259
Group Support Systems	204	88.3	27	11.7	0	0.0	231
Enterprise Reporting & Analysis	50	83.3	10	16.7	0	0.0	60
Data Warehouse	11	78.6	3	21.4	0	0.0	14
Intelligent DSS	86	98.9	1	1.1	0	0.0	87
Knowledge Mgt-based DSS	14	82.4	3	17.6	0	0.0	17
Negotiation Support Systems	17	94.4	1	5.6	0	0.0	18
Many	31	96.9	1	3.1	0	0.0	32
Total	663	92.3	54	7.5	1	0.1	718

empirical. Chen and Hirschheim's [15] analysis of overall IS research (in a literature review of 1893 IS papers) reported a different split between non-empirical (40%) and empirical (60%) research. This means that DSS research has significantly ($p<0.05$) more empirical research than general IS. It is noteworthy that 21% of papers fall into the empirical-objects categories. 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 organisational problems" [[39], p.77]. March and Smith [51] clearly draw the distinction between natural and design science: "Whereas natural science tries to understand reality, design science attempts to create things that serve human purposes" [p.253]. Because of the significant design science research experience evident in Table 4, DSS researchers have much to offer the current debate on IS design science methodologies; it may be one of the most significant contributions that DSS can make to its parent discipline.

Cross-tabulating the type of research with practical relevance shows that case studies have the highest proportion of articles with a high or very high assessment (35.9%), design science is next with 17.7%, with natural science style research (experiments, field studies, surveys, simulations) at 9.6%.

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 focussing 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. Table 5 shows 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

Table 4
Sample by article type

Article type			Number of papers	%
Non-empirical (33.6%)	Conceptual orientation (13.7%)	DSS frameworks	51	4.7
		Conceptual models	28	2.6
		Conceptual overview	48	4.4
		Theory	22	2.0
	Illustrative (14.0%)	Opinion and example	22	2.0
		Opinion and personal experience	5	0.5
		Tools, techniques, methods, model applications	126	11.5
	Applied concepts (5.9%)	Conceptual frameworks and their application	65	5.9
Empirical (66.4%)	Objects (21.0%)	Description of type or class of product, technology, systems etc.	36	3.3
		Description of specific application, system etc.	194	17.7
	Events/processes (45.4%)	Lab experiment	204	18.7
		Field experiment	19	1.7
		Field study	36	3.3
		Positivist case study	58	5.3
		Interpretivist case study	39	3.6
		Action research	4	0.4
		Survey	73	6.7
		Development of DSS instrument	4	0.4
		Secondary data	26	2.4
		Simulation	33	3.0

Table 5
Number of cited judgement and decision-making references by DSS type

Type of DSS	No of Articles	Citation Mean	Citation Standard Deviation	Citation Median
Personal DSS	389	2.15	3.72	0.00
Group Support Systems	319	2.62	3.15	2.00
Enterprise Reporting & Analysis	76	1.55	2.84	0.00
Data Warehouse	16	0.00	0.00	0.00
Intelligent DSS	160	0.73	1.61	0.00
Knowledge Management Based DSS	22	1.82	3.11	0.00
Negotiation Support Systems	43	2.33	2.61	1.00
Many	68	2.71	4.68	1.00
Total	1093	2.04	3.31	1.00

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 [74]. It may be more difficult to find models of behaviour to inform research in these DSS types.

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

One of the key contemporary debates in the IS discipline is the role of the IT artifact in IS research. How close should the research constructs that we use be to an IT-based system? Orlikowski and Iacono [68] argued that theorizing about IT artifacts should be at the core of IS research projects. Benbasat and Zmud [11] supported this view and argued that IS 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 [4], while subscribing to many of Benbasat and Zmud's recommendations, argue that IS research should also focus on the transformational aspects of IT in organizations. Essentially, Benbasat and Zmud present a micro view of IS research and Argarwal and Lucas, a macro focus.

