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ABSTRACT

In many respects, the decision making capability/promise of information technology has gone unfulfilled. In fact, many organizations have not advanced much past spreadsheets when it comes to computerized decision making assistance. This research attempts to examine why this is the case, and looks to the future by asking the questions "What's the next spreadsheet? Is there a next killer app for intelligent systems/DSS?" Fifty-eight business professionals were surveyed to assist in answering these questions. Results suggest that while the spreadsheet is still by far the most used intelligent system, continuing improvements in the ease of use of information technology are helping to allow some organizations to begin to easily test and use newer DSS technologies. As additional organizations then begin to understand the purpose and usefulness of these newer technologies, their long term impact could be substantial. Statistical results suggest that Knowledge Management and GDSS technologies have the best chance in the near term to equal the impact of spreadsheets.

INTRODUCTION

Advances in information technology continue at a remarkable pace, yet many questions remain concerning the fulfillment of the promise that technology would dramatically assist humans' decision making processes (Adam, et al., 1998; Aggarwal and Mirani, 1999; Chari et al., 1998; Courtney, 2001; Sen, 1998; Shim et al., 2002). While operational and transaction processing systems are reaching the point of stability, even commoditization, systems which could be deemed "intelligent" are much more difficult to identify in operating organizations (Carlsson, 1985; Downing and Ringuest, 2002; Kim and Burns, 1998; Lang and Whinston, 1999; Kivijärvi, 1997; McHaney and Douglas, 1997; Shim et al., 2002; Subramanian and Yen, 1997; Vahidov and Elrod, 1999; Zhang and Wang, 1998).

Gorry and Morton (1971) first illuminated the promise of decision making assistance in 1971 with the coining of the acronym "DSS", for "Decision Support System". Such a system was described as one which would interact with the user to help with decision making, rather than simply store or quickly calculate data. Such an idea was revolutionary at the time, and the advent of the personal computer and the spreadsheet in the early 1980s made the authors seem like brilliant prophets. The PC spreadsheet

allowed any individual to perform complex computational "what if" analysis quickly and easily. More than twenty years later, the spreadsheet remains an important decision making tool in nearly every organization (Chiasson and Lovato, 2001; Fazlollahi and Vahidov, 2001; Forgionne, 1999). While such ubiquity and usefulness is certainly a desirable and positive result, twenty years in technology time is a lifetime, and the question remains: What technological innovation has had or will have an equivalent impact on organizational decision making?

BACKGROUND AND CENTRAL QUESTION

A review of the literature suggests that no technological decision making aid surpasses the widespread usage of spreadsheets in organizations (see, e.g., Downing and Ringuest, 2002; Gregg, 1999; Gregg et al., 2002; Gundersen et al., 1995; Kivijärvi, 1997; Shim et al., 2002; Todd and Benbasat, 1999; Turban and Aronson, 2001). While many interesting and useful innovations have been put forth and are in fact in use in some organizations, seemingly no "killer app" has emerged in the decision making arena (Adam et al., 1998; Karim et al., 1998; Turban and Aronson, 2001).

A brief description of the newer decision technologies is useful here. Table 1 presents an enumeration of those technologies with an explanation and example of each.

Decision Technology	Simple Definition	Example
AI – "Artificial Intelligence"	Computer systems which mimic human thought.	Chess program.
ANN – "Artificial Neural Network"	Computer systems which mimic human learning.	Stock market predictors.
Data Mining	Computer systems which exhaustively scan data for patterns or relationships unhypothesized by humans.	Companies have learned that "Sales of Beer" and "Sales of Diapers" are correlated.
Data Warehousing	Large database of "clean", batch updated corporate data. Supports Data Mining and OLAP.	Sales data.
DSS – "Decision Support System"	Any interactive, ad-hoc, user-driven "what if" computer system. Increasingly becoming synonymous with "spreadsheet".	Forecasting spreadsheet.

