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DECISION SUPPORT SYSTEMS: IMPACT ON COMPANY PERFORMANCE

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Abstract

This study investigates a number of variables related to decision support systems (DSS): use of systems, contribution of systems, and user satisfaction. We use a simulation game as a vehicle for implementing DSS and for measuring the effectiveness of those systems. Fifty-Eight companies, consisting of about 300 senior graduate students participating in the simulation, developed DSS and reported on the systems developed. Questionnaires were later used to evaluate the results. Findings, consistent with previous empirical studies, strengthen the validity of the simulation exercise as a useful tool for measuring DSS effectiveness.

Keywords: Decision Support Systems, Simulation, Effectiveness.

1 INTRODUCTION

Information systems studies have used a variety of instruments to measure information systems (IS) effectiveness (see, for example, Bharati and Chaudhury, 2004; DeLone and McLean, 2003; Reinig, 2003; Sharda et al., 1988; Srinivasan, 1985). The focus of this study is decision support systems (DSS). DSS is used to provide computer-based support to decision makers involved in solving semi-structured and unstructured problems. Studies show that DSS will be effective if both the user and the system work toward the cooperative purpose of improving decision-making. That is, if the objectives or the expectations of the system are met, the system is effective. This is because the information needs of the users (the decision makers) are appropriately supported by the DSS (Khazanchi, 1991). Consequently, the question of measuring the effectiveness of a DSS appears to be in the hands of the users.

This study investigates DSS with a focus on factors that affect their effectiveness. We use a game simulation method for this research, where the game becomes the platform for the participants to experience DSS. We also examine the dissimilarity between the developed systems. This research follows an approach akin to that of Ben-Zvi (2007) in his business game studies. That study considered a very limited number of participants, we augment this investigation by significantly extending the number of participants and parameters of the game. We emphasize that all the studied game holds the same basic characteristics (several executive functions, simulated environment, etc.).

The paper is organized as follows: First, we review business game simulations. Then, we describe the employed game and set the study's hypotheses. Next, we examine the implementation of DSS in the proposed game and analyze related variables. Finally, we discuss the applicability of this study and draw conclusions.

2 LITERATURE REVIEW AND HYPOTHESES

This study aims to measure the effectiveness of the developed DSS. For that, we measure the participants' perceived benefits from using a DSS, variables related to DSS use, user satisfaction, and success.

As we use the business game as a tool for measuring MIS and DSS, we follow hypotheses examined by Ben-Zvi (2007). The first hypothesis in this study relates variables in DSS studies to DSS effectiveness.

Many researchers in MIS have studied the success and failure of DSS from several perspectives. Common measured criteria of DSS success include system's reliability and flexibility (Srinivasan, 1985), the ability of a system to support decision-making and problem-solving activities (Garrity and Sanders, 1998), use and user satisfaction (Baroudi et al., 1986; DeLone and McLean, 2003), and decision confidence (Goslar et al., 1986). In this study we examine the following DSS success variables: usefulness, user satisfaction, system contribution to functional area and company success, own use and colleague use.

The first hypothesis relates to both the individual and company level:

Hypothesis 1: The measures of success present high and significant correlation between their criteria.

The second hypothesis relates DSS effectiveness variables to company performance:

Hypothesis 2: The measures of DSS success are highly correlated with company performance.

As each company functions as a distinct entity in the game, we also examine the dissimilarity between the companies:

Hypothesis 3: Company differentiation in DSS: Variance between companies is significantly different from the variance within companies.

3 METHODOLOGY: THE SIMULATION EMPLOYED

A general-purpose business game is, by definition, a highly complex man-made environment. Its objective is to offer participants the opportunity to learn by doing in as authentic a management situation as possible and to engage them in a simulated experience of the real world (e.g., Garris et al., 2002; Martin, 2000). This usually enhances the characteristics of the game as a simulation of real life, and behavior observed may be generalized to reality (e.g., Lainema and Makkonen, 2003).