Table 6 shows that DSS research has embraced both micro and macro IS 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. Table 6 also shows that the two micro focuses on the IT artifact have declined in article numbers significantly ($p<0.01$) 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

Table 7 provides an overview of 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 IS 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

Table 6
Sample by decision support focus

Decision support focus	1990–1994		1995–1999		2000–2004		Total	
	No of articles	% of period	No of articles	% of period	No of articles	% of period	No of articles	% of sample
Systems Development	87	23.0	100	23.7	49	16.7	236	21.6
Information Technology	101	26.7	101	23.9	47	16.0	249	22.8
Decision Outcome/Org Impact	43	11.4	73	17.3	93	31.7	209	19.1
Decision-making Process	79	20.9	72	17.1	53	18.1	204	18.7
Many	58	15.3	70	16.6	42	14.3	170	15.6
Unclear	10	2.6	6	1.4	9	3.1	25	2.3
Total	378	100.0	422	100.0	293	100.0	1093	100.0

Table 7
DSS funding over time

Period	Some major competitive grant funding		Some industry grant funding		Internal university grant funding only		No grant funding	
	No of papers	% of period	No of papers	% of period	No of papers	% of period	No of papers	% of period
1990–1994	56	14.8	32	8.5	45	11.9	277	73.3
1995–1999	61	14.4	14	3.3	33	7.8	328	77.7
2000–2004	47	16.0	9	3.1	21	7.2	225	76.8
Total	164	15.0	55	5.0	99	9.1	830	75.9

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, Table 7 shows that 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 or tension 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.

Table 8 shows that around 35 years after the birth of the field, Personal DSS, one of the oldest types of DSS, still dominates the agenda of researchers. This is not to say that the PDSS of 1980 or 1990 are the PDSS of 2004. 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. Table 8 also shows 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.

A serious concern that stands out in Table 8 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

Table 8
Papers by DSS type over time

DSS type	1990–1994		1995–1999		2000–2004		Total	
	No of articles	% of period	No of articles	% of period	No of articles	% of period	No of articles	% of sample
Personal DSS	145	38.4	149	35.3	95	32.4	389	35.6
Group Support Systems	108	28.6	126	29.8	85	29.0	319	29.2
Enterprise Reporting & Analysis	27	7.1	32	7.6	17	5.8	76	7.0
Data Warehouse	0	0.0	2	0.5	14	5.0	16	1.5
Intelligent DSS	63	16.7	61	14.4	36	12.3	160	14.6
Knowledge Mgt-based DSS	3	0.8	6	1.4	13	4.4	22	2.0
Negotiation Support Systems	5	1.3	18	4.3	20	6.8	43	3.9
Many	27	7.1	28	6.6	13	4.4	68	6.2
Total	378	100.0	422	100.0	293	100.0	1093	100.0

distribution cannot be explained by novelty as they have been mainstream in practice for some time [21,46,62], 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 [56]. IDC, another commercial research firm, believes that DW and BI are central to contemporary IT investment and will remain so for some time [59]. Even allowing for serious overestimation by the CIOs and the commercial researchers, the distribution of papers in Table 8 shows 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.

A noticeable trend in Table 8 is 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 IS 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 IS, specialist IS, 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 IS 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 IS '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 IS scholarship is much less, both absolutely and relatively, than in US scholarship.

3.8. Key Issue 8 — discipline coherence

Hirschheim and Klein [40], in a critical analysis of the state of the IS, argue that fragmentation is "the root cause of the field's potential crisis" (p. 11). Arnott and Pervan [6], using an historical analysis, characterized DSS as a set of sub-fields partially connected by their

Table 9
Article sample by journal level and type

	No of DSS articles published	Total no of articles published	DSS articles as a percentage of published articles
'A' Journals	756	5033	15.0
'Other' Journals	337	2151	15.7
General IS 'A' Journals	653	2561	25.5
General IS 'A' Journals except *DSS*	187	1704	11.0
General IS 'Other' Journals	114	1605	9.0
General IS US 'A' Journals	614	2030	30.2
General IS US 'Other' Journals	98	818	12.0
General IS Europe 'A' Journals	39	531	7.3
General IS Europe 'Other' Journals	46	787	5.8

desire to provide ways of supporting decision makers. The "partially connected" descriptor hints at a field that may not be as coherent as may be imagined. One way of determining the coherence of a field is to see if researchers use a common or similar body of theory to inform their work. Table 10 shows the top five judgement and decision-making reference articles for each DSS type (using the selection logic outlined under Key Issue 3). 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 modelling and database design rather than in judgement and decision-making. Another interesting observation is the integrating nature of Simon's behavioural 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 Warehousing.

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 GroupSystems software). However, this may represent an opportunity to further integrate these products with appropriate decision-making methods and tools.