EIS – "Executive Information System", ESS – "Executive Support System"	DSS for executives. Primary difference from DSS is the sensitivity of the data (e.g., employee compensation) and the overview / summary nature of the interface (usually no more than one page).	System to assist with employee promotion decisions.
ES – "Expert System"	System which follows explicit, stable rules to give a user a specific "diagnosis" or decision.	Systems which give a medical diagnosis given certain patient symptoms.
Groupware, GDSS – "Group Decision Support Systems", GSS – "Group Support Systems"	Distributed systems which aggregate users' knowledge and opinions and aid the group in reaching a decision.	Creating a project proposal using Lotus Notes.
Knowledge Leveraging, KM – "Knowledge Management"	Database storage and organization of a group's intellectual property, with efficient search mechanisms to aid members of the group in quickly acquiring and/or distributing proprietary knowledge.	Consultancy's proposal databases.
Modeling and Optimization	Systems which find the best or optimal answer for a quantitatively described problem.	System to determine product mix which maximizes profit.
OLAP – "Online Analytical Processing"	Online DSS or EIS. Systems which allow a user to query a database for complex quantitative patterns or relationships among data. Differs from Data Mining primarily in that it is user-driven.	Online forecasting analysis.

Table 1. Modern Decision Making Technologies

Given all these fancy names and potential beneficial uses, the central question becomes: "Will any of these technologies equal or surpass the decision making impact spreadsheets have had on organizations? Have any already?"

METHODOLOGY AND DATA COLLECTION

To obtain a snapshot of current DSS usage in organizations, and gauge possible future use, an online survey was distributed to 196 business professionals randomly selected across industry groups. Qualitative questioning was used as a follow-up. Fifty-eight individuals completed the survey, for a return rate of 29.6%. The text of the e-mail request for participation appears in Appendix A, and the survey instrument appears in Appendix B. The instrument used was Sanders' (1984) "DSS Success Measure", which was obtained from ISWorld.org. It was used to ask respondents about how spreadsheets aided their decision making and also how other, more advanced intelligent systems aided their decision making. As the instrument was previously tested for both validity and reliability, no further testing was needed for this study. The online version of the instrument was constructed with Visual Studio.NET with a SQL Server backend.

On the survey, in addition to answering questions about spreadsheet decision support, respondents were asked to select the one "other, more advanced intelligent system" which most effectively supported decision making in their organization. Respondents were referred to a table similar to Table 1 for choices for this other intelligent system. When respondents' questionnaires were returned, qualitative comments were sought regarding why they had selected this particular system and what benefits and future promise the system offered.

RESULTS

Results of the survey appear in Tables 2 and 3. DSS and EIS have become synonymous with "spreadsheet" (see Table 1), and as such they are the focus of comparison in the survey. None of the 58 respondents listed "AI – Artificial Intelligence" or "ANN – Artificial Neural Network" as their information system other than a spreadsheet which they used for decision making. Therefore, AI and ANN do not appear in Tables 2 and 3. Note that the numbers in each box in Tables 2 and 3 are averages for the 58 respondents, with "1" being "Strongly Agree" and "5" being "Strongly Disagree".

Survey Question	All n=58	Data Mining n=8	ES n=6	GDSS n=9	KM n=13	Modeling n=9	OLAP n=13
1. I have become dependent on this system for decision making.	**DSS wins 2.26 to 3.50** t Stat = -7.2 (p<.000)	DSS Wins: 2.88 to 4.00	DSS Wins: 1.83 to 2.67	DSS Wins: 2.33 to 3.56	DSS Wins: 2.62 to 3.23	DSS Wins: 1.67 to 3.67	DSS Wins: 2.08 to 3.69