In 2003, a special issue of *Communications of the ACM*, named "A Game Experience in Every Application", was dedicated to simulation games in diverse applications. Furthermore, over the years, researchers have reported the extent of usage of simulation games in academe and business (e.g., Ben-Zvi, 2010; Courtney and Paradice, 1993; Dickson et al., 1977).

However, empirical studies employing simulations and measuring DSS effectiveness present mixed results. Some researches provide no support for the premise that the use of DSS improves group decision making effectiveness (Affisco and Chanin 1989, Goslar et al. 1986, Kasper 1985).

The game we employed represents a tool that successfully enables participants to develop analytical decision making skills, including problem identification skills; data handling skills and thinking skills. Furthermore, with the improvement of technology, simulation exercises have become more sophisticated and user friendly. We elaborate on the game in the next section.

This study employs the International Operations Simulation Mark/2000. We use the game to establish a managerial decision-making context: The game involves the participants in the executive process, motivates their need for decision-making aids and forces them to adopt a managerial viewpoint associated with management information systems (MIS) and DSS.

The game is played for a full semester. Each simulated company may cover any combination of the functions of manufacturing, marketing products or selling to overseas distributors, serving as a distributor or a subcontractor, exporting, importing, financing and licensing. The incoming participants play 6 to 10 game-periods. The task of the companies is to make decisions which will guide operations (simulated by the easy to realize computerized system) in the forthcoming period and which will affect operations in subsequent periods.

Decisions are made once a week. The length of the each time period simulated is usually referred to as one year. Dozens of decisions, covering the entire range of a typical business, are required of a company in each period. The decision-making process is based on an analysis of the company's history, interaction with other companies and the constraints stated in the player's manual (e.g., procedures for production, types of available marketing channels).

The performance of a company in each period is affected by its past decisions and performance, the current decisions, simulated customer behavior, and the competition – the other companies in the industry.

The game has become highly realistic as a result of the efforts invested in it to simulate the total environment. Participants in the game immerse themselves in this artificially created world. They form teams (without external intervention or manipulation), allocate responsibilities for specific functions, and work to achieve common goals which they themselves define.

The study was conducted in a university accredited by the Association to Advance Collegiate Schools of Business (AACSB). The participants were senior graduate students. The students were divided into 5-participant-groups (companies). We explored three runs: (1) Run I, consisting of 18 companies; (2) Run II with 20 companies; and (3) Run III with 20 companies.

At the end of each run, after the last set of decisions had been made, each group was required to present its DSS in class and to submit a report consisting of: (1) a definition of the scope of the system; (2) a decision analysis; (3) a system design; and (4) a discussion of the contribution of the system in achieving the group's objectives during the game. At that same meeting, each of the students was asked to complete a short individual questionnaire on the DSS assignment (see the appendix for the text of the questionnaire).

4 RESEARCH FINDINGS

4.1 Developed Systems

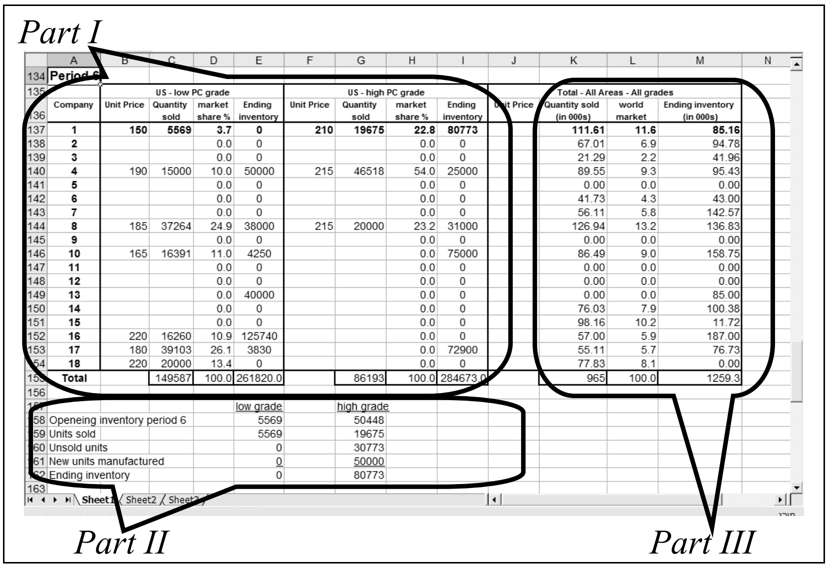
Two-thirds of the companies in all three runs nominated a Chief Information Officer (CIO). All companies reported developing an information system but none of the companies reported major modifications during the run. We present an example of the systems developed in Run I. Eighteen companies were created in that run, most of which developed a Microsoft Excel spreadsheet-based DSS. The major characteristics of the systems developed are exhibited in Table 1.

