EFFICIENCY AND EFFECTIVENESS OF A DECISION SUPPORT SYSTEM: A TEST

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ABSTRACT

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Title of Study: EFFICIENCY AND EFFECTIVENESS OF A DECISION SUPPORT SYSTEM: A TEST

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Scope and Method of Study: There have been many claims of increased decision quality resulting from the use of decision support systems. The objective of this study was to test the general hypothesis that a decision support system increases decision efficiency and effectiveness. An executive decision game was played in a senior level policy course. One section was exposed to a DSS while another section played the game in the normal way. Various measures of the quality of decisions were recorded.

Finding and Conclusions: Overall, it was found that a decision support system allowed for those with access to it to make significantly more efficient and effective decisions in the business simulation game. For virtually every measure of decision quality examined the DSS group outperformed their non-DSS counterparts. Concerning decision efficiency, the DSS group considered more alternatives, took longer to make their decisions and were more confident in the decisions they made.

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Without the patient understanding and encouragement of my parents neither this paper nor my advanced degree would have been possible.

This report is dedicated to Anne Elisa and Evelyn Anne for every reason.

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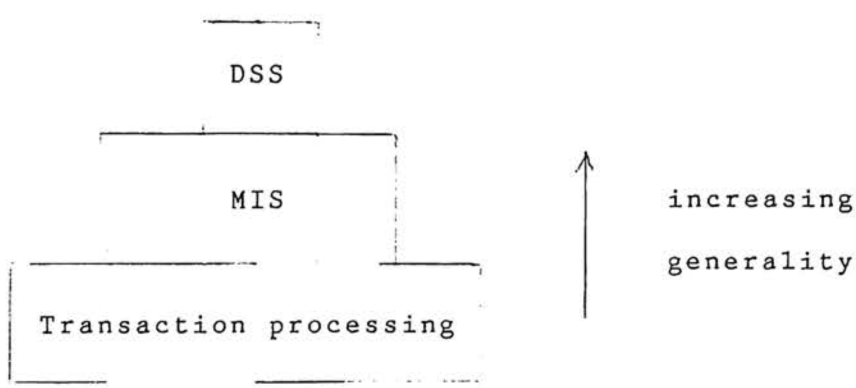
1. INTRODUCTION

1.1 GENERAL STATEMENT OF THE PROBLEM

1.1.1 DSS

A decision support system (DSS) is defined as an interactive system that provides the user with easy access to decision models and data in order to support semistructured and unstructured decision making tasks. Examples of decision support systems include Portfolio Management Systems, Brandaid and Routing and Scheduling System (Keen and Scott Morton 1978).

The two other generic types of information systems (management information systems and transaction processing systems) can be thought of as positioned below DSS in a heirarchy of generalness. This is shown in the figure below.



Transaction processing systems consist primarily of accounting information systems and focus on the collection of data and accumulation of information. Detailed information is what is of concern here and the emphasis is on control. Using Sears as an example, transaction processing would involve counting the number of lawn mowers sold at one store, dollars collected, and so on.

Management information systems are concerned with more general or more summarized information. Continuing with the Sears example, a district manager may use a MIS to help in decision making concerning the allocation of advertising dollars among the various stores in his district. The emphasis is operational with some planning involved.

Decision support systems are concerned with the most general or summarized information. Overall trends in data are what is of concern here and the emphasis is on planning. Upper management at Sears may use a DSS to aid in evaluating the benefits and weaknesses of making or buying their hardware lines. Both management information systems and decision support systems employ statistics and management science models.

1.1.2 DSS TECHNOLOGY

Technical tools for decision support systems can be grouped into three levels: specific DSSs; DSS generators; and DSS tools.

Specific DSSs are those which are designed to support a particular decision. They are dedicated and the user need not build or manipulate a model. Examples include Brandaid and PMS.

DSS generators are the tools which are used to build specific DSSs. A DSS generator in and of itself is not a decision support system, it is what is used to build one. Examples include IFPS, Lotus 1-2-3, and Express.

DSS tools may be used to build DSS generators. Sometimes these tools may also be used to develop a specific DSS. This group includes hardware and software. Examples of software include Fortran and Basic.

1.1.3 BENEFITS OF DSS

There have been many claims of increased efficiency and effectiveness resulting from the use of decision support systems. Alter (1980) points out the following:

i. Improved personal efficiency both in terms of computational time and the ability to analyze more alternatives.

ii. Expediting of problem solving.

iii. Facilitation of group communication.

iv. Improved learning or training.

v. Improved control. Alter claims that a DSS allows for more control over lower levels, forcing them to generate better information.

But skeptics note that most of these claims are based on anecdotal evidence or evidence with no laboratory tests. This study was aimed at testing the value of a decision support system.

1.2 RELEVANT STUDIES

1.2.1 RESEARCH IN MIS

1.2.1.1 Frameworks - Process/Design/Development

Mason and Mitroff (1973) describe an information system as: 1. a PERSON of a certain PSYCHOLOGICAL TYPE who; 2. faces a PROBLEM; 3. within some ORGANIZATIONAL CONTEXT for which he needs; 4. EVIDENCE to arrive at a solution, where evidence is; 5. made available through some MODE OF PRESENTATION.

They point out that previous research has focused on one underlying psychological type, one class of problem, one or two methods of generating evidence, and one mode or method of presentation. According to Ives et al (1980), the limitations of this model are that it focuses primarily on the PROCESS of using the information system in decision making. Development is not considered. Also, no reasonable dependent variable is suggested which might be used to measure the "goodness" of the model.

Chervany et al (1971), as cited in Ives et al (1980), attempt to isolate the major elements that determine the effectiveness of information systems (quality, cost, profit, time, etc.). Their result identifies the independent variables (factors which DETERMINE decision quality) and the dependent variables (factors which MEASURE decision quality). Ives et al (1980), point out the following limitations of Chervany et al. The list of variables is not exhaustive and the model focuses on designing the user system interface while overlooking development process considerations. Research using this model is best characterized by the Minnesota Experiments, which will be discussed later.

Nolan and Wetherbe (1980), note that Jenkins (1977) enhanced the work of Chervany et al to provide a research framework which is similar to that of Mason and Mitroff, but is more contemporary and streamlined. Jenkins' research framework is based upon the following definition of a management information system.

> An MIS is at least one person utilizing an information system to undertake a task and the resulting performance.

This definition identifies four basic MIS variables - decision maker, task, information system, and performance. Based upon this definition, he has proposed that MIS research be conducted into each of the variables and the interaction among them.

Nolan and Wetherbe (1980) point out that both the Mason/-Mitroff and Jenkins frameworks provide excellent "micro" frameworks for MIS research because they are concerned with the minimal elements of MIS (i.e. "an MIS is at least ...). But broader issues pertinent to MIS research are not addressed.

Lucas (1973), as Ives et al (1980) mention, presents a descriptive model of situational, personal and attitudinal variables and their impact on usage of the system and the performance of the information system user. This approach is primarily concerned with behavioral aspects. Similarly, as Ives et al (1980) state, Mock's (1973) model is behavioral in nature but focuses on constraints imposed on the system designer.

Gorry and Scott Morton (1971), as cited in Ives et al (1980), consider information systems from the perspective of the information that it provides to management.

Ives et al (1980) claim that all these models suffer from a common drawback in that each takes a limited view of the MIS field.

Ives et al (1980) present what they believe is a comprehensive framework for MIS research in which information systems are described in terms of interfaces with an external environment, the organizational environment, three information system environments (user, development and operations), and three information-system processes (user, development and operations). They use this framework to describe five categories of MIS research.

Nolan and Wetherbe (1980) note that MIS is a pervasive concept and it is difficult to define exactly where MIS begins and other fields leave off. Despite this, they propose a systems approach to MIS research and outline a framework which relates research to MIS and six major factors which influence MIS. The six areas are management science, management accounting, management, human behavior, computer science and data processing.

All of the above frameworks look at either specific elements of MISs or how MISs relate to external factors. While Ives et al, Chandler (1982), and Nolan and Wetherbe take somewhat macro prospective none explicitly includes the most macro or general case of MIS versus no MIS. As Aldag and Powers (1984) point out, the claims of improved decision quality must be taken on faith.

1.2.1.2 Specific Experiments

Based on the above frameworks, unpublished frameworks or no frameworks at all, many studies have been conducted in the MIS area. Most of these studies have been aimed at identifying the best parameters of an MIS. The following summarizes some of the studies.

1.2.1.2a) THE MINNESOTA EXPERIMENTS . The Minnesota Experiments consisted of nine experimental gaming studies in computer based environments. Five simulators were used and each created a particular decision making environment and possessed specific information system characteristics. Independent variables were of two types: 1. subjects' characteristics or attributes (psychological, experience measures);and 2. characteristics of the information system provided to subjects (CRT versus batch output, form of output, etc.). The dependent variables varied from experiment to experiment and included:

i. Measures of decision quality - when possible and appropriate.

ii. Time taken to make decision.

iii. Confidence placed in decision made.

iv. Data selected to make the decision.

v. Kind of decision made (decision outcome).

vi. Measures of user evaluation of the information system.

These experiments are described in Dickson et al (1977). Summaries of the nine experiments are as follows:

1. Chervany and Dickson (1974) looked at the effects of batch output versus statistically summarized batch output and found that those subjects with the summarized output had lower production costs but took longer and had lower confidence. Quantitative aptitude was associated with cost performance but not significantly to time or confidence.

2. As Dickson et al (1977) note, Kozar (1972) built on the previous experiment and looked at statistically summarized batch output and the same output presented on a CRT. He found that the CRT group had higher costs and took longer. No difference was found in confidence. Quantitative or verbal measures did not significantly explain performance.

3. Dickson et al (1977) point out that Smith (1975) added graphical report generation capability and found the groups with access to this capability performed better in keeping down costs.

4. Dickson et al (1977) further state that Barkin (1974) investigated "data selection" as influenced by two different forms of output and found that the amount of data selected varied by cognitive style.

5. Senn (1973) looked at three forms of output: detailed output, line printer; summarized output, line printer; and

summarized output, CRT. He found that the CRT users made faster decisions and required less information.

6. Wynne and Dickson (1975) looked at some psychological aspects of gaming and found that presence of goals improved performance and use of an interactive system enhanced performance.

7. Benbasat and Schroeder (1977) investigated tabular versus graphic output, decision aids versus no aids, exception versus full reporting, and reports with only "necessary" data versus reports with overload information. Among their findings were that subjects receiving graphical output and decision aids performed better, and subjects receiving decision aids took longer to make decisions.

8. Schroeder and Benbasat (1975) looked at the variability of the decision making environment and its effect on the utilization of an information system and the confidence in decision making. Among their findings were: low variability group used less detailed reports; and no decision confidence effects found.

9. Chervany and Sauter, used a one shot decision exercise and found, among other things, that confidence in the subjects' decision was influenced by whether or not subject had business experience.

1.2.1.2b) LUCAS AND NIELSEN (1980). Lucas and Nielsen investigated how the mode of presentation (form of output) affects user performance (profits, sales, etc.) and learning (rate of increase in performance). Each player competed against the same four phantom firms which played according to a common predeveloped algorithm. Thus, independence from the other real players was maintained and greater experimental control allowed. Among their findings: CRT output results in superior performance but seems to have minimal effect on learning; MBA's performed better than executives and industrial engineers.