2. As a result of using this system for decision making, I am seen as more valuable in this organization.	**DSS wins 2.48 to 3.41** t Stat = -5.1 (p<.000)	DSS Wins: 2.38 to 3.12	DSS Wins: 2.83 t=8o 3.17	DSS Wins: 2.22 to 3.11	DSS Wins: 2.46 to 3.62	DSS Wins: 2.22 to 3.56	DSS Wins: 2.77 to 3.62
3. I have come to rely on this system for decision making in performing my job.	**DSS wins 2.41 to 3.33** t Stat = -4.4 (p<.000)	DSS Wins: 2.75 to 3.50	DSS Wins: 2.67 to 4.33	DSS Wins: 1.89 to 3.33	DSS Wins: 2.54 to 3.00	DSS Wins: 2.11 to 3.11	DSS Wins: 2.54 to 3.23
4. All in all I think that this system is important for this organization.	**DSS wins 2.33 to 3.43** t Stat = -6.1 (p<.000)	DSS Wins: 2.12 to 3.62	DSS Wins: 2.33 to 3.33	DSS Wins: 2.67 to 3.33	DSS Wins: 2.62 to 3.31	DSS Wins: 2.00 to 3.33	DSS Wins: 2.15 to 3.62
5. This system is extremely useful.	**DSS wins 2.45 to 3.40** **t Stat** **= -5.7 (p<.000)**	DSS Wins: 2.62 to 3.12	DSS Wins: 2.17 to 3.50	DSS Wins: 2.00 to 3.33	DSS Wins: 2.69 to 3.31	DSS Wins: 2.22 to 3.67	DSS Wins: 2.69 to 3.46
6. I personally benefited from the existence of this system in this organization.	**DSS wins 2.22 to 3.40** t Stat = -7.1 (p<.000)	DSS Wins: 2.00 to 3.62	DSS Wins: 2.33 to 3.50	DSS Wins: 2.22 to 3.56	DSS Wins: 1.92 to 3.08	DSS Wins: 2.89 to 3.22	DSS Wins: 2.15 to 3.54
7. Utilization of this system has enabled me to make better decisions.	**DSS wins 2.48 to 3.21** t Stat	DSS Wins: 2.62 to 3.00	DSS Wins: 2.17 to 3.33	DSS Wins: 3.11 to 3.33	DSS Wins: 2.69 to 3.15	DSS Wins: 2.56 to 3.33	DSS Wins: 1.85 to 3.15

	= -4.2 (p<.000)					

Table 2.   Statistical Comparison of Spreadsheets ("DSS/EIS") vs. Other Decision Making Technologies, Questions 1-7.

Survey Question	All n=58	Data Mining n=8	ES n=6	GDSS n=9	KM n=13	Modeling n=9	OLAP n=13
8. As a result of this system, I am better able to set my priorities in decision making.	**DSS wins 2.40 to 3.12** t Stat = -3.7 (p<.000)	DSS Wins: 2.38 to 3.12	DSS Wins: 2.50 to 3.00	DSS Wins: 2.78 to 3.22	DSS Wins: 1.92 to 2.85	DSS Wins: 2.89 to 3.56	DSS Wins: 2.23 to 3.08
9. Use of data generated by this system has enabled me to present my arguments more convincingly.	**DSS wins 2.41 to 3.59** t Stat = -5.9 (p<.000)	DSS Wins: 2.62 to 2.88	DSS Wins: 2.33 to 3.83	DSS Wins: 2.33 to 3.44	DSS Wins: 2.46 to 3.92	DSS Wins: 2.78 to 4.00	DSS Wins: 2.08 to 3.38
10. This system has improved the quality of decisions I make in this organization.	**DSS wins 2.41 to 3.24** t Stat = -4.3 (p<.000)	DSS Wins: 2.00 to 3.12	DSS Wins: 2.50 to 3.00	DSS Wins: 2.78 to 3.00	DSS Wins: 2.23 to 3.08	DSS Wins: 2.67 to 3.56	DSS Wins: 2.38 to 3.54
11. As a result of this system, the speed at which I analyze decisions has increased.	**DSS wins 2.43 to 3.31** t Stat = -5.4 (p<.000)	DSS Wins: 1.88 to 3.25	DSS Wins: 2.50 to 3.83	DSS Wins: 2.00 to 3.22	DSS Wins: 2.54 to 3.23	DSS Wins: 2.67 to 3.44	DSS Wins: 2.77 to 3.15

