Developments In Business Simulation & Experiential Exercises, Volume 17, 1990

THE IMPACT OF DECISION SUPPORT SYSTEMS ON THE EFFECTIVENESS OF SMALL GROUP DECISIONS -REVISITED

John F. Affisco, Hofstra University
Michael N. Chanin - Baruch College, CUNY

ABSTRACT

This paper presents the results of an empirical investigation of the impact of Decision Support Systems on small group decision effectiveness. The study is conducted in the context of the Business Management Laboratory. Two production function modules from Wolfe's Business Management Laboratory Decision Support System (BMLDSS) were utilized to aid decision making by all treatment groups. Results indicate the use of these modules improved decision-making performance in the second year of play as measured by manufacturing costs and Earnings/CGS. Debriefing indicated that two control groups developed informal DSS outside of the laboratory setting. Reanalysis of the performance data with this fact in mind indicated treatment groups' performance was superior to control groups' only for Earnings/CGS in the second year. The results of a questionnaire administration dealing with the subjects' feelings about the DSS are also discussed.

INTRODUCTION

The last decade has been one of continuing development for Decision Support Systems. In their seminal work of 1978, Keen and Scott Morton (1978) forecasted the following accomplishments for Decision Support Systems (DSS): (i) The impact is on decision in which there is sufficient structure for computer and analytic aids to be of value but where manager's judgement is essential; (ii) The payoff is in extending the range and capability of managers' decision processes to help them improve their effectiveness; (iii) The relevance for managers is the creation of a supportive tool, under their own control, which does not attempt to automate the decision process. predefine objectives, or impose solutions. Thus, a basic premise of DSS is that they can improve a decision-maker's effectiveness. Implicit in this line of reasoning is the assumption that the product of man-computer interaction will exceed the sume of its component parts. That is, the man-computer partnership will think and process information in a way not approached by the man or the computer alone.

In the recent past a number of empirical studies aimed at determining whether, in fact, DSS do improve decision making effectiveness have been conducted. The results of these studies are clearly mixed. Thus the need for further research is quite evident. The present study is a continuation of one, documented in Affisco and Chanin (1989), which utilizes free simulation methodology to investigate the impact of DSS on small group decision making.

LITERATURE REVIEW

Shard, Barr, and McDonnell (1988) review the existing; literature on empirical studies of DSS effectiveness. They categorize these studies into four basic approaches: case studies, field tests, field studies, and laboratory studies. The authors conclude that while numerous case and field studies have been conducted, field tests and laboratory experiments are relatively sparse." Thus, the majority of claims regarding the benefits of DSS are based on case and field studies. They view this to be unfortunate since experimental methods allow for greater control and consequently allow for stronger inferences to be drawn. Believing this, they focus their paper on laboratory experimentation. They begin by reviewing the major laboratory studies in the area. For example, some representative studies that are reviewed include Benbasat and Dexter (1982), Goslar, Green, and Hughes (1986), and Cats-Baril and Huber (1987).

Benbasat and Dexter (1982) utilized a multiperiod production decision making game to investigate individual differences in the use of decision support aids. Specifically the study was designed to assess whether decision aids can improve the performance of low analytics in task environments unsuitable for their cognitive style. Subjects were divided into high and low analytic cognitive styles based on scores on the Group Embedded Figures Test. For each cognitive style half of the subjects used a decision aid while the remaining half did not. Results of the study provide support for the notion that appropriate information system design can help overcome a mismatch between task environment and psychological type.

Goslar, Green, and Hughes (1986) (1986) conducted a laboratory study aimed at determining how a specific DSS can assist decision-makers in dealing with ill-structured problems. Forty-three sales and marketing personnel of nineteen middle-to-large regional and national business organizations were subjects of the study. A case was utilized to provide a realistic, ill-structured marketing problem situation. Subjects were randomly divided into six groups, which received treatments based on three independent variables; DSS availability, DSS training, and data level. Contact with the DSS was through trained intermediaries who developed requested applications using IFPS. None of the factors DSS availability, DSS training, or data level significantly affected subjects' decision making confidence, decision making processes, or performance levels.