1.2.1.2c) PETERS (1984). Peters describes the administration of a simulation game that encouraged the design and use of efficient decision systems. In the game there is a cost attached to the use of these systems forcing students to recognize that information is not free. Thus, the students are confronted with a tradeoff between the cost of information gained through the use of the decision systems and the value of that information in improving their simulation decisions. By attaching an explicit cost to the use of this resource, the "brute force" approach of solving a problem by requesting huge amounts of information is avoided. It is hoped that students will use a more efficient means of arriving at a decision. The results of this approach are not given.

1.2.1.2d) LUCAS (1981). Lucas looked at the impact of computer based graphics on decision making. His results seem to support those of the Minnesota Experiments which provided some support for the use of graphics presentation in an information system. He also notes that decision or cognitive style appears to be an important variable influencing the performance of an individual and the reaction to an information system.

1.2.1.2e) GENTRY (1985). Gentry investigated the influence of the information presentation format on effectiveness of a retail information system. He concludes that the best information format depends upon the user's characteristics and upon the unique features of the task.

Courtney et al (1983) point out the following trends in business gaming research:

i. The studies have examined an impressive number of independent and dependent variables.

ii. The research clearly tends to be "behavioral" (versus technical).

iii. For the most part the research has been focused on the individual user or decision maker (rather than groups of users).

iv. Overwhelming majority of studies have concentrated on structured decisions in the Production Operations Management (POM) area of the firm (versus high level managerial decisions).

v. Subjects typically are not offered the opportunity to build their own decision models. This suggests that laboratory simulations have not been presenting subjects with modern DSS-type software. This drawback contributes to the external validity problem in laboratory research.

vi. Use of specialized simulations developed by an individual researcher for a particular experiment. This is expensive and time consuming. (They recommend use of a common simulator - THEIRS!)

vii. Oversimplicity of gaming studies. Most have presented subjects with fairly simple, structured problems to solve in rather limited time periods. Decisions are usually POM-oriented, require single winning strategy and take two hours to two days.

1.2.2 IMPACT OF DSS/MIS

Most computer systems are usually evaluated in terms of the cost/benefit analysis used for capital investment projects. The costs are measured in terms of hardware, software and personnel time costs. The benefits are estimated in terms of savings in personnel, reduced processing time, etc.

Keen and Scott Morton (1978) present a smorgasbord of methods, including:

i. Cost/benefit analysis

ii. Decision outputs

iii. Change in the decision making process

iv. Change in manager's concept of the problem

v. Procedural changes in the institution

vi. Speed and reliability of DSS

vii. Manager's assessment of the system's value

viii. Anecdotal evidence

Keen and Scott Morton note that not all methods can be used to evaluate every single DSS, but they recommend that more than one method should be used.

The problem with this, as well as other proposed schemes include:

i. Cost/benefit analysis is difficult because both the costs and benefits are very subjective.

ii. What is a change for the better in the decision making process is very subjective and such changes may be difficult to observe.

iii. Overall, most evaluations are after the fact.

Chandler (1982) evaluates an information system from two perspectives: one focusing on the computer system domain and the other on the user domain. He proposes an approach for analysis consisting of three stages; system evaluation, user goal evaluation, and design evaluation. Total system evaluation is viewed as being iterative, with each iteration involving the invocation of these three stages to improve system performance.

Aldag and Power (1984) point out that there has been little evaluation of decision support systems though they have reached a high level of development. They further suggest that to this date, claims of improved decision quality must be taken primarily on faith.

Their own experiment looked at the responses by subjects to a DSS as well as the impact of the DSS on various dimensions of task performance. Subjects were profiled according to several psychological measures and randomly assigned to two groups. Each group analyzed two cases, one with the use of the DSS and one without it.

Attitudes by the subjects, toward the DSS were generally positive, but independent raters' evaluations of the cases found no significant difference between cases completed with or without the DSS. In addition, the study found no significant relationships between cognitive style and performance.

The author would suggest that none of the work in these areas has looked at DSSs from a more macro perspective and evaluated the effectiveness and efficiency of DSS versus no-DSS. This paper reports the results of an experiment to test the hypothesis that a DSS improves efficiency and effectiveness of decision making. The tests involved the use of experimental gaming.

1.3 JUSTIFICATION OF THE STUDY

Studies abound on process/design/development but the impact of DSS has not been demonstrated. There are many skeptics who use computers for transaction processing and summarization but not for decision support in a more direct sense. Until it can be shown that a DSS can make a difference, this group will not convert to computer-aided decision making. While the MIS research has attempted to identify the best parameters of a MIS, it is useful to test effectiveness and efficiency of a DSS. Ideally, this DSS would include the features which have been identified as having an impact on the quality of decision making. But one question to answer is, is any DSS better than no DSS at all?

1.4 SPECIFIC OBJECTIVES OF STUDY

The specific objective of this study is to test the general hypothesis that a decision support system improves effectiveness and efficiency. It is designed to test in a laboratory setting the claims in favor of decision support systems.

The concerns of Courtney et al (1983) will also be addressed by this study and as such, the study will:

i. Not be behaviorally based.

ii. Focus on groups (rather than individual decision makers).

iii. Concentrate on unstructured decisions concerning high level management in an environment filled with uncertainty. No single winning strategy will exist and the experiment will be conducted over a full semester.

1.5 EXPERIMENTAL GAMING AS A RESEARCH TOOL: LITERATURE REVIEW

Clearly, field research designed to evaluate the efficiency and effectiveness of a DSS would be impractical and impossible to administer. No ongoing organization with a DSS in place would agree to drop its use for a length of time long enough to allow a researcher to evaluate the organization's resulting efficiency and effectiveness. It's equally unlikely that one could find an organization that overnight could move from being DSSless to having a DSS fully installed and operating. On the other hand, strict laboratory research in this areas is also impractical. It is difficult to imagine how a researcher can design a laboratory experiment which would yield results that can be considered analogous to the infinitely more complex real world.

Gentry et al (1983) suggest that field research and laboratory experimentation are two ends of a continuum and somewhere in the middle of this continuum exists experimental gaming. Further, gaming enjoys many of the benefits of both extremes while also suffering some of the weaknesses of each. It is hoped that the net result is more benefits and less weaknesses. For example, gaming allows sufficient control so as to ensure internal validity while at the same time being sufficiently realistic so as to have some external validity. Courtney et al (1983) also examined experimental gaming. Ge t y et al and Courtney et al point out the following advantages and disadvantages of experimental gaming.

1.5.1 ADVANTAGES

Gentry et al (1983) note that in many areas the alternatives to experimental gaming are infeasible, or nearly so. Field studies are costly and largely uncontrollable. Surveys require self reporting and recall of the decision process. Both are infeasible when the issue studied is sensitive. Experimental gaming is less expensive than field studies and removes the sensitivity issue. Further, it allows for higher participant involvement, presence of complex decision processes, interactions with other groups and longitudinal monitoring. Gaming also allows for greater control of the environment than field studies do.

Courtney et al (1983) suggest that experimental gaming allows for greater measurement and control of the independent, dependent and extraneous variables.

1.5.2 DISADVANTAGES

Gentry et al (1983) point out that because of experimental gaming's lack of resemblence to real organizations and the awareness of participants that they are participating in a game, its major weakness is artificiality. Games may be realistic in a mundane sense (decisions required relate well to those found in the real world) but usually suffer in terms of experimental realism (how seriously a subject takes the experiment). Further, gaming still requires a lot of resources (time required to administer and play), is usually played in small groups (problems with statistical power) and lacks control when the game is dynamic (game induced differences may result in vastly different perceptions of the manipulation). Also, the ethical problem of research versus teaching exists.

Courtney et al (1983) note that experimental gaming has problems with external validity, confounding, expense and time, and the need to continually upgrade software.

With the general advantages and disadvantages of experimental gaming in mind attention will now be turned to specific studies which have looked at the value of experimental gaming.

1.5.3 EFFECTS ON LEARNING

Jauch and Gentry (1976) summarize the effects on learning as follows. Fritzche (1974) found that gaming allowed for more learning than a lecture-centered teaching approach while Seitz and Thornton (1974) indicated that simulation motivated students but did not provide more traditional teaching approaches. Wolfe and Guth (1975) found no significant differences in learning when experimenting with the case versus game approach.

1.5.4 INTERNAL VALIDITY

Many authors have tried to assess the internal validity of experimental gaming through evaluations of players' previous academic performance and the results obtained by teams of players in a particular simulation. It has been hypothesized that high academic achievers should outperform low academic achievers. Studies along these lines have yielded mixed results.

Wolfe (1978) notes that Dill (1961) reported no correlation between a team's average ATGSB score and cumulative profits. He also notes that Potter (1965) found slight correlations between ATGSBs and a firm's rate of return, and a moderate correlation between a student's GPA and the firm's ROI. McKenney and Dill (1966), according to Wolfe (1978), discovered that firms with above average ratings on an academic performance index earned the highest profits while below average firms earned the lowest. Seginer (1980), as cited in Gosenpud et al (1984) found a significant positive relationship between previous academic ability and game performance. Gosenpud et al (1984) also state that Niebuhr and Norris (1980) reported a relationship between academic background (measured by college major) and performance.

Wolfe (1978) suggests that the reason for these discrepant findings is that research has consistently taken individually obtained academic achievement and related that achievement to game performance outcomes that were obtained through team work and team play and not through individual skills and abilities. "This practice has inadvertently introduced an individual's group maintenance and interpersonal skills into the research design."

Wolfe studied the relationship between standard measures of academic aptitude and achievement and the performance results obtained by students in sole control of their firms in a complex business game. He found a positive relationship between grades and aptitude scores and firm performance. More specifically, coursework grades were more strongly associated with firm performance than apptitude test scores.

As noted in Niebuhr and Norris's paper (1980), Niebuhr, Pope and Norris found that GPA was a significant predictor of performance only when the game situation was initially favorable for the participants. If the initial situation was made extremely unfavorable (negative cash flow, heavy loss position, low market share, etc.) the relationship between GPA and performance was not significant. The authors found that under the very unfavorable conditions, individual motivation states appeared to dominate the relationship with performance.

1.5.5 *EXTERNAL VALIDITY*

Assuming one accepts the conclusion that the experimental gaming approach is valid internally, one must investigate the question of external validity. Wolfe and Roberts (1983) outline the methods which have been used to investigate this area:

i. Comparing behaviors of students with those of successful business executives playing the same simulation.

ii. Contrasting the traits of successful student players with those of successful executives.

iii. Examine the quality range of play obtained by executives who have been differentially successful in their business careers.

According to Wolfe and Roberts (1983), studies in these areas have provided only circumstantial evidence supporting the external validity of a business game experience.

Norris and Snyder (1982) attempted a longitudinal study and determined that there were no correlations between students' game performance and students' career success five years later. Wolfe and Roberts (1983) performed a similar longitudinal study and found that successful business game play was associated with successful business careers when measured in terms of salary levels and job satisfaction. According to Wolfe and Roberts, "The Business Game (the business management laboratory)" seemed to implement those skills and cognitions which had previously led to academic achievement. These abilities in turn were carried into real world careers. Thus, the evidence on external validity of a participants' performance appears to be mixed.