Table 10
Key reference articles per DSS type

DSS type	Key reference articles — frequency
Personal DSS	1. Simon [81] — 30
(389 papers, 828 references)	2. Newell & Simon [65] — 22
	3. Keeney & Raiffa [45] — 17
	4. Tversky & Kahneman [84], Mintzberg et al. [58] — 15
Group Support Systems	1. DeSanctis & Gallupe [20] — 82
(319 papers, 834 references)	2. McGrath [53] — 35
	3. Daft & Lengel [17] — 19
	4. Nunamaker et al. [66] — 16
	5. Steiner [82] — 15
Enterprise Reporting & Analysis	1. Mintzberg [57], Isenberg [43] — 5
(76 papers, 117 references)	3. Newell & Simon [69], Simon [80], Mintzberg et al. [58], Cyert & March [16] — 4
Data Warehouse	No key references
(16 papers, 0 references)	
Intelligent DSS	1. Newell & Simon [69], Saaty [76] — 5
(160 papers, 115 references)	3. Keeney & Raiffa [45] — 4
	4. Simon [81] — 3
KM-based DSS	1. Newell & Simon [69] — 3
(22 papers, 40 references)	2. Simon [81], Mintzberg et al. [58], many others — 1
Negotiation Support Systems	1. Raiffa [75] — 5
(43 papers, 101 references)	2. Shakun [78], Mumpower [60] — 4
	4. DeSanctis & Gallupe [20] — 3
	5. McGrath [53], Daft & Lengel [17], many others — 2

4. Conclusion, limitations and future research

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 [85] 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 11.

Table 11
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 judgement 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 judgement 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	The 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 sub-fields.

4.1. Suggestions for improving DSS research

Our suggestions for improving DSS research are framed by a long-term issue in IS research: the tension between academic rigor and professional relevance [3,4,10,15,29,44]. For most of our analysis period the emphasis of IS research has been on achieving rigor. This emphasis was appropriate for a new discipline and much has been written about the need for IS to be accepted as a valid discipline in universities. Benbasat and Zmud [10] argue that the IS discipline is now relatively mature and it "can afford to shift attention to relevance without undue concern about being criticised by others…" (p. 7). We start this section with suggestions for increasing research relevance because we believe that relevance is the area in most need of improvement.

The first strategy for improving the relevance of DSS research is to increase the number of case studies, especially interpretive case studies. As was discussed in Key Issue 2, case studies are the research papers with the highest proportional relevance scores. Case studies can illuminate areas of contemporary practice in ways that studies such as laboratory experiments and surveys cannot [14,23]. A field that is as removed from practice as is evident from the analysis of Table 2 needs case study work to ensure that the questions it is addressing are both relevant and important. Researchers need to select problems with a consideration for professional relevance and interest, in addition to considering the recommendations of previous academic research. When considering professional-related problems, researchers need to think about the likely relevance of their work three to five years after the start of a project, a common time period from initiation of a project to publication in a good journal. Lee [48] argues that the dominant positivist approach in IS research has adversely affected the relevance of the field. He argues that interpretive and critical social theory investigations are needed to develop deep understandings of professional practice. Because DSS research is more dominated by positivism than general IS research, Lee's call for broadening the approaches to case study research is particularly important for DSS scholarship. Further, in these new areas, practice can (and perhaps should) lead research and provide opportunities for researchers to inductively build new theories using approaches based on the interpretive and

critical paradigms. Importantly, contemporary case studies can inform DSS education.

By its nature, case study research can build lasting links between academics and senior professionals and executives. This can in turn assist researchers with obtaining funding from industry. Industry funding is essential for two reasons. First, as mentioned above, researchers can no longer rely on non-competitive internal university funds to fully support their research. Further, major competitive grant funding is becoming more difficult to win in many countries. The second reason why industry funding is desirable is that it increases the commitment of all parties to a research project. When an industry partner contributes funds they treat the project more seriously and often researchers have access to more senior personnel than is the case for non-funded projects. The additional pressure to perform that is placed on researchers by accepting industry funding can improve the quality of research. As a result, successfully seeking industry funding is our second strategy for improving DSS research relevance.