Co.	System Area	Nature of System	Data Analysis	Graphics
1	Production, Finance, Market Analysis	Electronic Sheet	Yes	No
2	R&D, Production, Finance, Marketing	Electronic Sheet	No	Yes
3	Production, Finance, Market Analysis	Electronic Sheet	Yes	No
4	R&D, Production, Finance, Marketing, Market Analysis	Electronic Sheet, Regressions	Yes	No
5	Production, Finance	Electronic Sheet	No	No
6	R&D, Production, Finance, Marketing, Market Analysis	Electronic Sheet	Yes	No
7	Production, Finance	Electronic Sheet	No	No
8	R&D, Production, Finance, Marketing, Market Analysis	Electronic Sheet	Yes	No
9	Production, Finance	Electronic Sheet	No	No
10	Production, Finance, Marketing	Electronic Sheet	No	No
11	R&D, Production, Finance, Marketing	Electronic Sheet	No	No
12	R&D, Production, Finance, Market Analysis	Electronic Sheet, Regressions	Yes	No
13	R&D, Production, Finance	Electronic Sheet	No	Yes
14	Marketing, Market Analysis	Electronic Sheet, Regressions	Yes	No
15	Finance, Marketing, Market Analysis	Electronic Sheet	Yes	Yes
16	Production, Marketing	Electronic Sheet	Yes	Yes
17	Production, Finance	Easy Plan, Electronic Sheet	No	No
18	Finance, Marketing	Electronic Sheet	No	No

Table 1. Characteristics of Systems Developed by Companies in Run I

For this study, the most relevant aspect of Table 1 is the extent to which the companies differed on their systems. Companies, in all three runs, adopted different application areas with models including various statistical analyses, spreadsheets—and even linear regressions. Only 3 companies (5% of all companies) employed any type of package software. Thirty five companies developed complicated data analysis tools (mostly statistical or engineering analyses) for their systems (60% of all companies). Only 19 companies developed graphic outputs (about a third of all companies), while the remaining 39 did not. Finally, the sophistication and complexity of the models employed varied significantly from simple spreadsheet analyses (companies 5 and 7 in Run I) to a complex linear model (company 4 in that same run). While it cannot be claimed that the distribution of attributes of systems exactly measures that in the real world, the degree of diversity of systems developed, based on existing tools, does appear to be quite real.

Figures 1 and 2 present a sample of those systems. Figure 1 demonstrates the market analysis conducted by company 1 in the 6th played period of Run III. Part I of Figure 1 presents an analysis of the US market. Company 1 mainly operated in the US market and therefore, a full analysis of prices, models, market share and inventory was required. Part II analyzes the company's inventory in the US market. Part III exhibits an aggregated analysis of all companies' world-wide.