Cats-Baril and Huber (1987) also conducted an empirical study of the use of DSS for ill-structured problems. Senior business students were faced with a career planning task in which they were required to generate a list of career objectives and prioritize them, develop a list of strategies that would allow them to achieve the most important objectives, and, finally, prioritize these strategies. The study investigated six experimental configurations created by manipulating three system-design characteristics: heuristics, interaction, and computerization. Quality of performance, productivity, satisfaction, and decision-making confidence were measured for each configuration. The major finding of interest is that while the use of heuristics led to better performance, this was so whether the heuristics were implemented by paper and pencil or by computer.

Based on their review Sharda et al (1988) offer two explanations for the pattern of inconsistent results that were observed. First, it is possible that the introduction of a BSS does not generally result in increased decision performance. Or second, methodological limitations and differences between investigations may account for part of the inconsistencies. Assuming the latter to be true, a set of characteristics of these studies which may explain the conflicting results were identified. These include a lack of "hard' (quantitative) measures of decision quality, one-time measurement of performance, and a "black-box" approach to the DSS whereby the subjects had limited understanding of underlying models and were provided with limited capability to do "what-if analyses. Further, the authors noted that only one of the studies focused on group decision-makers. This last point was also made in an article reviewing the present state of DSS research by Henderson (1987) where he concludes that the bast majority of applications research has concentrated on individual decision makers dealing with a single specific task. He suggests that there remains a need for additional empirical studies aimed at determining the effectiveness of DSS and improving existing implementation methodology. A further conclusion is that research directed at small group decision making should be encouraged since little has been done in this area.

In an attempt to address the limitations cited above, Sharda et al (1988) report the results of a free simulation study conducted in the context of The Executive Game. The experimental groups used a financial analysis (DSS, built by the experimenters using the Interactive Financial Planning System (IFPS), for eight quarters of decision making. The control groups made decisions without the support of a DSS. The findings were that the use of the DSS resulted in significantly superior decision making performing based on net earnings. In addition, teams that used the DSS exhibited lower variance in profit performance that the control groups. In terms of subjective data, DSS groups reported that they investigated more alternatives and had greater confidence in their decisions than did non----DSS groups. Interestingly, only during the first three periods did it take the DSS groups longer to reach decisions. This suggestions that there may be a learning effect associated with the use of DSS, benefits may therefore appear after a learning period. Reinforcing this was the finding that a like lagged effect was evident with respect to comparative earnings performance. The authors suggest that the findings of the study indicate that future research should be of a longitudinal nature, and that replication using other designs, decisions tasks, and subjects is required before generalizations of the impact of DSS on decision making performance can be made.

Affisco and Chanin (1989) report the results of a study aimed at replicating the Sharda et al study. This free simulation study was conducted in the context of The Business Management Laboratory. Twenty groups were randomly divided into two six team and one eight team industries across two course sections. Half the teams in each industry were experimental groups while the other half were control groups. Each of the control groups made eight quarterly game decisions in class under the observation of the instructor. These decisions were made without the use of any DSS or any other computer support. In a like manner, treatment groups made the first four quarterly game decisions. After the first year was completed the treatment groups were required to use Wolfe’s (1988) Business Management Laboratory Decision Support System (BMLDSS) to support their second year decisions.

Decision effectiveness related to the use of the BMLDSS was tested by comparing average differences in financial performance variables over the two-year horizon. Specifically, no significant differences could be attributed to the use of the DSS. Further, while satisfaction and confidence scores increased for both the DSS and non---DSS groups over the two years, this improvement was not statistically significant. Data with respect to the number of decision alternatives considered and the amount of data utilized in the decision making process showed no significant difference over the two years for either the treatment or control groups.

The results of this study clearly contradict the conventional wisdom that the use of DSS improves decision making for these findings. Among these are the fact that the amount of computer time available to each treatment group was limited to thirty minutes per decision session. Debriefing of subjects indicated that this was an extremely inadequate amount of time to ex excute all the modules of the BMLDSS. Further, much of the time was spent with the mechanics of the BMLDSS rather than with its decision support capabilities. Other methodological problems include the facts that subjects received no instruction in the models that were contained in the BMLDSS, and that no training in the use of the BMLDSS as part of a logical decision making process was offered. Finally, the difficulty of maintaining stringent experimental control in an era of easy outside availability of personal computers was mentioned.