The third strategy for improving discipline relevance is the conduct of high quality design science research, for example [19,41,47,55,69]. As was mentioned in the discussion of Key Issue 2, DSS has a long tradition of design science, although the proportion of design science research has been declining. Design science represents a significant escalation of industry involvement over case studies and requires different skills in researchers. Importantly, design science has the potential to influence, even lead, industry practice in ways that other research methods can't emulate. Lyytinen [50] identifies two types of relevance—the first is research that is quickly and easily digestible by a CIO, and the second is research that can "elevate and reshape professionals' thinking and actions in a longer perspective" (p. 26). Design science research, when it is properly grounded in relevant high-quality theory, has the potential to achieve the deeper concept of relevance associated with reshaping professional ideas. DSS design science also has the opportunity to embrace non-positivist approaches to design science. The early IS design science papers assumed a positivist stance [51,86]. More recent contributions have added to the understanding of design science. For example, Carlsson [13] proposed a design science method based on critical realism and McKay and Marshall [54] proposed a design science process that extends IS researcher's experience with action research.

A large part of the improvement of DSS research relevance could come from shifting research agendas towards the effective development and deployment of data warehouse and business intelligence systems. This shift may not be as radical as may be first thought. Most of the research problems that are the focus of other DSS types can be made relevant to BI and DW. These problems include development methodology, system usability, organizational impact, technology adoption, project success and failure, project evaluation and approval, and IT governance. The benefits of increased relevance, funding, quality, and professional influence far outweigh the cost of the agenda change.

The second theme in improving DSS research that arises from the analysis in this paper concerns the rigor of our work. While relevance is the theme that needs greatest attention, academic rigor needs to be central to research designs and the average rigor of DSS research needs to be improved. Further, academic rigor is what many professionals value in IS research, particularly when academic studies are compared with commercial research reports and vendor white papers. One indicator of a rigor problem is the field's relatively low success rates in 'A' journals other than *DSS*. The low success rate could be biased by the influence of *Management Science* in the sample. *Management Science* is a multidisciplinary journal that publishes a relatively large number of papers of which only 2.1% are DSS. Another reason why DSS may be underrepresented in 'A' journals is its large proportion of design science research. While design research is prominent in DSS research it is a small part of overall IS research [14]. Minority areas often find it difficult to make headway in 'A' journals. The recent decline in DSS design science publication could be due to researchers changing their research agendas to target projects that will achieve the prestigious publication they need for academic reputation. However, the prospects for design science research in 'A' journals are improving. The specification of quality guidelines for design science research by Hevner et al. [38] is an important step in this improvement. DSS design science research is being published in 'A' journals (for example, Markus, Majchrzak and Gasser [52] in a US 'A' journal, and Arnott [5] in a European 'A' journal). We encourage DSS researchers to maintain their interest in design science. However, this interest will only be successful if that work is rigorous and well executed.

The second element of improving academic rigor identified in the analysis (Key Issues 3 and 8) concerns the theoretical foundations of the field. Around half of the papers in the sample are not founded on judgement and decision-making research, and those that are tend to be based on relatively old references. In general, DSS

research needs to be based on more contemporary behavioural decision theory [for example, [31,32,37]]. Other theoretical aspects of judgement and decision making could be imported from management and related fields to provide a stronger theoretical basis for projects. The current narrow base of reference theory may have acted to overly constrain what projects have been tackled by DSS researchers.

In summary, we suggest that to improve DSS research, researchers should:

1. Undertake more case studies, particularly using an interpretive approach,
2. Continue the design science tradition of the field but pay greater attention to the rigor of projects,
3. Select research problems based on genuine long-term professional relevance,
4. Seek more industry funding for projects,
5. Pay greater attention to the effective development and implementation of data warehouse and business intelligence systems,
6. Update and broaden the theoretical foundations of projects with respect to judgement and decision-making.

4.2. 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.

4.3. Further research

We plan to continue the content analysis of DSS articles and produce a further overall analysis of the field around 2010. Based on the suggestions for improving DSS research made above, two further investigations of the intellectual foundations of DSS are well under way. The first is a critical review of DSS design science research using the guidelines developed by Hevner et al. [38]. The aim of this analysis is to provide prescriptions for improving the rigor and relevance of DSS design science research. The second project is a more detailed analysis of the judgement and decision-making foundations of DSS research with a special emphasis on the role of Simon's theory of behavioral decision-making has played in shaping the field. A third project that we wish to pursue is to investigate the management and organization theory foundations of DSS research.

Acknowledgements

We thank Gemma Dodson for her research assistance on the project especially in sourcing the papers and her contribution to the article coding. The comments and suggestions of the four anonymous reviewers significantly improved the paper. The research was supported by a Curtin University visiting professorship and a Monash University visiting fellowship.