1.5.6 GROUP SIZE AND GAMING

As discussed above, Wolfe has argued that teams of one should be used in experimental gaming so that internal validity can be verified. But, in the business world people are expected to perform in teams of several members. Group maintenance and interpersonal skills are clearly important. Thus, researchers may have to sacrifice running teams of one (to allow for the verification of internal validity) and work with teams composed of several members (to ensure external validity).

Gentry (1980) summarized the literature in this area as follows. Shaw found that group decisions yield results superior to those of individual decision makers. Remus and Jenner found that groups resulted in higher initial goals, more conservative decision making and more time and effort expenditure per person. Napier and House found group performance to be superior on a normative basis over individual performance. Wilson found that teams of three to five students generally foster more involvement than smaller or larger teams. Gentry (1980) found that smaller groups (two to three members) work better than four member groups in terms of minimizing group dissension. He also found that group size has no effect on the relative performances of larger groups. The reasoning for this finding is that larger groups are subject to greater group dissension but also are more likely to have a more talented group member. These two effects, according to Gentry, counterbalance.

1.5.7 QUANTITATIVE TRAINING AND GAMING PERFORMANCE

Niebuhr and Norris (1980) investigated the influence of quantitative training on performance in a business game simulation under varying conditions of situational favorableness. Overall, the study found that both academic major and degree of quantitative training were significantly related to game performance. However, examination of this relationship under the various conditions of situational favorableness indicated that the correlation between quantitative training and performance was significant only in the very favorable situation.

1.6 SUMMARY OF EXPERIMENTAL GAMING RESEARCH

Experimental gaming will be used as the research vehicle in this study. As previously discussed, Gentry et al (1983) have described field studies and laboratory work as two ends of a continuum. Experimental gaming lies somewhere on this continuum, closer to the laboratory end. It is hoped that this approach will allow for sufficient control while at the same time allow for realism. Dickson et al (1977) concluded that laboratory experiments, in particular experimental gaming, are valuable tools for testing hypotheses in the MIS area.

But, as has been previously discussed, the overall evidence concerning the external and internal validity of experimental gaming is mixed. The results on other factors such as grade, major, cognitive style and quantitative training also do not show a clear pattern. Since no other approach would be without problems for testing the hypothesis that a DSS improves decision effectiveness and efficiency, we adopted the experimental gaming approach.

2. METHODOLOGY

2.1 GENERAL DESCRIPTION OF APPROACH

The basic scheme of the experiment was as follows: all seniors in the College of Business Administration at Oklahoma State University are required to take an integrative Business Policy course. This course has students with diverse backgrounds and majors. Many sections are offered each semester. Some sections of this course play a decision making game (UCLA's Executive Decision Game). We built a DSS using a DSS generator, IFPS (Interactive Financial Planning System) for one of these sections and compared their performance in the game with that of another section where the DSS was not introduced.

2.2 THE GAME

The UCLA Executive Decision Game is a game for decision-making in which actual results of decisions are quickly "fed back" to the participants as bases for evaluation of performance and for improved decision-making in the future (Henshaw and Jackson 1983). Students participating in the game take themselves as top management of a firm in the manufacturing industry. Each period (or quarter) they make the following decisions:

Firm Level: Plant and equipment purchases
Purchase (sale) of securities

Product Level: Price
Marketing budget
Design and Styling budget
Production volume
Production budget

Each firm manufactures and sells up to three individual products, all of the same general species, but differing in price and quality. (Thus there are 17 decisions per quarter - two at the firm level and five at each of three product levels.) Each industry has eight firms which provide a variety of products at different prices and qualities aimed at different market segments. The demand for products is affected by general economic conditions which are measured in terms of a business index. The business index affects the overall demand of the product and the quality mix within that product line. There is also seasonality in product demand during each of the four quarters.

The top management makes the above mentioned decisions. These decisions are fed into the computer, which takes decisions of all eight firms as well as general economic conditions into account and produces the following reports for each firm.

Firm Level: Profit and Loss
Cash Flow
Financial Condition

Plant Report

Product Level: Income and Expenses

Production-Sales-Inventory

Industry Level: Business Index

Industry Report

Figures 1a and 1b exhibit the firm level reports. Figure 2 exhibits the industry level report.

The game simulates a competitive industry. The teams know how their competitors are performing, but all of them are affected by the general economic conditions, purchaser attitudes and the actions of other firms of the industry.

The decision problem in this game is somewhat unstructured because of the uncertainty in competitors' actions, and economic conditions. The problem is a good candidate for decision support. Using an interactive system, the top management may be able to investigate the effect of various uncertainties by examining many "what-if" scenarios. Once a general model of the decision problem is built, an interactive system would allow one to change the basic assumptions of the model as well. Thus the expectation would be that the firms having access to the DSS would make better decisions than the ones without access to the model.

EXECUTIVE GAME OUTPUT: FIRM REPORT

EXECUTIVE DECISION GAME — PERIOD 11

CONSOLIDATED REPORT FOR FIRM 7

PROFIT AND LOSS

TOTAL SALES REVENUE, ALL PRODUCTS		$ 1807481.
TOTAL LABOR AND MATERIALS COSTS	$ 640249.	
COMBINED INVENTORY VALUE ADJUSTMENTS	-50673.	
TOTAL MARKETING EXPENDITURES	250000.	
TOTAL DESIGN AND STYLING EXPENDITURES	75000.	
TOTAL WAREHOUSING AND SHIPPING COSTS	68132.	
DEPRECIATION	192645.	
ADMINISTRATION, ETC.	385532.	
TOTAL EXPENSES		$ 1560885.
TOTAL OPERATING PROFIT		$ 246596.
INCOME FROM SECURITIES		138645.
TOTAL TAXABLE INCOME		$ 385241.
TAX ON CURRENT INCOME		200000.
NET EARNINGS		$ 185241.

CASH FLOW

TOTAL SALES REVENUE, ALL PRODUCTS	$ 1807481.	
INCOME FROM SECURITIES	138645.	
TOTAL RECEIPTS		$ 1946125.
TOTAL EXPENSES, LESS INVTRY ADJ, DEPRN	$ 1418912.	
NEW PLANT INVESTMENT	0.	
NEW SECURITIES INVESTMENT	0.	
TAX ON CURRENT INCOME	200000.	
TOTAL DISBURSEMENTS		$ 1618912.
NET CASH INFLOW		$ 327213.

FINANCIAL CONDITION

NET CASH ASSETS	$ 1421427.
INVENTORY VALUE	131534.
PLANT AND EQUIPMENT VALUE	7513156.
SECURITIES	9243000.
NET ASSETS	$ 18309117.

PLANT REPORT

PLANT CAPACITY, PERIOD 12	375658.
LOSS FROM DEPRECIATION	9391.
GAIN FROM NEW INVESTMENT	20000.
PLANT CAPACITY, PERIOD 13	386267.

FIGURE 1A

EXECUTIVE GAME OUTPUT: PRODUCT REPORT

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E X E C U T I V E   D E C I S I O N   G A M E          P E R I O D  11

R E P O R T   O N   P R O D U C T   1     F I R M   7

I N C O M E   A N D   E X P E N S E

    REVENUE FROM SALES, AT  4.95 PER UNIT                       $   880931.

    LABOR AND MATERIALS, AT  1.60 PER UNIT,
        PLUS DIRECT COST OF OVERTIME          $   280000.
    INVENTORY VALUE ADJUSTMENT                       4746.
              DIRECT COST OF GOODS SOLD                         $   284746.

              G R O S S   P R O F I T                           $   596185.

    MARKETING EXPENDITURE                     $    90000.
    DESIGN AND STYLING EXPENDITURE                 25000.
    WAREHOUSING AND SHIPPING COST                  36024.
    DEPRECIATION, ALLOCATED                       105353.
    ADMINISTRATION, ETC.,ALLOCATED                171050.
              INDIRECT EXPENSE                                  $   427427.

              O P E R A T I N G   P R O F I T                   $   168759.

P R O D U C T I O N - S A L E S - I N V E N T O R Y

    INVENTORY QUANTITY, END OF PERIOD  10           10868.
    PRODUCTION VOLUME, PERIOD  11                  175000.
              G O O D S   A V A I L A B L E                         185868.

    ORDERS RECEIVED, PERIOD  11                    188960.
    SALES LOST DUE TO INVENTORY SHORTAGES           10994.
              S A L E S   V O L U M E                               177966.

              INVENTORY QUANTITY, END OF PERIOD  11                   7902.

              INVENTORY VALUE, AT  1.60 PER UNIT                $    12643.

              SHARE OF INDUSTRY SALES VOLUME, PERCENT                    5.
```

FIGURE 1B

EXECUTIVE GAME OUTPUT: INDUSTRY REPORT

```
E X E C U T I V E   D E C I S I O N   G A M E        P E R I O D  11

B U S I N E S S   I N D E X

        PERIODS  8 TO  11 (ACTUAL)          825       846       880       912
        PERIODS 12 TO  15 (ESTIMATED)       939       945       963       977
        PERIODS 16 TO  19 (ESTIMATED)       962       992       990       946

I N D U S T R Y   R E P O R T

F I R M   1
  PROFIT AND LOSS    FINANCIAL COND          INDIVIDUAL PRODUCTS
SALES RVNUE  2175.  NET CASH   ,    5314.   PRICE         350.   200.   350.
TOT EXPENSE  2485.  INVENTORY  ,       0.   MARKETING     102.    85.    68.
OPER PROFIT  -310.  PLANT-EQUP,    10247.   DESIGN-STYL    10.    19.     6.
SECURTY INC    55.  SECURITIES,     1688.   DIRECT CPU    155.   168.   173.
NET EARNED   -122.  NET ASSETS,    17249.   SLS VOLUME    267.   494.    82.

F I R M   2
  PROFIT AND LOSS    FINANCIAL COND          INDIVIDUAL PRODUCTS
SALES RVNUE  2947.  NET CASH   ,     324.   PRICE         450.   600.   745.
TOT EXPENSE  2596.  INVENTORY  ,       0.   MARKETING     157.   152.   140.
OPER PROFIT   352.  PLANT-EQUP,    11059.   DESIGN-STYL    25.    27.    28.
SECURTY INC   113.  SECURITIES,     7543.   DIRECT CPU    152.   249.   297.
NET EARNED    224.  NET ASSETS,    18925.   SLS VOLUME    295.   131.   102.

F I R M   3
  PROFIT AND LOSS    FINANCIAL COND          INDIVIDUAL PRODUCTS
SALES RVNUE  2904.  NET CASH   ,    1254.   PRICE         460.   600.   757.
TOT EXPENSE  2386.  INVENTORY  ,       0.   MARKETING     153.   126.   132.
OPER PROFIT   518.  PLANT-EQUP,     9360.   DESIGN-STYL    32.    35.    34.
SECURTY INC   126.  SECURITIES,     8593.   DIRECT CPU    179.   221.   275.
NET EARNED    309.  NET ASSETS,    19207.   SLS VOLUME    333.   177.    61.