12. As a result of this system, more relevant information has been available to me for decision making.	**DSS wins 2.50 to 3.10** t Stat = -3.1 (p<.002)	DSS Wins: 2.88 to 3.00	DSS Wins: 2.67 to 3.33	DSS Wins: 2.44 to 3.22	DSS Wins: 2.92 to 3.15	DSS Wins: 2.22 to 3.00	DSS Wins: 2.00 to 3.00
13. This system has lead me to greater use of analytical aids in my decision making.	**DSS wins 2.45 to 3.47** t Stat = -5.8 (p<.000)	DSS Wins: 2.25 to 3.38	DSS Wins: 2.67 to 3.17	DSS Wins: 2.56 to 3.22	DSS Wins: 2.23 to 3.46	DSS Wins: 2.56 to 3.67	DSS Wins: 2.54 to 3.69
All Questions	**DSS wins 2.40 to 3.35**	**DSS wins 2.41 to 3.29**	**DSS wins 2.42 to 3.38**	**DSS wins 2.41 to 3.30**	**DSS wins 2.45 to 3.26**	**DSS wins 2.42 to 3.47**	**DSS wins 2.33 to 3.40**

Table 3. Statistical Comparison of Spreadsheets ("DSS/EIS") vs. Other Decision Making Technologies, Questions 8-13 and totals.

The first column of Tables 2 and 3 is the survey question itself (with no enumeration for parts "a" and "b"), and the second column shows the comparison between all decision making technologies (the "b" part of each survey question) other than spreadsheets and spreadsheets (the "a" part of each survey question… "DSS"). Given the sample size of 58, the Central Limit theorem applies for this full comparison and a Normal distribution can be assumed. As such, Paired t-testing was used for each of the thirteen questions to compare the means for spreadsheets and the mean for all other decision making technologies. As shown in Tables 2 and 3, spreadsheets had a better (lower, on the 5 point Likert scale) mean for ALL thirteen questions than the other technologies. The t-statistic was no smaller than 3.1 for all questions, and thus the statistical significance of these results is decisive.

The means were also tested separately for each of the other decision making technologies versus spreadsheets ("DSS") and the results are again reported in Tables 2 and 3, beginning in Column 3 and continuing to Column 8. Once again, spreadsheets beat each decision technology for each of the thirteen questions. Given the statistically small sample size for each of the other decision making technologies (see the "n=" sample size indications in Tables 2 and 3), nonparametric statistics (Mann-Whitney) were used to determine significance for Columns 3-8.

While the fact that DSS did so well against ALL other decision making technologies is an interesting result in and of itself, it is also important to note that Knowledge Management technologies did the best as far as being "close" to DSS. The overall Knowledge

Management spread versus DSS was .81. On the other hand OLAP and Modeling technologies were farthest behind DSS, with OLAP having the largest overall difference at 1.07, and Modeling second at 1.05.

DISCUSSION AND CONCLUSIONS

There is evidence from this study that organizations have not advanced much past spreadsheets, as far as computerized decision making assistance is concerned. While it is of course wise to use spreadsheets extensively, it seems possible that organizations have not understood or had the inclination to explore new forms of decision making systems. However, newer, easier to use technologies (e.g., Visual Studio.NET, PHP) seem to be moving organizations to try some new advanced decision support options. The first step is understanding what is available, and how it might be used. The following suggestions are based on the results of this research, and hopefully will help guide organizations as they explore advanced decision making technologies.

Data Mining

Many of the respondents reported using "Data Mining" successfully, but further qualitative questioning revealed that what was really happening was sophisticated searching and querying of their spreadsheets ("DSS") and Access databases. It seems that Data Mining performed so closely to spreadsheets in the survey largely because respondents did not understand what "Data Mining" really means. When the concept was explained to them, it was clear that the eight respondents who reported using Data Mining probably would have chosen another decision making technology as receiving more use. In fact, they noted that constructing and maintaining a "clean", batch-updated Data Warehouse would be time and cost prohibitive, and thus Data Mining in a full form probably had a very small chance of receiving significant attention in their organization in the near future.

ES – "Expert System"

Only six of the fifty-eight respondents to this study's survey reported ES as their "other" decision making technology, and those six did not rate it as being close to spreadsheets as far as being helpful with decision making. Respondents noted that their experience was that the effort involved in getting the expertise quantified and put into the system was often greater than the perceived benefit. Further, even when those tasks were completed, respondents often saw enough of a change in the knowledge domain or the business rules that the ES needed to be reconstructed. Organizations in which such an experience occurred at least once were sufficiently frustrated with ES to cancel or reduce future plans for ES development.