Wolfe and Gregg (1989) also raise some valid concerns about the methodology used in this study. They concur that the amount of PC-access time was extremely inadequate since the BMLDSS has proven to be a very time-consuming exercise in the conversational mode. Further, they question the efficacy of introducing the BMLDSS after one year of play has passed. They base this on the belief that at this juncture the typical firm has already implemented its grand strategy and consequently is experiencing the attendant results. Additionally, they suggest that the insertion of the BMLDSS at the midpoint of the game could have been more intrusive than beneficial to the decision making processes established by each company since it may have complicated the process and been perceived as an unnecessary burden.

The present study seeks to rectify some of these methodological difficulties of the previous study. Further, it seeks to replicate the Scharda et al (1988) study in a second simulation gaming environment. By this improved research design a better reading of the role of DSS in small group decision-making effectiveness will be obtained.

RESEARCH METHODOLOGY

This research was conducted in the context of the Business Management Laboratory simulation game of Jesen & Cherrington (1984). In the version used approximately thirty five decisions were made for every quarter of play. Specifically, two products were manufactured and sold in a single market area. The BML has been successfully utilized as a research environment for studies of decision making previously (See, for example, Affisco & Chanin (1989, 1988, 1987. 1986), Courtney, DeSanctis, and Kasper (1983), and Wolfe & Gregg (1989).

Sixteen groups of senior business students in the required capstone Business Policy course during the Summer 1989 session were the subjects of the study. These groups were generally constructed of four members with different majors (i.e. Accountancy, Finance, Marketing, Management, etc.) within constraints imposed by the registration process. The groups were randomly divided into two eight team industries across two course sections. Thus, in each industry there were four teams from each section, a control section and an experimental section. Additionally, it was insured that at least one member of each group in the experimental section had experience in the use of Lotus 1-2-3.

Each of the control groups made a trail decision followed by eight quarterly decisions under the observation of the instructor. These decisions were made without the use of any Decision Support System or any other computer support. Control group members were allowed to use calculators as a computation aid. In a like manner, experimental groups were required to use a DSS to support their manufacturing function decisions. Specifically, two modules Short-term Raw Materials Requirements and Operations Manager, of Wolfe’s Business Management Laboratory Decision Support System

(BMLDSS) were employed.

The BMLDSS is a library of eight Lotus 1-2-3 spreadsheet templates. Each module may be operated in one of two modes. The Conversational Mode simulations a convensation with an expert in a particular business function. The Data Entry Mode allows simple data entry directly to the program bypassing the opportunity for expert consultation. The two modules that were used in this experiment consist of: 1) Short-time Material Requirements - Derives quarterly raw material requirements, costs alternative purchase policies for two quarters; 2) Operations Manager - Schedules production, suggests maintenance budgets, costs alternative production schedules, evaluates alternative inventory accounting methods, and derives cash disbursements based on the production variables. It was decided to use only two of the BMLDSS modules in this research due to the limited amount of computer time that was available. These two modules were selected for the following reasons: 1) Decision making in the production function of the BML is computation intense; 2) Student's at the institution where the study was conducted are less experienced in the production function than in either marketing or finance. Consequently, it is conceivable that the production decisions would improve significantly from computer-based support; 3) The game output provides a number of quantitative measures that may be directly traced to production decisions. Therefore, measuring the impact of the DSS on performance is facilitated.

The control and the experimental sections were given the same lecture on the production decisions at the beginning of play. In addition, a complete description of the two BMLDSS modules was distributed to each student in the experimental groups. Each group was trained in the use of the programs by an experienced Doctoral Research Assistant. In addition, time was made available for hands on practice with the system for each group. To assure that only the two production modules were used, the other modules of the BMLDSS were disabled by removing certain instructions from the main menu. For all treatment groups the decision making sessions were conducted in a laboratory equipped with a local area network with tour IBM PC/XT computers serving as work stations. However, during this research these PCs were operated as stand alone machines. Thus, during each decision making session time on these four machines was equally divided among the eight groups. To assure the use of the DSS, treatment groups were required to hand in printed output with each of their decisions. In addition, each decision making session was observed by the instructor and a research assistant.