F I R M   4
  PROFIT AND LOSS    FINANCIAL COND          INDIVIDUAL PRODUCTS
SALES RVNUE  2573.  NET CASH   ,    1210.   PRICE         444.   597.   749.
TOT EXPENSE  2264.  INVENTORY  ,       0.   MARKETING     142.   158.   141.
OPER PROFIT   309.  PLANT-EQUP,     9950.   DESIGN-STYL    22.    22.    23.
SECURTY INC   113.  SECURITIES,     7543.   DIRECT CPU    165.   210.   248.
NET EARNED    203.  NET ASSETS,    18703.   SLS VOLUME    307.   138.    79.

F I R M   5
  PROFIT AND LOSS    FINANCIAL COND          INDIVIDUAL PRODUCTS
SALES RVNUE  3468.  NET CASH   ,    1170.   PRICE         460.   597.   755.
TOT EXPENSE  2825.  INVENTORY  ,     410.   MARKETING     174.   112.   130.
OPER PROFIT   643.  PLANT-EQUP,    10141.   DESIGN-STYL    36.    30.    26.
SECURTY INC    98.  SECURITIES,     6543.   DIRECT CPU    174.   204.   321.
NET EARNED    356.  NET ASSETS,    18264.   SLS VOLUME    362.   184.   112.