Groupware, GDSS – "Group Decision Support Systems", GSS – "Group Support Systems"

GDSS/GSS functionally received second place status among the "other" decision technologies in the survey as far as being successful in aiding decision making (allowing for the misunderstanding in the definition of Data Mining). Qualitative comments from the respondents indicated that the ubiquity of the Web and corporate networks created this high ranking. In fact, while many of the decisions GDSS was helping with in these organizations were "simple", just connecting disparate parties on an "anytime, anyplace" basis was seen as extremely valuable. Even creating the survey for this study and subsequent data collection was "easy" using Visual Studio.NET (approximately three hours of technical time expended), whereas only five years ago it would have been substantially more complex from a procedural standpoint (and may have been done via "snail mail"). When the decisions being supported over GDSS become more complex, the organizational impact of these systems could explode.

Knowledge Leveraging, "KM" - Knowledge Management

While the margin was small, KM was the overall winner as far as having a chance to compete with spreadsheets in the near future in adding organizational decision making value. Respondents noted that storing and searching for documents was increasingly easy, and organizational members were beginning to see the value and purpose of contributing to the knowledge base. And even when the system was not a recognized, sophisticated "packaged" system (e.g., Lotus Notes), respondents noted that with the increasing ease of development of Web applications and file transfer, storage, and manipulation, "home-grown" systems were also widely used and deemed to be effective. It seems the future is bright for Knowledge Management, and spreadsheets might finally have a decision making competitor.

Modeling and Optimization

Modeling and Optimization were second to last in the survey results among the "other" decision making technologies. Respondents claimed that the complex algorithms used in these systems created an environment in which it was difficult to get organizational support for the systems, and subsequently it was difficult to convince users to learn and use the systems.

OLAP – "Online Analytical Processing"

More and more, in modern, networked organizations, "OLAP" is synonymous with "DSS". This phenomenon is due to the fact that OLAP is simply an ad-hoc, user-driven query of information, *which is done online* (where the client contains little processing power, and the server to which the client is connected is doing the processing). Thus, given that it is increasingly easy for organizations to set up an online environment, OLAP is simply a centralized spreadsheet in many cases. The fact that OLAP finished last among the "other" decision making technologies is therefore somewhat of a surprise.

However, when respondents were pressed as to the differences between their spreadsheet applications and their OLAP applications, they reported that the differences were small, almost indistinguishable. They stated that the only reason that DSS was more helpful than OLAP was because of their local control of the system and not because of any inherent superiority of the system (in fact, they often saw the systems as being equivalent). Therefore, rather than predicting that OLAP *will be* the next spreadsheet, it is the opinion of this researcher that it may *already be* the next spreadsheet, and we may have a case of a redundant acronym as much as anything else. Or at least an acronym which simply reminds us that as the online environment becomes more ubiquitous, OLAP and DSS will merge together in function and use.

Looking at the results in their entirely, spreadsheets remain the most prominent decision making technology in use in organizations today. However, several decision making technologies show promise of equaling or surpassing the organizational impact of spreadsheets in the not-too-distant future, most notably Knowledge Management and GDSS/GSS. Increasing online accessibility and ease of use of Web development tools seem to be driving the surging impact of these technologies.

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APPENDIX A – INTRODUCTORY TEXT FOR E-MAIL SURVEY

You have been randomly selected from an email database of business professionals to be contacted as a possible survey respondent.

Professor <name> of <University> University is studying the future of Intelligent Systems, and would appreciate approximately 15 minutes of your time to complete a thirteen question online survey. The survey is located at the following URL:

http://busetl.business.<university>.edu/<professor>/intelligence/survey.aspx

The survey asks about your experience with computer spreadsheets and other forms of automated decision making assistance. The survey is completely anonymous. Responses will only be reported in aggregate. Should you wish to obtain a copy of the study's results, you may do so by contacting Professor <professor> at <professor email>.

One year after the study all individual response data pertaining to the study will be destroyed.