After the completion of play, as part of debriefing, a questionnaire composed of series of seven point Likert-scale questions was administered to the DSS groups. The questions dealt with the groups experiences in utilizing the DSS for decision making in the BML. Concurrently, the control groups received a lecture on decision support systems and the particular modules of the BMLDSS that were used by the experimental groups were demonstrated. Students in these groups were then administered the same questionnaire with the instructions to answer the questions based on the premise that such a DSS was available to support them in their decision making for their BML f inns.

RESULTS AND DISCUSSION

Actual game performance data were used to determine the impact of the DSS (the treatment) on decision making effectiveness. Specifically, quarterly manufacturing cost data for each product, and the ratio of earnings to cost of goods sold for each quarter were utilized to measure the impact of the DSS on performance. The former are clearly measures of manufacturing performance since these costs are directly related to capacity planning, production scheduling, and raw materials purchasing decisions. The latter is a more global measure of the impact of the manufacturing function on overall firm performance.

The nonparametric Mann-Whitney U test was employed to determine if performance by firms utilizing the DSS was different from that of Non-DSS firms in each of the two years. After Wolfe and Gregg (1989), nonparametric statistics were considered appropriate, as the performance results in a business game are not normally distributed. Table 1 presents the results of the statistical tests on the three variables for both years of play. For the first year DSS groups did not significantly outperform the control groups on any of the three variables. However, for the second year DSS groups experienced manufacturing costs that were significantly lover at the 0.01 level. In addition, DSS groups outperformed Non-DSS groups on earnings per cost of goods sold at the 0.0768 level in a two-tail test. These findings replicate results presented in Sharda et al (1988) in that learning seems to have occurred and a lagged impact of the DSS on performance was observed.

A comparison of response of selected questionnaire items is presented in Table 2. It must be remembered that we are comparing data based on actual usage with that based on perceptions of usage in the table. Mean scores and the results of t-tests are given. Four variables exhibit significant differences between treatment and control groups. First, Non-DSS groups perceived that they would learn from the use of the DSS to a greater degree than the actual learning reported by the DSS groups. Second, the experimental groups reported that they would be less able to do without the DSS than the control groups perceived. Third, the experimental groups reported that the DSS was helpful in performing their job while the control groups did not perceive such importance to as high a degree. Finally, the treatment groups reported significantly greater use of the output and reports generated by the DSS than the perceived use by the control groups. None of these results are particularly surprising considering the mechanics of the questionnaire administration.

In an effort to determine how successfully the experimental conditions were controlled, as part of the post-experimental debriefing process, Non-DSS groups were questioned as to whether they had actually used any form of computer support for their decision making. Initially, groups were quite reticent in admitting their use of such support due to their fear that some penalty would be imposed by the instructor. Essentially they thought part of the intent of the course was a paper and pencil exercise. Once they were reassured and it was made clear that the instructor had no intention of imposing any sanctions but was extremely interested in learning about any systems they had used to help in the decision making process, two control groups admitted they had developed systems that they used outside of the classroom laboratory sessions. They students were asked to hand in these systems on a diskette along with a hard copy of the output of a typical session. The result was the both systems were discovered to be Lotus 1-2-3 templates, which emphasized financial statement preparation. In addition, a forecasting model and some production scheduling elements were included. However, the production decision support was significantly less sophisticated than that available in the BMLDSS modules.

To determine what the impact of these user developed systems was on the previously presented findings, it was decided to consider these groups as treatment groups and reanalyze the data. In order to maintain the experimental balance, these two original control groups were exchanged with two original DSS groups and the data were reanalyzed. A review of the quarterly experimental notes indicated that two original treatment groups used the BMLDSS modules only as a pro forma to satisfy the instructor's requirements, but in reality used a paper and pencil approach to arrive at their decisions. In the adjusted results these groups were treated as control groups.

The quantitative performance results for the adjusted structure are presented in Table 3. Note that once again none of the results are statistically significant for the first year. For the second year, DSS firms outperformed Non-DSS firms only On Earnings/CGS. Thus, there is a loss of significance for manufacturing cost when compared to the original results. This might be explained by the fact that the user developed systems were more general and focused on marketing and financial variables at the expense of production variables.