Appendix A. Article coding protocol

Research type

R1. Dominant Research Stage:	Theory Building	Theory Testing		Theory Refinement	Unclear	
	1	2		3	4	
R2. Epistemology:	Positivist	Interpretivist	Critical	Mixed	Unclear	N/A
	1	2	3	4	5	6
R3. Article Type (coded according to Table 4)						
R4. Comments:						
R5. Did the paper acknowledge the support of a formal grant? Yes No						
R6. If yes, was it:						
Major Competitive	University	Industry	MC&U	MC&I	U&I	All 3
1	2	3	4	5	6	7

DSS factors

D1. What type of DSS is the paper addressing?	
1. Personal DSS (includes modelling and analytics)	2. Group support systems
3. EIS, BI, OLAP, and enterprise wide reporting	4. Data warehouse (includes data marts)
5. Intelligent DSS (includes knowledge-based DSS)	6. Knowledge management-based DSS
7. Many	8. Negotiation support systems
D2. What organizational level is addressed?	
1. Individual	2. Small number of independent managers
3. Group	4. Department
5. Division	6. Organization
7. Unclear	
D3. What is the decision support focus of the paper?	
1. Development	2. Technology
3. Decision outcome/organizational impact	4. Decision process
5. Many	6. Unclear
D4. What is the practical relevance of the paper?	
1. Very High	2. High
3. Medium	4. Low
5. None	
D5. Comments:	

Judgement and decision-making factors

J1. Who is the primary client?						
	Executive 1	Non-executive Manager 2	Professional 3	Other 4	Unclear 5	
J2. What is the primary user's functional area?					Unclear	
J3. Who is the primary user?						
	Executive 1	Non-executive Manager 2	Professional 3	Other 4	Unclear 5	Many 6
J4. Is judgement and decision-making reference research cited?	Yes	No				
J5. If cited what reference theories? (author/date citations)						
What general approach to decision-making is used?						
J6.	Descriptive 1	Prescriptive 2	Unclear 3			
J7.	Economic 1	Behavioural 2	Both 3	Unclear 4		
J8. Is a phase model of decision-making used? Yes No						
J9.If yes, then which						
J10. Comments:						

References

[1] M. Alavi, P. Carlson, A review of MIS research and disciplinary development, Journal Management Information Systems 8 (4) (1992) 45–62.

[2] M. Alavi, E.A. Joachimsthaler, Revisiting DSS Implementation research: a meta-analysis of the literature and suggestions for researchers, MIS Quarterly 16 (1) (1992) 95–116.

[3] L.M. Applegate, J.L. King, Rigor and relevance: careers on line, MIS Quarterly 23 (1) (1999) 17–18.

[4] R. Argarwal, H.C. Lucas Jr., The information systems identity crisis: Focussing on high-visibility and high-impact research, MIS Quarterly 29 (3) (2005) 381–398.

[5] D. Arnott, Cognitive biases and decision support systems development: a design science approach, Information Systems Journal 16 (1) (2006) 55–78.

[6] D. Arnott, G. Pervan, A critical analysis of decision support systems research, Journal of Information Technology 20 (2) (2005) 67–87.

[7] D. Arnott, G. Pervan, G. Dodson, Who pays for decision support systems research? Review, directions and issues, Communications of the Association for Information Systems 16 (2005) 356–380.

[8] D. Arnott, G. Pervan, G. Dodson, A descriptive analysis of decision support systems research from 1990 to 2003, Australian Journal of Information Systems 12 (2) (2005) 178–191.

[9] I. Benbasat, B. Nault, An evaluation of empirical research in managerial support systems, Decision Support Systems 6 (1990) 203–226.

[10] I. Benbasat, R.W. Zmud, Empirical research in information systems: the practice of relevance, MIS Quarterly 23 (1) (1999) 3–16.

[11] I. Benbasat, R.W. Zmud, The identity crisis within the IS discipline: defining and communicating the discipline's core properties, MIS Quarterly 27 (2) (2003) 183–194.

[12] R. Benbuman-Filch, S.R. Hiltz, M. Turoff, A comparative content analysis of face-to-face vs. asynchronous decision making, Decision Support Systems 34 (4) (2002) 457–469.