Your participation in the survey is voluntary. Should you elect to participate, your completion of the survey implies consent to participate in the research. Thank you for your time and hopefully participation.

APPENDIX B – ONLINE SURVEY INSTRUMENT

MIS/DSS Success Measure

Perceived Usefulness

1a. I have become dependent on a spreadsheet for decision making.	Strongly Agree	Agree	Uncertain	Disagree	Strongly Disagree
1b. I have become dependent on an information system other than a spreadsheet for decision making. <name and describe system>	Strongly Agree	Agree	Uncertain	Disagree	Strongly Disagree
2a. As a result of using this spreadsheet for decision making, I am seen as more valuable in this organization.	Strongly Agree	Agree	Uncertain	Disagree	Strongly Disagree
2b. As a result of using this other system for decision making, I am seen as more valuable in this organization.	Strongly Agree	Agree	Uncertain	Disagree	Strongly Disagree
3a. I have come to rely on this spreadsheet for decision making in performing my job.	Strongly Agree	Agree	Uncertain	Disagree	Strongly Disagree
3b. I have come to rely on this other system for decision making in performing my job.	Strongly Agree	Agree	Uncertain	Disagree	Strongly Disagree
4a. All in all I think that this spreadsheet is important for this organization.	Strongly Agree	Agree	Uncertain	Disagree	Strongly Disagree
4b. All in all I think that	Strongly	Agree	Uncertain	Disagree	Strongly

this other system is important for this organization.	Agree				Disagree
5a. This spreadsheet is extremely useful.	Strongly Agree	Agree	Uncertain	Disagree	Strongly Disagree
5b. This other system is extremely useful.	Strongly Agree	Agree	Uncertain	Disagree	Strongly Disagree
6a. I personally benefited from the existence of this spreadsheet in this organization.	Strongly Agree	Agree	Uncertain	Disagree	Strongly Disagree
6a. I personally benefited from the existence of this other system in this organization.	Strongly Agree	Agree	Uncertain	Disagree	Strongly Disagree
Decision Making Satisfaction					
7a. Utilization of this spreadsheet has enabled me to make better decisions.	Strongly Agree	Agree	Uncertain	Disagree	Strongly Disagree
7b. Utilization of this other system has enabled me to make better decisions.	Strongly Agree	Agree	Uncertain	Disagree	Strongly Disagree
8a. As a result of this spreadsheet, I am better able to set my priorities in decision making.	Strongly Agree	Agree	Uncertain	Disagree	Strongly Disagree
8b. As a result of this other	Strongly	Agree	Uncertain	Disagree	Strongly

system, I am better able to set my priorities in decision making.	Agree				Disagree
9a. Use of data generated by this spreadsheet has enabled me to present my arguments more convincingly.	Strongly Agree	Agree	Uncertain	Disagree	Strongly Disagree
9b. Use of data generated by this other system has enabled me to present my arguments more convincingly.	Strongly Agree	Agree	Uncertain	Disagree	Strongly Disagree
10a. This spreadsheet has improved the quality of decisions I make in this organization.	Strongly Agree	Agree	Uncertain	Disagree	Strongly Disagree
10b. This other system has improved the quality of decisions I make in this organization.	Strongly Agree	Agree	Uncertain	Disagree	Strongly Disagree
11a. As a result of this spreadsheet, the speed at which I analyze decisions has increased.	Strongly Agree	Agree	Uncertain	Disagree	Strongly Disagree
11b. As a result of this other system, the speed at which I analyze decisions has increased.	Strongly Agree	Agree	Uncertain	Disagree	Strongly Disagree
12a. As a result of this spreadsheet, more relevant	Strongly Agree	Agree	Uncertain	Disagree	Strongly Disagree

information has been available to me for decision making.				
12b. As a result of this other system, more relevant information has been available to me for decision making.	Strongly Agree	Agree	Uncertain	Disagree	Strongly Disagree
13a. This spreadsheet has lead me to greater use of analytical aids in my decision making.	Strongly Agree	Agree	Uncertain	Disagree	Strongly Disagree
13b. This other system has lead me to greater use of analytical aids in my decision making.	Strongly Agree	Agree	Uncertain	Disagree	Strongly Disagree