Period 6

Company	US - low PC grade Unit Price	Quantity sold	market share %	Ending inventory	US - high PC grade Unit Price	Quantity sold	market share %	Ending inventory	Unit Price	Total - All Areas - All grades Quantity sold (in 000s)	world market	Ending inventory (in 000s)
1	**150**	**5569**	**3.7**	**0**	**210**	**19675**	**22.8**	**80773**		**111.61**	**11.6**	**85.16**
2			0.0	0			0.0	0		67.01	6.9	94.78
3			0.0	0			0.0	0		21.29	2.2	41.96
4	190	15000	10.0	50000	215	46518	54.0	25000		89.55	9.3	95.43
5			0.0	0			0.0	0		0.00	0.0	0.00
6			0.0	0			0.0	0		41.73	4.3	43.00
7			0.0	0			0.0	0		56.11	5.8	142.57
8	185	37264	24.9	38000	215	20000	23.2	31000		126.94	13.2	136.83
9			0.0	0			0.0	0		0.00	0.0	0.00
10	165	16391	11.0	4250			0.0	75000		86.49	9.0	158.75
11			0.0	0			0.0	0		0.00	0.0	0.00
12			0.0	0			0.0	0		0.00	0.0	0.00
13			0.0	40000			0.0	0		0.00	0.0	85.00
14			0.0	0			0.0	0		76.03	7.9	100.38
15			0.0	0			0.0	0		98.16	10.2	11.72
16	220	16260	10.9	125740			0.0	0		57.00	5.9	187.00
17	180	39103	26.1	3830			0.0	72900		55.11	5.7	76.73
18	220	20000	13.4	0			0.0	0		77.83	8.1	0.00
Total		149587	100.0	261820.0		86193	100.0	284673.0		965	100.0	1259.3

	low grade	high grade
Openeing inventory period 6	5569	50448
Units sold	5569	19675
Unsold units	0	30773
New units manufactured	0	50000
Ending inventory	0	80773

Figure 1. A Sample of DSS Developed by Company 1 in Run III

Figure 2 illustrates a DSS developed by company 5 in Run III. It shows the average investment in Research and Development (R&D) of each company against the investment made by company 5 in the corresponding periods. As company 5 followed a strategy of R&D superiority, a non-linear regression was constructed to make predictions of future investments to stay ahead of the R&D investment curve.

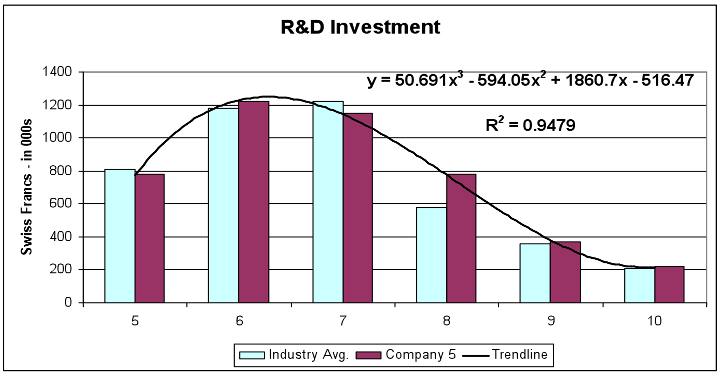


Figure 2. A Sample of Graphical R&D Analysis Made by Company 5 in Run III.

4.2 Analysis

In order to enhance the validity our results, we compared them to previous findings reported by Ben-Zvi (2007). The analysis of the data relates both to individuals and to companies. Company data in this study aggregate the individual data of the company's members, and is conducted in order to determine whether the participants in the game coalesce into distinguishable companies.

First, the customary variable in DSS studies, degree of success, is analyzed. Next, company performance is analyzed with regard to the developed DSS. Finally, we discuss company differentiation. The internal consistency among the items, Cronbach's alpha, is 0.8345 at the individual level and 0.8532 at the company level. Means and variance of responses to the first 11 questions are exhibited in Table 2.