[13] S.A. Carlsson, Towards and information systems design research framework: a critical realist perspective, Proceedings of the First

International Conference on Design Science in Information Systems and Technology (DERIST 2006), Claremont CA, 2006.
[14] A.L.M. Cavaye, Case study research: a multi-faceted research approach for IS, Information Systems Journal 6 (1996) 227–242.
[15] W.S. Chen, R. Hirschheim, A paradigmatic and methodological examination of information systems research from 1991 to 2001, Information Systems Journal 14 (2004) 197–235.
[16] R.M. Cyert, J.G. March, A Behavioral Theory of the Firm, Prentice–Hall, New York, 1963.
[17] R.L. Daft, R.H. Lengel, Organizational information requirements, media richness and structural design, Management Science 32 (5) (1986) 554–571.
[18] A. Datta, H. Thomas, The cube data model: a conceptual model and algebra for on-line analytical processing in data warehouses, Decision Support Systems 27 (3) (1999) 289–301.
[19] A.R. Dennis, T.A. Carte, G.G. Kelly, Breaking the rules: success and failure in groupware-supported business process reengineering, Decision Support Systems 36 (1) (2003) 31–47.
[20] G. DeSanctis, R.B. Gallupe, A foundation for the study of group decision support systems, Management Science 33 (5) (1987) 589–609.
[21] B.A. Devlin, P.T. Murphy, An architecture for a business and information system, IBM Systems Journal 27 (1) (1988) 60–81.
[22] G. Dodson, D. Arnott, G. Pervan, The client and user in decision support systems: review and research agenda, Proceedings of CIDMDS2006 (IFIP WG 8.3 Working Conference), IFIP/ London School of Economics, 2006.
[23] K.M. Eisenhart, Building theories from case study research, Academy of Management Review 14 (1989) 532–550.
[24] S.B. Eom, Decision support systems research: reference disciplines and a cumulative tradition, omega, International Journal of Management Science 23 (5) (1995) 511–523.
[25] S.B. Eom, Mapping the intellectual structure of research in decision support systems through author cocitation analysis (1971–1993), Decision Support Systems 16 (4) (1996) 315–338.
[26] S.B. Eom, Decision support systems research: current state and trends, Industrial Management and Data Systems 99 (5) (1999) 213–220.
[27] S.B. Eom, S.M. Lee, A survey of decision support system applications (1971–1988), Interfaces 20 (1990) 65–79.
[28] S.B. Eom, S.M. Lee, Leading universities and most influential contributors in DSS research: a citation analysis, Decision Support Systems 9 (3) (1993) 237–244.
[29] R.D. Galliers, Relevance and rigour in information systems research: some personal reflections on issues facing the information systems research community, in: B.C. Glasson, I.T. Hawryszkiewycz, B.A. Underwood, R. Weber (Eds.), Business Process Re-Engineering: Information Systems Opportunities and Challenges, Elsevier North-Holland, Amsterdam, 1994, pp. 93–101.
[30] R.D. Galliers, M. Meadows, A discipline divided: globalization and parochialism in information systems researcht, Communications of the Association for Information Systems 11 (2003) 108–117.
[31] G. Gigerenzer, R. Selten (Eds.), Bounded Rationality: The Adaptive Toolbox, MIT Press, Cambridge, MA, 2001.
[32] G. Gigerenzer, Adaptive Thinking: Rationality in the Real World, Oxford University Press, New York, 2000.
[33] M.L. Gillenson, J.D. Stutz, Academic issues in MIS: journals and books, MIS Quarterly 15 (4) (1991) 447–452.