F I R M   6
  PROFIT AND LOSS    FINANCIAL COND          INDIVIDUAL PRODUCTS
SALES RVNUE  1762.  NET CASH   ,     599.   PRICE         449.   598.   750.
TOT EXPENSE  1710.  INVENTORY  ,       0.   MARKETING     148.   155.   154.
OPER PROFIT    52.  PLANT-EQUP,     8827.   DESIGN-STYL    27.    26.    33.
SECURTY INC   128.  SECURITIES,     8503.   DIRECT CPU    171.   157.   145.
NET EARNED     86.  NET ASSETS,    17928.   SLS VOLUME    261.    63.    24.
```

FIGURE 2

2.3 DESCRIPTION OF DSS

Our decision support system (EXEC-DSS) was built using the DSS generator IFPS (Appendix B). IFPS is very user friendly and as such allowed us to code the model in natural language. In other words, variable names can be coded just as they are written. COST OF GOODS SOLD is referred to in the model as COST OF GOODS SOLD and not some cryptic code. This greatly enhances the users' ability to understand and work with the model. IFPS is also interactive and is set up in a spreadsheet format. Most importantly, IFPS has "what-if", "goalseeking" and "Monte Carlo simulation" features. This allows the user to quickly and easily consider various alternatives to deal with an uncertain world.

The model itself can be broken down into four main sections:

1. Given and Estimated Values
2. Decision Variables
3. Output
   - Income and Expenses, Product 1
   - Income and Expenses, Product 2
   - Income and Expenses, Product 3
   - Consolidated Report
   - Cash Flow
   - Financial Condition
   - Plant Report
4. Miscellaneous

2.3.1 GIVEN AND ESTIMATED VALUES

"Given Values" refers to where the user inputs values which have been determined in previous periods. This is necessary because the results of many decisions are dependent upon the results of previous decisions. In the model, PRIOR refers to one period back and PRIOR 2 refers to two periods back in time. At the beginning of the game all the teams received an output which summarized the position of the firm and contained the results of prior decisions, two periods back.

"Estimated Values" refers to the demand expected in the current period for each of the three products. It is the demand which actually occurs that drives the results for each of the firms. By varying the demand for each product according to various "what-ifs" the user can see what results will be obtained given that his estimated demand actually materializes. "Goal-seeking" can also be used here to determine what type of demand would be necessary in order to achieve some desired revenue or net earnings level.

2.3.2 DECISION VARIABLES

This is where the user inputs his potential decisions. As previously stated there are 17 decisions each quarter - two concerning the firm as a whole and five concerning each of three products. Here again, "what-if" and "goalseeking" analysis can be used to investigate the effects of various scenarios.

2.3.3 OUTPUT

This section displays the results that would be obtained with the given decision values and demand levels, if those demand levels actually materialized. This output is presented in a format similar to that which they receive from the game.

2.3.4 MISCELLANEOUS

This section contains the relationships which are used to calculate the results, given the decision values and demand levels.

It should be emphasized that the author designed and built the model with only as much insight into the game as the students had. The author was not involved in the actual running of the game and did not have access to any more information than the students were given. The model thus could have conceivably been built by any of the students if they had knowlwdge and experience of working with IFPS or some other modeling language.

Each team was assigned its own computer account number (with password) which contained a copy of the model.

2.4 A FLOWCHART FOR DECISION MAKING USING EXEC-DSS

It is important to note the distinction between the two computer programs involved in this experiment (see Figure 3). Both the control and treatment groups played the UCLA Executive Game. The inputting of decisions into this game and the returning of feedback was administered by an assistant to the professor who taught both groups.

Each of the teams in the DSS group had access to a copy of a decision support system named EXEC-DSS (see Figure 4). It resided on the mainframe at OSU and was accessible on interactive terminals by use of individual passwords. A team with access to EXEC-DSS could, if it chose, assess various "what-if" scenarios with EXEC-DSS before submitting their decisions. Once they arrived at their decisions, their decisions would be recorded on a piece of paper and turned in to the teaching assistant who would then input them into UCLA's Executive Game. The assistant would later return output from the game to them.

The teams without access to EXEC-DSS would ponder their choices and make their decisions however they saw fit. Once they arrived at their decisions, input and output would be performed by the teaching assistant as above.

2.5 EXPERIMENTAL DESIGN

As mentioned earlier, the experiment was conducted in two sections of a policy course at OSU during the spring semester of 1984. Both sections played UCLA's Executive Game.

One section was treated as a control group and presented with no information concerning IFPS. Sixteen teams of three players were in this group.

EXPERIMENTAL DESIGN

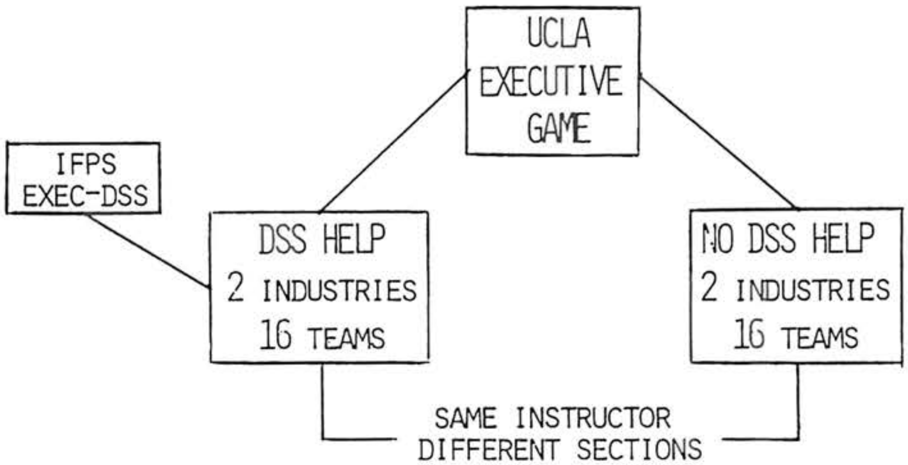


FIGURE 3

FLOW CHART FOR DECISION MAKING

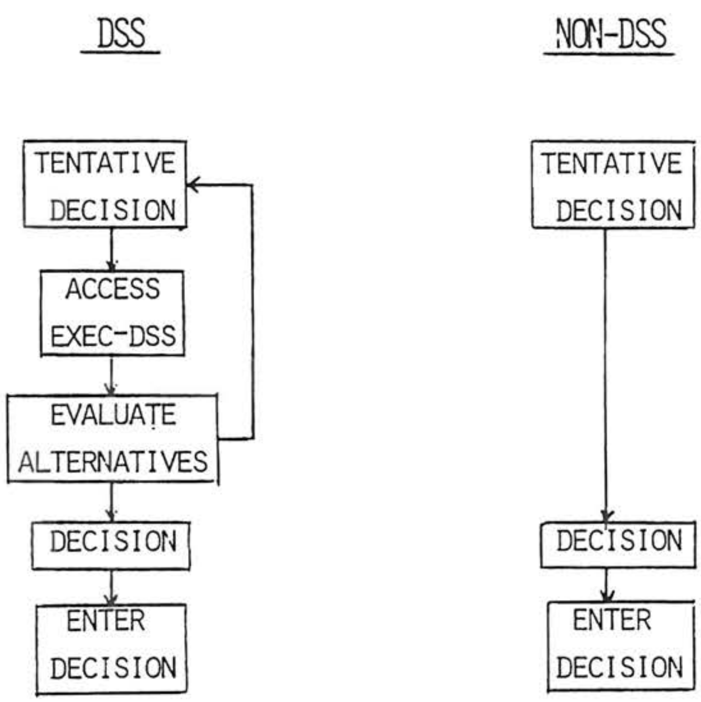


FIGURE 4

Another section was exposed to the DSS and taught how to access and work with it. In addition, they were informed that they were expected to use the DSS in decision making. Since their grade was based in part on their performance in the game and their record of their decision process, motivation existed to use the DSS. This group also had 16 teams with three players each (see Figure 3). There were thus 32 observations per week (16 control, 16 treatment). The game was played for a total of nine weeks. This resulted in 144 observations for each group or 288 in total over the entire experiment.

It was hoped that the experiment could have been played over a longer time period. This was not possible due to a variety of reasons. It should be noted though that even at nine weeks, this experiment is clearly one of the longest performed.

Much thought was given to whether the teams should be assigned by random draw or whether the students should be allowed o form their own groups. Mixed results have been found concerning subjects' GPA or level of quantitative training and their performance in gaming simulators. Dill (1961) found no correlation between ATGSB scores and performance measured in terms of profits. Seginer (1980), on the other hand, found a strong relationship between academic ability and game performance. To further cloud the issue, Chervany and Dickson (1974) found quantitative aptitude associated with performance while Kozar (1972) did not.

We chose to allow the students to form their own groups because it is believed that this best replicates reality. In the business world people form groups on many bases and we felt that our experimental design should reflect this. However we did record each of the students' GPA, major, and after the experiment, the grade they received in this class. This data was then analyzed to identify any major discrepencies in the composition of the teams.

A team size of two students was chosen because it was believed that this size would allow for maximum team interaction and ease of administration. Gentry's study (1980) in which he found that smaller groups (two or three members) work better in simulation games supports this decision.

From observation of computer billing records while the game was being played and from conversations with the treatment students, it is believed that the DSS was used heavily and that all the treatment teams used it roughly equally. Unfortunately, the computer billing records were not available in a form to be used as direct evidence of these observations.