Variable	n=290	
	Mean	S.D.
Familiarity	5.52	0.97
Usefulness	5.73	0.90
Own use	5.71	0.92
Contribution to functional area	5.70	0.92
User satisfaction	5.69	0.93
Use by colleagues	4.92	1.23
Contribution to company success	5.67	0.91
Participation	4.82	1.28
Disturbance	3.48	0.96
Met expectations	5.65	0.91
Overall Effectiveness	5.69	0.90

Table 2. Means and Standard Deviations (S.D.) of Responses

4.3 Success of DSS

In this section we examine the following six DSS success variables:

- Usefulness of the system as evaluated by participants (question 2).
- Own use by respondents (question 3).
- Use by colleagues (question 6).
- The system's contribution to the company's performance in respondents' functional areas (question 4).
- The system's contribution to the company's overall success (question 7).
- User satisfaction (question 5).

We adopt the common approach of regarding all success criteria as being co-determined; that is, we do not assume cause-and-effect relationships between them.

Table 3 exhibits all correlations between the success criteria for individual respondents in this study, as defined above. The table shows strong and highly significant relationships between the criteria, except for the correlation between own use and colleague use. The strong correlations found would seem to indicate that the criteria are indeed all related and presumably all measure some aspect of success. The lack of mathematical correlation between the own use and the colleague use variables does not imply that those two variables are not correlated. A detailed analysis showed that participants were divided into two major groups, by company: one with a highly positive correlation and one with a highly negative one. This caused the average correlation between the two variables to become small.

	Use		Contribution		User satisfaction
	Own Use	Use by Colleagues	Functional area	Company success	
Usefulness	0.412	0.441	0.62	0.673	0.726
	p=0.001	p<0.001	p<0.001	p<0.001	p<0.001
Own use		0.028	0.651	0.373	0.291
		p=0.437	p<0.001	p=0.002	p=0.01
Colleague use			0.259	0.409	0.378
			p=0.01	p<0.001	p=0.001
Contribution to functional area				0.609	0.569
				p<0.001	p<0.001
Contribution to company success					0.702
					p<0.001

Table 3. Relationships between Criteria of DSS Success for Individual Respondents (n=290)

Table entries: Spearman's rho correlation coefficient

Significance level

Table 4 demonstrates all correlations between the success criteria at the company level. It appears that there are very strong correlations between the measures of success at this level, and in most cases the relationships are significant. Note that the grouping procedure by companies largely increased the correlation between own use and use by colleagues. Thus, the data in the study strengthen the hypothesis concerning the nature of success and failure of DSS and replicates previous empirical findings.

	Use		Contribution		User satisfaction
	Own Use	Use by Colleagues	Functional area	Company success	
Usefulness	0.407	0.631	0.706	0.741	0.814
	p=0.043	p=0.002	p<0.001	p<0.001	p<0.001
Own use		0.297	0.572	0.322	0.27
		p=0.102	p=0.006	p=0.091	p=0.139
Colleague use			0.399	0.454	0.455
			p=0.048	p=0.027	p=0.028
Contribution to functional area				0.589	0.633
				p=0.005	p=0.002
Contribution to company success					0.803
					p<0.001

Table 4. Relationships between Criteria of DSS Success for Companies (n=58)

Table entries: Spearman's rho correlation coefficient

Significance level

4.4 Company Performance Analysis

This section investigates company performance versus all measured variables. In all three runs, company performance was measured by the companies' accumulated retained earnings (accumulated profits). Table 5 exhibits the correlations between company performance and all DSS measured variables of this study. Correlation was made for the company level.

The results indicate that five variables are strongly related to the company's performance: system's usefulness, user satisfaction, contribution of the DSS to the diverse functional areas and to the entire company success and whether the DSS met its expectations. It seems that the greater the satisfaction from the developed system in meeting its intended aim as set by the users, the better the company's performance in the game. Nevertheless, the two variables related to the participation of users in defining the DSS present negative correlation with the company's performance. It seems that added involvement in developing the DSS impairs performance.

Variable	Correlation
Familiarity	0.02
Usefulness	0.60
Own use	0.19
Contribution to functional area	0.62
User satisfaction	0.87
Use by colleagues	0.36
Contribution to company success	0.77
Participation	-0.21
Disturbance	-0.01
Met expectations	0.72

Table 5. Results for the Measured Variables (n=290). The Correlation is with Company Performance.