[34] C. Graham, Business Intelligence Software Market Grows by 12% (Gartner Research Report ID. G00130216), Gartner Inc, Stamford, CT, 2005.
[35] Z. Guo, J. Sheffield, A paradigmatic and methodological examination of KM research: 2000 to 2004, Proceedings of the 39th Hawaii International Conference on System Sciences, IEEE, 2006.
[36] B.C. Hardgrave, K.A. Walstrom, Forums for MIS scholars, Communications of the ACM 40 (11) (1997) 119–124.
[37] R. Hastie, R.M. Dawes, Rational Choice in an Uncertain World, Sage, Thousand Oaks, CA, 2001.
[38] A.R. Hevner, S.T. March, J. Park, S. Ram, Design science in information systems research, MIS Quarterly 28 (1) (2004) 75–106.
[39] R. Hirschheim, Information systems epistemology: a historical perspective, in: R. Galliers (Ed.), Information systems research: Issues, methods and practical guidelines, Blackwell Scientific Publications, Oxford, 1992, pp. 28–60.
[40] R. Hirschheim, H. Klein, Crisis in the IS field? A critical reflection on the state of the discipline, Journal of the Association for Information Systems 4 (5) (2003) 237–293.
[41] C.W. Holsapple, R. Pakath, V.S. Jacob, J.S. Zaveri, Learning by problem processors: adaptive decision support systems, Decision Support Systems 10 (2) (1993) 85–108.
[42] C. Holsapple, L. Johnson, H. Manakyan, J. Tanner, Business computing research journals: a normalized citation analysis, Journal of Management Information Systems 11 (1) (1994) 131–140.
[43] D.J. Isenberg, How senior managers think, Harvard Business Review 84 (6) (1984) 81–90.
[44] P. Keen, Relevance and rigor in information systems research: improving quality, confidence, cohesion, and impact, in: H.E. Nissen, H.K. Klein, R. Hirschheim (Eds.), Information Systems Research: Contemporary Approaches and Emergent Traditions, North Holland, Amsterdam, 1991, pp. 27–49.
[45] R.L. Keeney, H. Raiffa, Decision with Multiple Objectives, John Wiley, New York, 1976.
[46] R. Kimball, The Data Warehousing Toolkit, John Wiley and Sons, New York, 1996.
[47] K.-Y. Kwahk, Supporting business process design using cognitive maps, Decision Support Systems 25 (2) (1999) 155–178.
[48] A.S. Lee, Rigor and relevance in MIS research: beyond the approach of positivism alone, MIS Quarterly 23 (1) (1999) 29–34.
[49] P.B. Lowry, D. Romans, A. Curtis, Global journal prestige and supporting disciplines: a scientometic study of information systems journals, Journal of the Association for Information Systems 5 (2) (2004) 29–77.
[50] K. Lyytinen, Empirical research in information systems: on the relevance of practice in thinking of IS research, MIS Quarterly 23 (1) (1999) 25–28.
[51] S. March, G.F. Smith, Design & natural science research on information technology, Decision Support Systems 15 (1995) 251–266.
[52] M.L. Markus, A. Majchrzak, L. Gasser, A design theory for systems that support emergent knowledge processes, MIS Quarterly 26 (3) (2002) 179–212.
[53] J.E. McGrath, Groups: Interaction and Performance, Prentice–Hall, New Jersey, 1984.
[54] J. McKay, P. Marshall, A review of design science in information systems, Proceedings of the 16th Australasian Conference on Information Systems and Technology (ACIS 2005), Sydney Australia, 2005.
[55] W. Michalowski, S. Rubin, R. Slowinski, S. Wilk, Mobile clinical support for pediatric emergencies, Decision Support Systems 36 (2) (2003) 161–176.
[56] K. Mills, Raiding the data bank, The Australian IT Business, October 16, 2004, pp. 1–4.