Both the treatment and control groups had the same teacher, Professor Fritz Reiger, for regular class instruction. They met with him for three hours a week for 16 weeks, or a total of 48 hours over the semester. For two out of those 48 hours, at the beginning of the semester, the treatment group was introduced to IFPS and then the specific model by the authors for the purpose of introducing and explaining the DSS. This represents approximately four percent of the total instruction time. It is hoped that this amount of time was insufficient to introduce any significant instructor effect by the authors. It is difficult to imagine how one could insure no instructor effect as the treatment group had to be instructed in the use of the DSS.

We considered having the treatment group use DSS for half of the experiment and then letting them make decisions without using the DSS. This idea was rejected on the grounds that the carryover or learning effect would be too great to obtain unbiased results. After removing the DSS the group would clearly retain at least the basic idea of what critical elements must be considered in the decision making process and how they interact with one another. Even if the students were to play the game without the model first and then with the model, the results could be biased in favor of DSS because the students would have learnt some of the idiosyncracies of the game.

Aldag and Power (1984) divided their subjects into two groups and had them solve two cases, once with a computer aid and once without a computer aid. There were four case conditions:- cases solved with and without a decision aid and with or without prior use of the decision aid. We could not use a similar design for many reasons. Their experiment was different than the one at hand. The computer aid was a collection of generalized heuristic programs, and students worked individually. Further, the case solutions were judged by three raters. Because the experimental designs are so different, it is difficult to draw any conclusions regarding how allowing the subjects in this experiment to use the decision aid only part of the time would have affected the results. Further, a design of that type would not allow a longitudinal study, one of the concerns of Courtney et al.

It was thought that perhaps the subjects should be allowed to build their models themselves. But, in the real world, upper level managers do not construct models, rather they develop various "what-if" scenarios that are inputted into models developed by subordinates. Thus subjects should not build their own models, though enough flexibility should be retained in the model to allow them to modify it if they so desire.

The concerns of Courtney et al (1983) with regards to trends in business gaming research have already been discussed. It is believed that the design of this experiment addresses those concerns in the following way.

i. It is not behavioral in nature.

ii. Focuses on groups of users rather than the individual user or decision maker.

iii. Concentrates on high level managerial decisions rather than structured decisions in the POM area.

iv. Allows the students to manipulate the DSS-software somewhat, making it more valid externally.

v. Presents students with a complex, rather unstructured problem to solve over a long course of time (one semester).

2.6 EFFECTIVENESS AND EFFICIENCY DEFINED

Clearly, some decisions are better than others. Most people have an intuitive feel for the quality of a decision. When asked why one decision was better than another, often a person will note the more desirable outcome it effected. Or perhaps they will cite the fact that the implementation of many different decisions would have yielded the same result, but the higher quality decision brought the outcome about more quickly or more easily.

These two intuitive notions people have towards decision quality can be termed decision effectiveness and decision efficiency. Effectiveness refers to getting something done, while efficiency refers to how well it is done.

Defining decision effectiveness operationally is fairly easy. If a manager's objective is to increase revenue then total revenues for a firm can be examined over time. If they have grown satisfactorily then one could conclude that the manager has made effective decisions concerning revenues. In the business world, managers have multiple goals and objectives so a variety of effectiveness measures should be used. For example, a CEO's decisions may be evaluated for effectiveness in terms of total revenues, net earnings and ROE, with ROE weighing most heavily.

Decision efficiency is a more elusive measure of decision quality. If a manager's objective is to increase market share, then an efficient decision could be one that is effective, yet is brought about sooner, or is based upon the consideration of more alternatives.

The Minnesota Experiments looked at a host of independent and dependent variables. Concerning decision effectiveness, the dependent variables examined centered on production costs in gaming simulators. In this experiment, the following dependent variables will be examined to evaluate decision effectiveness.

i. Total revenues for the firm

ii. Total expenses for the firm

iii. Net earnings for the firm

iv. Net cash inflow for the firm

v. Net assets for the firm

vi. Revenue for each product of the firm

vii. Income for each product of the firm

viii. Market share for each product of the firm

Keen and Scott Morton (1978) recognize the importance of evaluating decision outputs but point out that other dependent variables should be included as well. They suggest speed and reliability among others. In order to evaluate decision efficiency this experiment will examine:

i. Time spent in decision making

ii. Number of alternatives examined before arriving at a decision

iii. Level of confidence in the decision

It is hoped that these eleven general measures will allow us to evaluate in quantitative terms the quality of decision making resulting from the use of a DSS.

If a DSS improves effectiveness and efficiency of decision making, one would expect that the net earnings for the firms using DSS would be higher than those for the non-DSS firms. Efficiency would suggest that the DSS firms would be able to make decisions faster and examine more alternatives. They should also exhibit a higher confidence in their decisions.

2.7 SPECIFIC HYPOTHESES

As has been stated, the purpose of this experiment is to test the general hypothesis that a DSS improves effectiveness and efficiency of decision making. Measures of efficiency and effectiveness will be taken each period during the game for each team. The generic hypothesis for each of these measures for each period is as follows:

$$\text{Ho:} \quad \mu_{\substack{\text{measure } i \\ \text{period } j \\ \text{dss}}} - \mu_{\substack{\text{measure } i \\ \text{period } j \\ \text{non-dss}}} = 0$$

$$\text{Ha:} \quad \mu_{\substack{\text{measure } i \\ \text{period } j \\ \text{dss}}} - \mu_{\substack{\text{measure } i \\ \text{period } j \\ \text{non-dss}}} = 0$$

where μ_{ij} is the average value of measure i over the 16 teams for period j.

In words, the null hypotheses states that there is no significant difference between the average value of each measure in each period for the DSS groups and the non-DSS groups. Significance is as determined by the t-test procedure, and a 95% confidence level is used unless otherwise stated.

Specific null hypotheses in this experiment are as outlined below. In each case the alternative hypothesis is that the difference between the means is not equal to 0. Thus, in this experiment, we would expect to reject each null hypothesis.

2.7.1 OVERALL

Let μ^* be the overall mean of a particular variable calculated as the average of all the observations for a particular group.

2.7.1.1 *Effectiveness Measures*

2.7.1.1a) Total Revenues for the Firm

Ho: $\mu^*_{\substack{\text{total revenues}\\ \text{dss}}} - \mu^*_{\substack{\text{total revenues}\\ \text{non-dss}}} = 0$

2.7.1.1b) Total Expenses for the Firm

Ho: $\mu^*_{\substack{\text{total expenses}\\ \text{dss}}} - \mu^*_{\substack{\text{total expenses}\\ \text{non-dss}}} = 0$

2.7.1.1c) Earnings for the Firm

Ho: $\mu^*_{\substack{\text{net income}\\ \text{dss}}} - \mu^*_{\substack{\text{net income}\\ \text{non-dss}}} = 0$

2.7.1.1d) Cash Flow for the Firm

Ho: $\mu^*_{\substack{\text{net cash inflow}\\ \text{dss}}} - \mu^*_{\substack{\text{net cash inflow}\\ \text{non-dss}}} = 0$

2.7.1.1e) Net Assets for the Firm

Ho: $\mu_{\substack{\text{net assets}\\ \text{period 10}\\ \text{dss}}} - \mu_{\substack{\text{net assets}\\ \text{period 10}\\ \text{non-dss}}} = 0$