A comparison of the results on the questionnaire items for the revised structure is presented in Table 4. Nine variables exhibit some level of significance. Interestingly the learning effect of the DSS is no longer significant. Perhaps the focus of the user prepared systems on calculations related to the marketing and finance functions were merely a mechanical exercise since the subjects are much more familiar with these areas than production. Whereas, the consultation mode of the BMLDSS modules actually taught subjects something about the production area with which they were unfamiliar. The impact of the DSS on decision quality, appreciation of the DSS, satisfaction with decisions, increased decision speed, and usefulness of the DSS were all significant for the adjusted groupings and not significant for the original groupings. Once again DSS groups reported that they could not get along without the use of the systems. Finally, systems users reported that the DSS helped them do their job and the comparison to non-users was highly significant, and greatly improved from the original structure.

An overall look at this revised questionnaire data compared to the original data indicates that subjects were more willing to attribute 'success to systems they developed than those that were provided for them from external sources (at least for the four teams that exchanged places). There are two possible explanations for this: (1) A 'halo effect may be at work here; or (2) The conventional wisdom that end user computing provides the user-developer with a stake in the system and leads to increased utilization, understanding, and superior man-machine performance is in fact true.

This research points out a major dilemma for those who seek to conduct experimental studies of the impact of Decision Support Systems on decision-making effectiveness. If one accepts the need to conduct longitudinal studies in the area, methods to assure that strict experimental control is maintained must be developed. For example, in longitudinal research conducted in the context of a business simulation game, such as the research presented in this paper, how does one ensure that "informal" computer based systems are not developed and utilized outside of the laboratory setting over the course of play? In today's environment the possibility of such contamination is enchanced by the easy availability of personal computers and the software to run them.

CONCLUSION

This free simulation study investigated whether the use of a Decision Support System could improve small group decision-making effectiveness. Findings indicated that the use of a DSS to support manufacturing function decisions resulted in decreased manufacturing costs and increased Earnings/CGS in the second year of play. These findings replicate some of previous research and indicate that there may be a lag in performance improvement due to a learning effect related to the use of the DSS. A second look at the data prompted by the discovery that two control groups developed their own "informal" DSS outside the boundaries of the experiment pointed out that some significant benefits may be derived by end user computing. However, these results are sketchy, at best. Further empirical research into the impact of end user computing versus systems provided by outside analysis on decision-making performance is required. Finally, the study exposes the crucial problem of maintaining strict experimental control when conducting a longitudinal study in the context of a business simulation game.

REFERENCES

Affisco, J.F. & Chanin, M.N. (1989), 'The Impact of Decision Support Systems on the Effectiveness of Small Group Decisions -An Exploratory Study", in T. Pray & J. Wingender (Eds.), Developments in Business Simulation & Experiental Exercises, Stillwater, OK: Association for Business Simulation and Experiential Learning, 132-135.

Affisco, J.F. & Chanin, M.N. (1988), "An Empirical Investigation of Integrated Spatial-Proximity MCDM-Behavioral Problem Solving Technology Group Decision Models", in P. Sanders & T. Pray (Eds.), Developments in Business Simulation & Experiential Exercises. Stillwater, OK: Association for Business Simulation and Experiential Learning, 56-60.

Affisco, J.F. & Chanin, M.N. (1987), "Simulation Gaming as an Experimental Context for the Study of Multicriteria Decision Making," in L. Kelly & P. Sanders (Eds.), Developments in Business Simulation & Experiential Exercises. Stillwater, OK: Association for Business Simulation and Experiential Learning, 1-5

Affisco, J.F. & Chanin, M.N. (1986), "A Study of the Effectiveness of Assumption Making in Strategic Planning", Proceedings of the Northeast American Institute for Decision Sciences, 91-93.

Benbasat, I. & Dexter, A.S. (1982), "Individual Differences in the Use of Decision Support Aids", Journal of Accounting Research, 20(No. 1), 1-11.

Cats-Baril, W.L. & Huber, G.P. (1987), Decision Support Systems for Ill-Structured Problems: An Empirical Study", Decision Sciences, 18(No.3), 350-372.

Courtney, J.F., DeSanctis, G. & Kasper, G.M. (1983), "Continuity in MIS/DSS Laboratory Research: The Cast for a Common Gaming Simulator', Decision Sciences, 14(No. 3), 419-439.

Goslar, M.D., Green, G.I., & Hughes, T.H. (1986), "Decision Support Systems: An Empirical Assessment for Decision Making', Decision Sciences, 17(No. 1), 79-91.