[57] H. Mintzberg, The Nature of Managerial Work, Prentice–Hall, Englewood Cliffs, NJ, 1973.
[58] H. Mintzberg, D. Raisinghani, A. Theoret, The structure of "unstructured" decision processes, Administrative Science Quarterly 21 (6) (1976) 246–275.
[59] H.D. Morris, S. Graham, P. Andersen, K.D. Moser, M. Carr, R. Blumstein, D. Vesset, N. Martinez, Financial impact of business analytics: the key findings, IDC White Paper (January, 23, 2003).
[60] J. Mumpower, The judgement policies of negotiators and the structure of negotiation problems, Management Science 37 (1991) 1304–1324.
[61] N.A. Mylonopoulos, V. Theoharakis, On-site: global perceptions of IS journals, Communications of the ACM 44 (9) (2001) 29–33.
[62] NCR, How to build a data warehouse, Data Warehousing Workshop: Module 4. (Course notes), NCR Corporation, 1998.
[63] R.R. Nelson, P.A. Todd, B.H. Wixom, Antecedents of information and system quality: an empirical examination within the context of data warehousing, Journal of Management Information Systems 21 (4) (2005) 199–235.
[64] W.L. Neuman, Social Research Methods: Qualitative and Quantitative Approaches, Fourth edition, Allyn and Bacon, Needham Heights, MA, 2000.
[65] A. Newell, H.A. Simon, Human Problem Solving, Prentice Hall, Englewood Cliffs, NJ, 1972.
[66] J.F. Nunamaker Jr., A.R. Dennis, J.S. Valacich, D.R. Vogel, J.F. George, Electronic meeting systems to support group work, Communications of the ACM 34 (7) (1991) 40–61.
[67] W.J. Orlikowski, J.J. Baroudi, Studying information technology in organizations: research approaches and assumptions, Information Systems Research 2 (1991) 1–28.
[68] W.J. Orlikowski, C.S. Iacono, Research commentary: desperately seeking the "IT" in IT research — a call to theorizing the IT artifact, Information Systems Research 12 (2001) 121–134.
[69] M. Paolucci, R. Sacile, A. Boccalatte, Allocating crude oil supply to port and refinery tanks: a simulation-based decision support system, Decision Support Systems 33 (1) (2002) 39–54.
[70] G.P. Pervan, A review of research in group support systems: leaders, approaches and directions, Decision Support Systems 23 (2) (1998) 149–159.
[71] G. Pervan, D. Arnott, Research in data warehousing and business intelligence: 1990 to 2004, Proceedings of CIDMDS2006 (IFIP WG 8.3 Working Conference), IFIP/London School of Economics, 2006.
[72] G. Pervan, D. Arnott, G. Dodson, Trends in the study of group support systems, Proceedings of Group Decision and Negotiation 2005, Vienna, Austria: INFORMS/University of Vienna, 2005.
[73] P.L. Powell, J.E.V. Johnson, Gender and DSS design, Decision Support Systems 14 (1) (1995) 27–58.
[74] R. Price, G. Shanks, A semiotic information quality framework: development and comparative analysis, Journal of Information Technology 20 (2005) 80–102.
[75] H. Raiffa, The Art and Science of Negotiation, Harvard University Press, Cambridge, MA, 1982.
[76] T.L. Saaty, The Analytic Hierarchy Process, McGraw–Hill, New York, 1980.
[77] R. Santhanam, T. Guimaraes, J. George, An empirical investigation of ODSS impact on individuals and organizations, Decision Support Systems 30 (1) (2000) 51–72.
[78] M.F. Shakun, Evolutionary Systems Design: Policy Making Under Complexity and Group Decision Support Systems, Holden-Day, Oakland, CA, 1988.
[79] J.P. Shim, M. Warkentin, J.F. Courtney, D.J. Power, R. Sharda, C. Carlsson, Past, present, and future of decision support technology, Decision Support Systems 33 (2) (2002) 111–126.
[80] H. Simon, Models of Man, Wiley, New York, 1957.
[81] H.A. Simon, The New Science of Management Decision (rev. ed.), Prentice–Hall, Englewood Cliffs, NJ, 1977 (Original work published 1960).
[82] I.D. Steiner, Group Process and Productivity, Academic Press, New York, 1972.
[83] E.A. Stohr, B.R. Konsynski (Eds.), Information Systems and Decision Processes, IEEE Computer Society Press, Los Alamitos, CA, 1992.
[84] A. Tversky, D. Kahneman, Judgment under uncertainty: Heuristics and biases, Science 185 (September 1974) 1124–1131.
[85] A. Tversky, D. Kahneman, The framing of decisions and the psychology of choice, Science 211 (January (1981) 453–458.
[86] J.G. Walls, G.R. Widmeyer, O.A. El Sawy, Building an information systems design theory for vigilant EIS, Information Systems Research 3 (1) (1992) 36–59.
[87] K.A. Walstrom, B.C. Hardgrave, R.L. Wilson, Forums for Management Information Systems scholars, Communications of the ACM 38 (3) (1995) 93–107.
[88] J. Webster, R.T. Watson, Analyzing the past to prepare for the future: writing a literature review, MIS Quarterly 26 (2) (2002) xiii–xxiii.
[89] M.E. Whitman, A.R. Hendrickson, A.M. Townsend, Research commentary. Academic rewards for teaching, research and service: data and discourse, Information Systems Research 10 (2) (1999) 99–109.

David Arnott is Professor of Information Systems at Monash University, Melbourne, Australia and Director of Monash's Centre for Decision Support and Enterprise Systems Research. His current research areas include the development of IT-based systems for managers, business intelligence, data warehousing and IT governance. He is the author of more than 60 scientific papers in the decision support area, including papers in journals such as the *European Journal of Information Systems*, *Information Systems Journal*, *Decision Support Systems* and the *Journal of Information Technology.*

Graham Pervan is the Dean, R&D, at Curtin Business School, and has over 30 years experience in education, research, and practice in Information Systems and Information Technology (IS/IT). He has published on various IS/IT issues in journals including Communications of the AIS, Decision Support Systems, Information and Management, International Journal of Medical Informatics, and Journal of Information Technology.