2.7.1.1f) Revenue for Each Product of the Firm

Ho: $\mu^*_{\substack{\text{revenue}\\ \text{product } i\\ \text{dss}}} - \mu^*_{\substack{\text{revenue}\\ \text{product } i\\ \text{non-dss}}} = 0$

for i = 1 to 3

2.7.1.1g) Income for Each Product of the Firm

Ho: $\mu^*_{\substack{\text{op profit}\\ \text{product } i\\ \text{dss}}} - \mu^*_{\substack{\text{op profit}\\ \text{product } i\\ \text{non-dss}}} = 0$

for i = 1 to 3

2.7.1.1h) Market Share for Each Product of the Firm

Ho: $\mu^*_{\substack{\text{market share}\\ \text{product } i\\ \text{dss}}} - \mu^*_{\substack{\text{market share}\\ \text{product } i\\ \text{non-dss}}} = 0$

for i = 1 to 3

2.7.1.2 Efficiency Measures

2.7.1.2a) Time Spent in Decision Making

Ho: $\mu^*_{\substack{\text{time spent}\\ \text{dss}}} - \mu^*_{\substack{\text{time spent}\\ \text{non-dss}}} = 0$

2.7.1.2b) Number of Alternatives Examined Before Arriving at a Decision

Ho: $\mu^*_{\substack{\text{\# alternatives}\\ \text{dss}}} - \mu^*_{\substack{\text{\# alternatives}\\ \text{non-dss}}} = 0$

2.7.1.2c) Level of Confidence in the Decision

Ho: $\mu^*_{\substack{\text{confidence}\\ \text{dss}}} - \mu^*_{\substack{\text{confidence}\\ \text{non-dss}}} = 0$

2.7.2 BY PERIOD, ACROSS TIME

2.7.2.1 Effectiveness Measures

2.7.2.1a) Total Revenue for the Firm

Ho: $\mu_{\substack{\text{total revenues}\\ \text{period } j\\ \text{dss}}} - \mu_{\substack{\text{total revenues}\\ \text{period } j\\ \text{non-dss}}} = 0$

j = 2 to 10

2.7.2.1b) Total Expense for the Firm

Ho: $\mu_{\substack{\text{total expenses}\\ \text{period } j\\ \text{dss}}} - \mu_{\substack{\text{total expenses}\\ \text{period } j\\ \text{non-dss}}} = 0$

$j = 2$ to 10

2.7.2.1c) Net Earnings for the Firm

Ho: $\mu_{\substack{\text{net income}\\ \text{period } j\\ \text{dss}}} - \mu_{\substack{\text{net income}\\ \text{period } j\\ \text{non-dss}}} = 0$

$j = 2$ to 10

2.7.2.1d) Cash Flow for the Firm

Ho: $\mu_{\substack{\text{net cash inflow}\\ \text{period } j\\ \text{dss}}} - \mu_{\substack{\text{net cash inflow}\\ \text{period } j\\ \text{non-dss}}} = 0$

$j = 2$ to 10

2.7.2.1e) Net Assets for the Firm

Ho: $\mu_{\substack{\text{net assets}\\ \text{period } j\\ \text{dss}}} - \mu_{\substack{\text{net assets}\\ \text{period } j\\ \text{non-dss}}} = 0$

$j = 2$ to 10

2.7.2.1f) Revenue for Each Product of the Firm

Ho: $\mu_{\substack{\text{revenue}\\ \text{product } i\\ \text{period } j\\ \text{dss}}} - \mu_{\substack{\text{revenue}\\ \text{product } i\\ \text{period } j\\ \text{non-dss}}} = 0$

$i = 1$ to 3

$j = 2$ to 10

2.7.2.1g) Income for each Product of the Firm

Ho: $\mu_{\substack{\text{op profit prod1}\\ \text{product } i\\ \text{period } j\\ \text{dss}}} - \mu_{\substack{\text{op profit prod1}\\ \text{product } i\\ \text{period } j\\ \text{non-dss}}} = 0$

$i = 1$ to 3

$j = 2$ to 10

2.7.2.1h) Market Share for Each Product of the Firm

Ho: $\mu_{\substack{\text{market share}\\ \text{product } i\\ \text{period } j\\ \text{dss}}} - \mu_{\substack{\text{market share}\\ \text{product } i\\ \text{period } j\\ \text{non-dss}}} = 0$

$i = 1$ to 3

$j = 2$ to 10

2.7.2.2 Efficiency Measures

2.7.2.2a) Time Spent in Decision Making

Ho: $\mu_{\substack{\text{time spent}\\ \text{period } j\\ \text{dss}}} - \mu_{\substack{\text{time spent}\\ \text{period } j\\ \text{non-dss}}} = 0$

$j = 2$ to 10

2.7.2.2b) Number of Alternatives Examined Before Arriving at a Decision

Ho: $\mu_{\substack{\text{\# alternatives}\\ \text{period } j\\ \text{dss}}} - \mu_{\substack{\text{\# alternatives}\\ \text{period } j\\ \text{non-dss}}} = 0$

$j = 2$ to 10

2.7.2.2c) Level of Confidence in the Decision

Ho: $\mu_{\substack{\text{confidence}\\ \text{period } j\\ \text{dss}}} - \mu_{\substack{\text{confidence}\\ \text{period } j\\ \text{non-dss}}} = 0$

$j = 2$ to 10

3. ANALYSIS AND RESULTS

3.1 STATISTICAL TESTS

3.1.1 OVERALL

The following is a summary of the weekly means of the dependent variables for each group based on the entire nine week course of the experiment (a partial graphical summary is shown in Figure 5). Unless otherwise indicated, the differences between the means of the groups that had access to the DSS and the groups that did not are significant (according to the t-test procedure) at the 95% confidence level. First, the results over the entire game will be examined. Then the results will be analyzed across time, period by period, in an effort to detect trends. All of the results, overall and across time, are summarized in Tables 1 through 20 in the appendix.

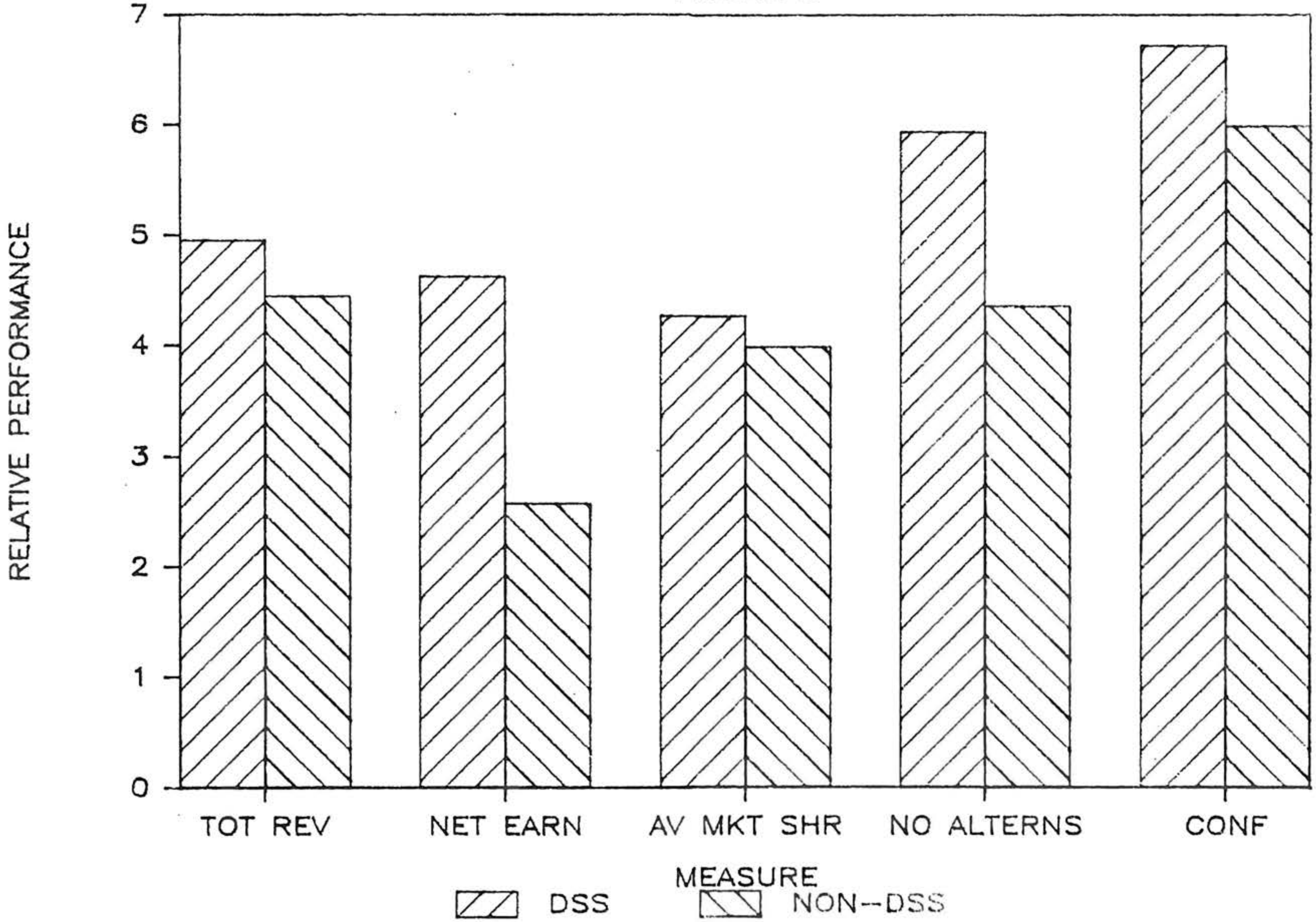
3.1.1.1 Effectiveness Measures

3.1.1.1a) Profit/Loss for the firm

Total revenue averaged $2,228,555 for the non-DSS groups each period. The average for the DSS groups was $2,479,188, 11.2% higher. Total expenses were also higher for the DSS group, but by only 5.3% ($2,264,306 for the DSS group versus $2,150,074 for the non-DSS group). This seems to suggest that the DSS group approached the game with the view that more money must be spent in order to make even more money. Whatever the underlying reason, the DSS groups averaged 79.4% higher in net earnings

PARTIAL SUMMARY OF OVERALL RESULTS

FIGURE 5



(total revenue - total expenses + income from securities - taxes). The average net earnings were $154,184 for the DSS groups, while only $85,932 for the non-DSS groups.

3.1.1.1b) Cash flow for the firm

Net cash inflow is the residual of total disbursements from total receipts. Included in total disbursements are investments in new plant and equipment.

Net cash inflow averaged -$105,300 for the non-DSS group and -$87,093 for the DSS group. Both figures contained wide variances and the differences between the means are not significant at the 95% confidence level while they are at the 90% level.

It appears that many of the firms, particularly in the non-DSS group were spending heavily towards the middle and end of the experiment on plant and equipment in order to improve their profit pictures. Intuitively, one might not expect expenditures on plant and equipment to fall towards the end of the game, as the additional production capacity is not realized until two periods after the expenditures are made. The last three periods of the game occurred during a low in the business cycle and net earnings were being hit hard for both groups. Expenditures on new plant and equipment may have been high in anticipation of the next upturn in the cycle. In addition, it should be noted that the students were not sure of exactly how long the game was going to be run. These two factors, anticipation of an upturn in the business and uncertainty over the length of the game, may have contributed to the large expenditures on plant and equipment and, as a result, the low net cash inflow figures.

It can be further suggested that the DSS groups made more timely and efficient decisions on plant and equipment expenditures. The average dollar value of net assets was $17,735,478 for the non-DSS groups and $18,416,334 for the DSS groups, by the end of the game, a 3.8% increase. Although more assets are not necessarily good in and of themselves, clearly, the DSS groups made more timely and efficient decisions regarding them as the DSS groups' net earning figures discussed earlier indicate.

3.1.1.1c) Income for each product of the firm

On average, the DSS groups had higher prices, revenues, operating profits and market share for all three of the products offered by each firm over the nine periods of the game. Specifically, the results are as follows.

The average price asked for product 1 over the nine periods was $4.39 for the non-DSS groups and $4.63 by the DSS groups, a 5.5% difference. Revenues associated with product 1 averaged $971,188 for the non-DSS groups and $1,057,331 for their counterparts, an 8.9% difference. Operating profits were a whopping 106.6% higher for the DSS groups over the the non-DSS groups. The average figures were $66,080, non-DSS and $136,508, DSS. Average market share was 6.8% higher for the DSS groups over non-DSS groups with values of 6.62% and 6.20% respectively.

This trend continues into product 2 where the average price asked was 4.9% higher for the DSS groups over non-DSS groups ($5.97 and $5.69 respectively). Revenues associated with product 2 were 12.7% higher ($772,186 and $685,041 respectively) and operating profit 85.3% higher ($64,958 and $35,049). Also higher, by 9.3%, was the average market share figure with values of 3.76% and 3.44% respectively.