Furthermore, we measured a correlation of 0.29 between the number of functions the DSS cover (e.g., production, finance, market analysis) and the companies' performance. There is also a correlation of 0.35 and 0.05 between a company's performance and its use of data analysis tools and graphics, respectively.

To summarize, it can be claimed that a successful DSS in the eyes of the users is related to better company performance in the game. However, investing a lot of human resources in developing a complicated system that makes use of several features does not necessarily guarantee enhanced company performance.

5 DISCUSSION AND CONCLUSIONS

This study examined simulated companies. Although the general environment was mutual to all participants, the companies became differentiated. Each company assumed a considerably different strategy, different operating decisions, and a different approach to DSS. And leaving DSS development decisions to the companies resulted in a variety of applications and a wide array of models, programs and modes of operation. It appears that these companies reflect most real life business approaches to DSS.

In addition, this study tested three hypotheses. All three hypotheses were confirmed, replicating a number of previous findings. Overall, results at both the individual participant and the company levels underscore that the business game may be used as a vehicle for implementation of MIS and DSS.

More generally, our experience suggests that the efficacy of business games as platforms for implementing DSS is twofold. First, participants practice the art of decision-making; participants are excited, motivated and strive to make better decisions; they become actively involved in the simulated decision-making process and in the development of MIS and DSS of their choice. Second, because the game is very practical, the participants themselves frame the relationship between the decision-making processes, the designed information systems and the outcomes of their use. This exemplifies how decision-making is more successful using DSS and also provides an integrative view of some of the tasks and practical uses of DSS. The ultimate result is more successful MIS and DSS in the real world.

In the games associated with this study, most companies developed a spreadsheet-based DSS. Although some may regard spreadsheets as too simplified DSS, our study reveals that complicated systems do not guarantee better company performance. Nowadays, even the frequently used spreadsheets are sufficient tools to create extremely powerful and useful DSS. Moreover, spreadsheets offer some substantial pedagogical advantages: Individuals today, not necessarily IS oriented, are familiar with spreadsheet tools, so they can quickly employ them for the development of a DSS. Spreadsheets also allow a dynamic data updating and facilitate data visualization. Also, modern spreadsheet programs contain powerful data analysis tools (e.g., Analysis ToolPak in Excel); Sixty percent of all participating teams incorporated data analysis tools into their DSS.

However, while feedback from participants is favourable and the game is sufficiently complex to provide challenges and a realistic simulation of decision making, no business game can encompass all aspects of information systems. Because the game decisions are more simplistic than those of the real world, the DSS required to support the decisions are less complicated than those in reality. Therefore, there is a need to determine how business games, as learning laboratories, can be augmented to study the more complex, dynamic aspects of the DSS domain: use and performance can be easily measured and evaluated, but the cost/benefit or return of investment of a specific information system is as vague in the game as it is in real life.

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Appendix. The Questionnaire

The following questions relate to the Decision Support System, which was developed in your company. Please indicate your answers:

		Strongly Disagree	Disagree	Tend to Disagree	Neutral	Tend to Agree	Agree	Strongly Agree
1.	I am familiar with the system developed in the company	1	2	3	4	5	6	7
2.	The system is useful for decision making	1	2	3	4	5	6	7
3.	I personally used the system for making decisions in my role in the company	1	2	3	4	5	6	7
4.	The system contributed to the company's performance in my functional area	1	2	3	4	5	6	7
5.	I am satisfied with the system	1	2	3	4	5	6	7
6.	My colleagues in the company used the system for decision making	1	2	3	4	5	6	7
7.	The system contributed to the company's success	1	2	3	4	5	6	7
8.	I participated in defining the system	1	2	3	4	5	6	7
9.	Developing the system interfered with my functional role in the company	1	2	3	4	5	6	7
10.	The system's benefits met my expectations	1	2	3	4	5	6	7
11.	Overall: The system was effective	1	2	3	4	5	6	7