Henderson, J.C. (1987), "Finding Synergy Between Decision Support Systems and Expert Systems Research", Decision Sciences, 18(No. 3), 333-349.

Jensen, R. & Cherrington, D.J. (1984), 'The Business Management Laboratory", 3rd. Ed., Plano, TX: BPI.

Keen, P.G.W. & Scott Morton, M.S. (1978), Decision Support Systems An Organizational Perspective, Reading, MA: Addison-Wesley.

Sharda, R., Barr, S.H., & McDonnell, J.C. (1988), 'Decision Support System Effectiveness: A Review sand An Experimental Test", Management Science, 34(No.2), 139-159.

Wolfe, J. (1988), The Business Management Laboratory Decision Support System, Tulsa, OK: University of Tulsa.

Wolfe, J. & Gregg, J. (1989), 'On the Efficacy of Decision Support Systems within Business Gaining Contexts", Paper presented at ISAGA 89.

Table 1

DSS PERFORMANCE MEASURES

Variable	DSS	Non-DSS	Z
	Year 1 Medians		
Manufacturing Cost - Product 1	11.241	11.104	-0.389+
Manufacturing Cost - Product 2	9.872	9.960	-1.383+
Earnings/CGS	0.174	0.074	-1.544+
	Year 2 Medians		
	DSS	Non-DSS	Z
Manufacturing Cost - Product 1	10.931	11.194	-2.283*
Manufacturing Cost - Product 2	9.602	9.814	-2.289*
Earnings/CGS	0.357	0.174	-1.772**

\+ Not Significant at the 0.05 level,
* Significant at the 0.01 level,
** Significant at the 0.10 level (p = 0.0768),
2-tail tests

Table 2

COMPARISON OF QUESTIONNAIRE RESPONSES

Variable	DSS Mean	Non-DSS Mean	t
Learning	5.259	5.933	-1.747*
Appreciation	2.407	2.533	-0.346
Usefulness	5.074	5.633	-1.433
Satisfaction with Decision	5.185	5.267	-0.220
DSS Improved Decision Quality	5.185	5.467	-0.845
DSS Increased Decision Speed	5.370	5.867	-1.165
Actual vs Expected Use of DSS	4.296	4.103	0.588
Get along without DSS	3.815	4.467	-2.168**
DSS Assists in Job Performance	4.815	4.167	2.178**
Actually Used DSS Output/Reports	5.074	4.200	2.734***
DSS Troublesome to Use	3.037	2.793	0.761

* Significant at 0.10 level,
** Significant at 0.05 level,
*** Significant at 0.01 level.

Table 3

REVISED DSS PERFORMANCE MEASURES

Variable	DSS	Non-DSS	Z
	Year 1 Medians		
Manufacturing Cost - Product 1	11.241	11.218	-0.269+
Manufacturing Cost - Product 2	9.844	9.968	-0.819+
Earnings/CGS	0.191	0.079	-1.537+
	Year 2 Medians		
	DSS	Non-DSS	Z
Manufacturing Cost - Product 1	10.896	11.231	-0.457+
Manufacturing Cost - Product 2	9.607	9.956	-1.363+
Earnings/CGS	0.327	0.149	-2.679*

\+ Not Significant at the 0.05 level,
* Significant at the 0.01 level,
2-tail tests

Table 4

COMPARISON OF REVISED QUESTIONNAIRE RESPONSES

Variable	DSS Mean	Non-DSS Mean	t
Learning	5.815	5.433	1.006
Appreciation	2.148	2.767	-1.791*
Usefulness	5.815	4.967	2.316**
Satisfaction with Decision	5.593	4.900	2.012**
DSS Improved Decision Quality	5.667	5.033	2.041**
DSS Increased Decision Speed	6.000	5.300	1.722*
Actual vs Expected Use of DSS	4.692	3.767	2.886***
Get Along without DSS	3.815	4.467	-2.175**
DSS Assists in Job Performance	5.074	3.933	4.254+
Actually Used DSS Ouput/Reports	4.926	4.333	1.756*
DSS Troublesome to Use	3.115	2.733	1.204

*Significant at the 0.10 level,
** Significant at the 0.05 level,
*** Significant at the 0.01 level,
\+ Significant at the 0.0001 level.