We also observe this trend in product 3. The average price asked was 4.5% higher for the DSS groups over the non-DSS groups ($7.63 and $7.30 respectively). Revenues associated with product 3 averaged 12.6% higher for the DSS groups ($644,410 and $572,344). The average market share figures had a high degree of variability in them and the differences in their means are significant at only the 70% confidence level. The DSS group had an average figure of 2.44%, 4.7% above the 2.33% figure associated with the non-DSS group. The average operating profit figures for product 3 are significant at the 95% confidence level, as are all the other figures in this section except for market share for product 3 as just mentioned. Operating profit associated with product 3 was an astounding 153.3% higher for the DSS group averaging $11,938 versus -$22,402 for the non-DSS group.

3.1.1.2 Efficiency Measures

3.1.1.2a) Time spent in decision making

This section, and the two which follow, discuss measurements of efficiency as reported on a questionnaire turned in by the students each period. Difficulties were encountered in collecting the questionnaires during the last three periods of the game and as a result the number of observations for these measures during the last three periods is low. It is difficult to draw conclusions from data which includes these last three periods so for this reason they have been excluded. All figures are significant at the 95% levels, unless otherwise indicated.

The average amount of time spent in decision making each period over the first six periods was 2.96 hours for the non-DSS groups and 3.72 hours for the DSS groups. This represents a 25.7% difference for the DSS groups. It is not clear whether this suggests that use of the decision support system was of help or a hinderance to the DSS group. On the one hand, they spent more time making their decision which intuitively translates to lower efficiency. On the other hand it could be argued that because of exposure to the capabilities of a decision support system, they were encouraged to explore many more possibilities and "what-ifs". As has been shown in previous sections, the DSS groups performed significantly better in virtually all areas, but whether or not the marginal extra time they used to arrive at their decisions (25.7% more) was worth the marginal returns they gained in net earnings and so forth is difficult to quantify. In retrospect, a cost should have been attached for the use of the DSS (like Peters 1984) to avoid the possibility of students using the "brute force" approach to problem solving.

3.1.1.2b) Number of alternatives examined before arriving at a decision

The average number of alternatives examined by the DSS group each period, over the first six periods, was 36.2% higher than their counterparts (4.36 and 5.94 respectively). There existed a wide degree of variability among both groups and the difference between the means is significant only at the 85% confidence level. Although thses figures do not meet the previously stated 95% confidence limit, one can be fairly certain that the DSS groups as a whole did consider roughly one third more alternatives each period.

3.1.1.2c) Confidence in Decision

The students were also asked to rate their confidence in their decisions on a scale of one to ten (ten being the most confidence). The average for the non-DSS groups was 5.99 and 6.72 for the DSS groups, a 12.2% difference. The DSS groups took longer to arrive at their decisions but they considered more alternatives and were more confident in the decisions they arrived at. This difference was significant at the 95% level.

3.1.2 BY PERIOD, ACROSS TIME

Part 3.1.1 of the Analysis and Results section discussed the results of the experiment over its entire course. In this section the results are broken down by period and trends are examined. Because the number of observations is much lower in each individual period, our 95% confidence limit is often not met. The confidence limits which are appropriate will be pointed out so that the reader may judge for himself the validity of the conclusions which are drawn. Again, see Tables 1 through 20 in the Appendix for a statistical summary.

3.1.2.1 Effectiveness Measures

3.1.2.1a) Profit/Loss for the Firm

As applies to total revenues, three periods met the 95% confidence limit (5,6,7), four met the 80% confidence limit (4,8,9,10), and two fell at less than 50% (2,3).

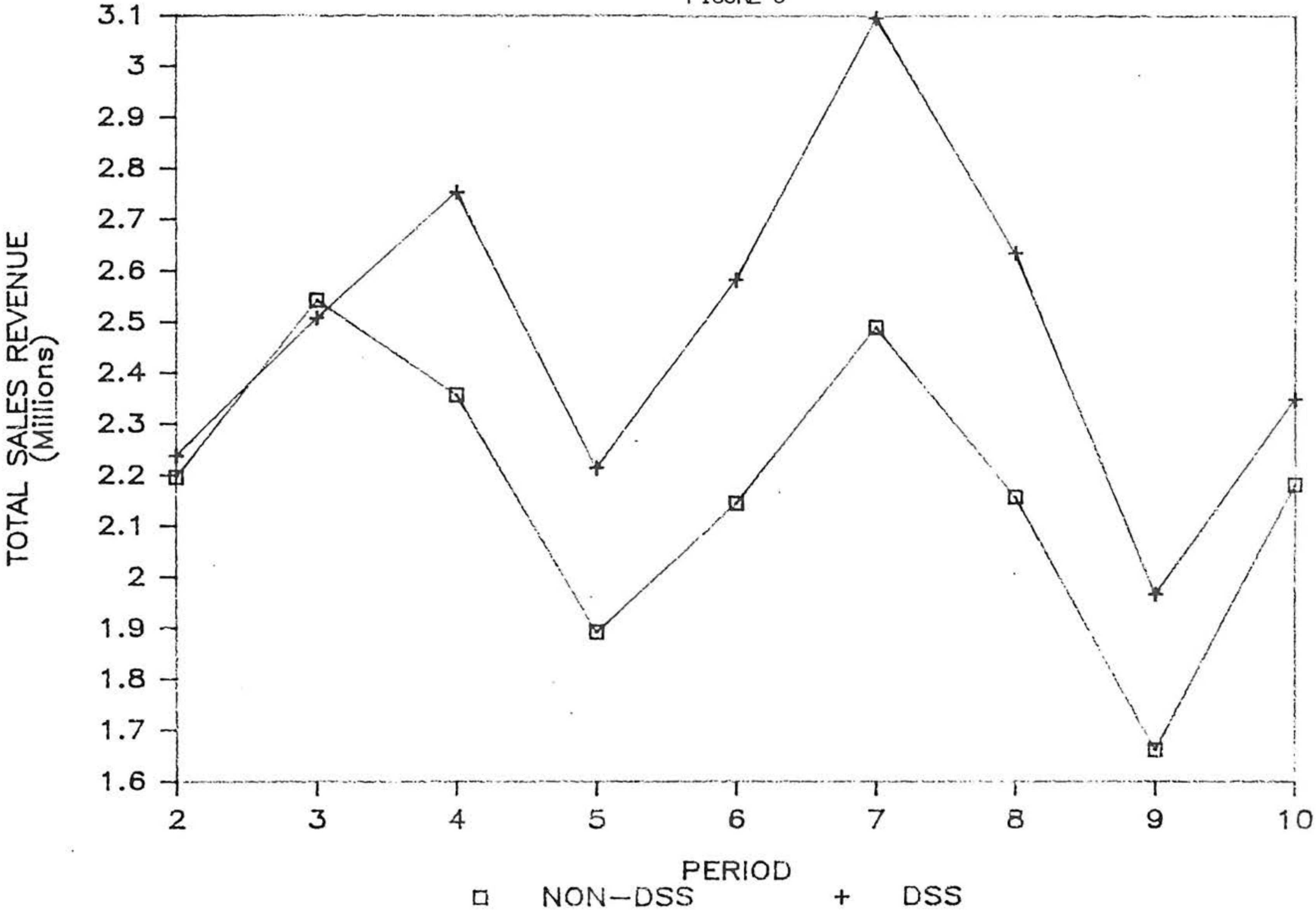
For total expenses, one period met the 95% limit (7), one met the 90% limit (6), two met the 80% limit (4,5), one met the 75% limit (8), one met the 60% limit (9) and three fell below 50% (2,3,10).

For net earnings, three periods met the 95% limit (5,6,7), three met the 85% limit (4,8,10), one met the 75% limit (2), one met the 60% limit (9), and one fell below 50% (3).

The game covered two complete business cycles and both groups were clearly affected by them (see Figures 6,7,8). Given the cyclical nature of the game, the DSS groups outperformed their counterparts after the second period of the game (period 3). Inspection of total revenue, total expenses and net earnings over time reveals that both groups performed roughly equivalently in the first two periods, but thereafter, the DSS groups were not hit as hard during business lows and were better

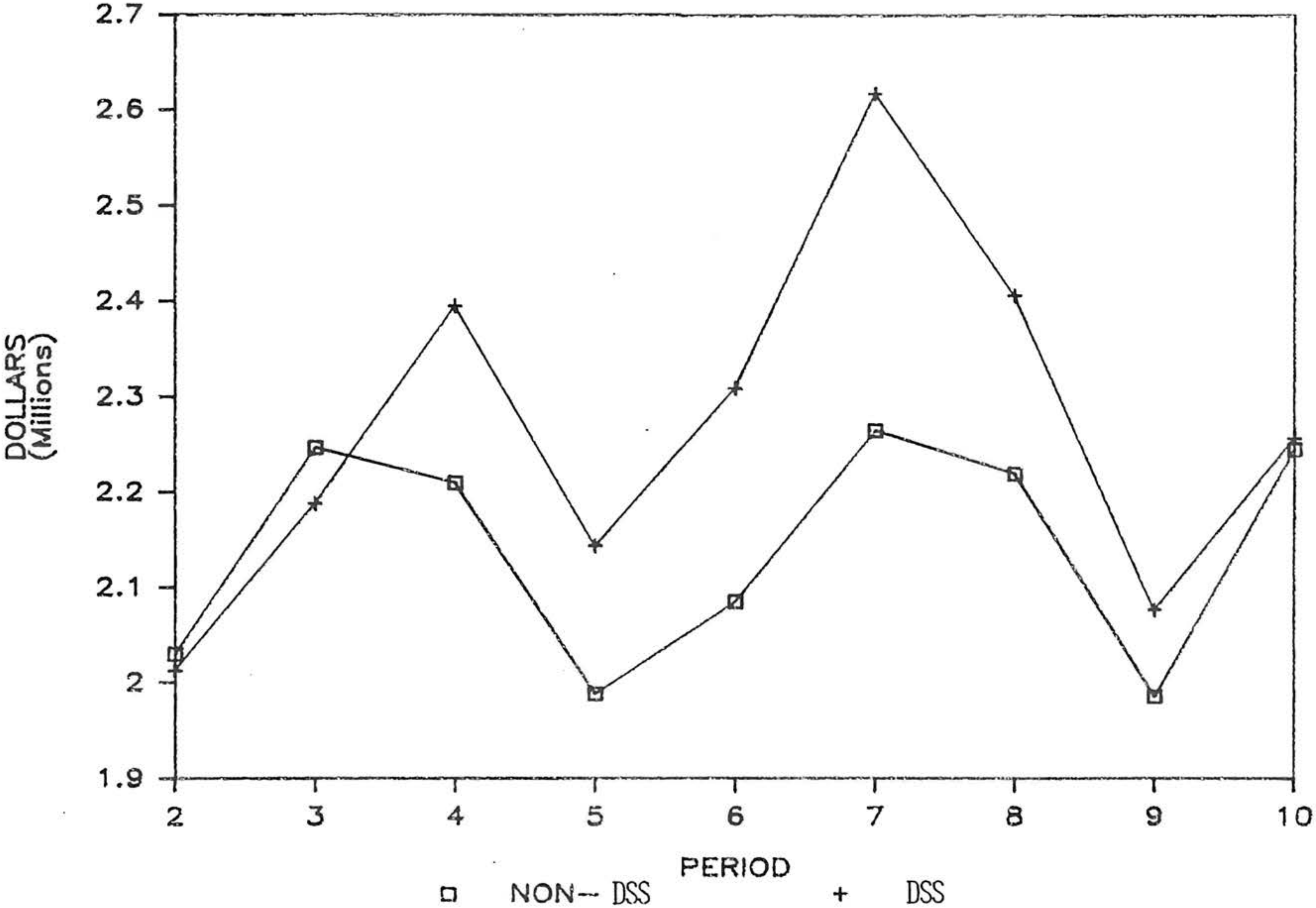
TOTAL SALES REVENUE

FIGURE 6



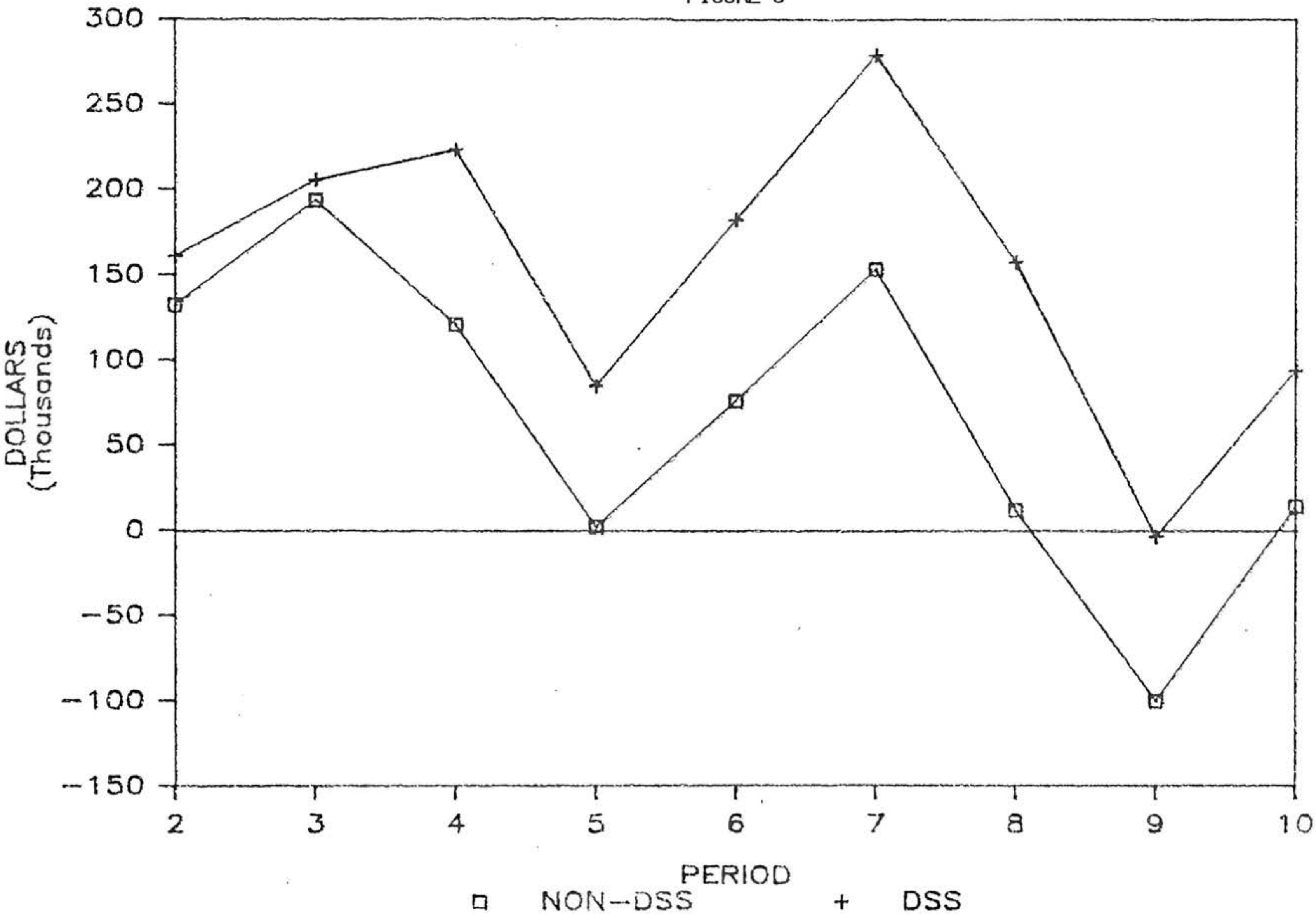
TOTAL EXPENSES OVER TIME

FIGURE 7



NET EARNINGS PER PERIOD

FIGURE 8



able to take advantage of business upturns. It should be noted that during the first two periods of the game, the DSS groups were being trained in the use of the decision support system.

3.1.2.1b) Cash Flow for the Firm

There existed a high degree of variability among the net cash inflow figures for both groups each period. Because of this and the low number of observations, the differences in the means between the groups are significant at the 80% level in one period (2), at the 60% level in two periods (5,7) and at less than 50% in the remainder (3,4,6,8,9,10).

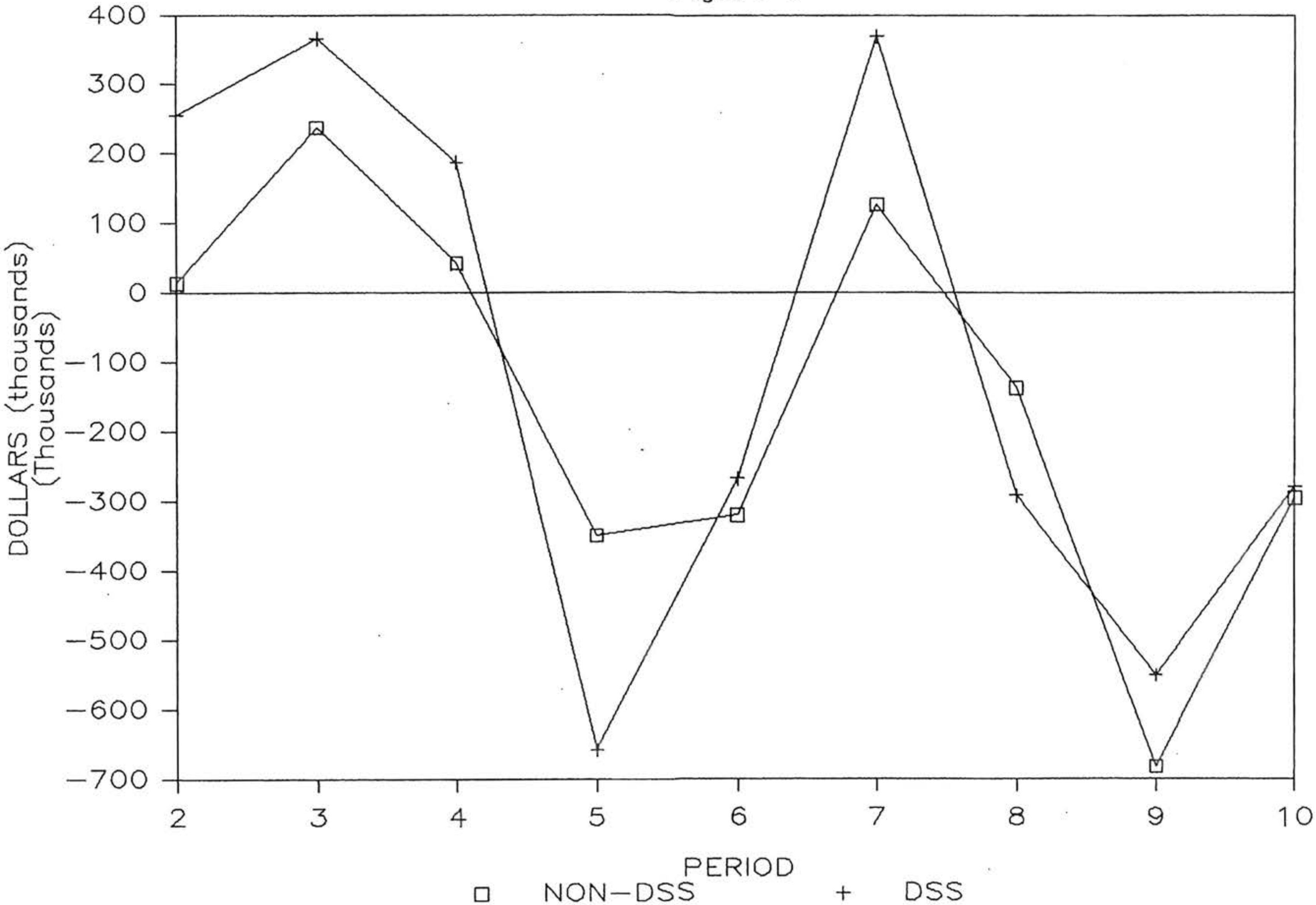
As Figure 9 suggests, there was relatively no significant difference between the groups' cash inflows over time. Despite this, the DSS groups were able to accumulate more assets over time and put them to more effective use, as was discussed earlier. Figure 10 illustrates this point. In addition, the significance levels for the total asset figures are fairly high. Three periods met the 95% limit (2,7,10), two periods met the 90% limit (5,6), three met the 80% limit (4,8,9), and one met the 65% limit (3).

3.1.2.1c) Income From each Product of the Firm

Each firm produces and markets three products. The DSS group performed better overall in operating profits associated with each of the three products in each period. The significance

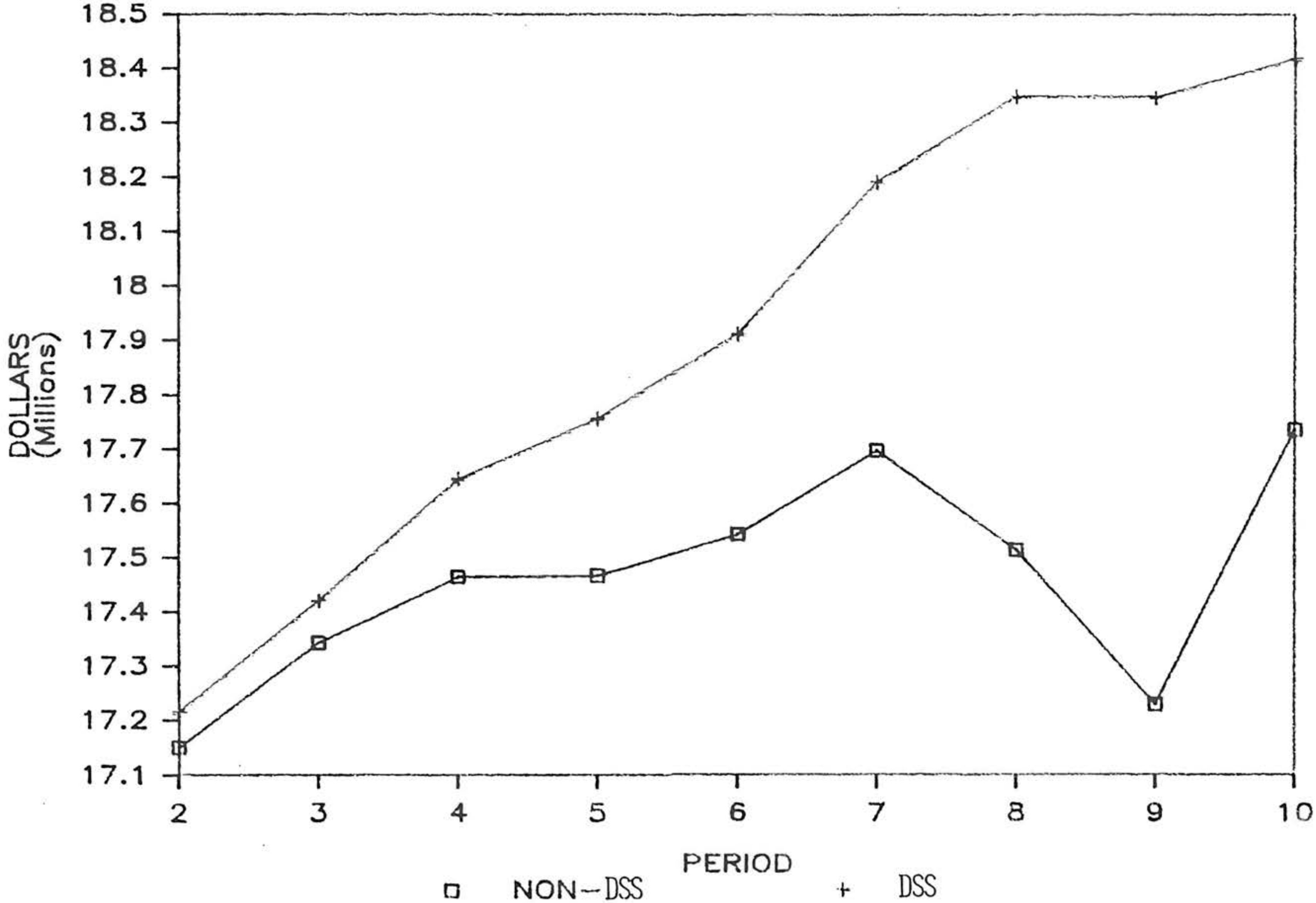
NET CASH INFLOW

Figure 9



NET ASSETS OVER TIME

FIGURE 10



level of the differences between the means of the two groups each period are as follows.

For product 1, two periods met the 95% limit (6,7), two met the 90% limit (4,5), two met the 80% limit (8,10), and the remainder met the 65% limit (2,3,9).

Concerning product 2, one period met the 95% limit (6), two met the 85% limit (5,10), three met the 70% limit (2,7,8), and the remainder fell below 50% (3,4,9).

For product 3, three periods met the 95% limit (5,6,7), one met the 85% limit (4), four met the 65% limit (2,3,8,10) and one met the 55% limit (9).

3.1.2.2 Efficiency Measures

3.1.2.2a) Time Spent in decision making

At our 95% confidence level the results of the number of hours students spent in decision making are significant only for the first three periods. The remaining periods fall at or below the 50% level. During the first three periods, the DSS groups spent more hours than their counterparts and whether or not this suggests that the decision support system is effective has been discussed earlier (see Figure 11).

3.1.2.2b) Number of alternatives examined before arriving at a decision

Again, because of the high degree of variability among the responses by the students, the results concerning the number of alternatives considered are not significant at the 95% confidence level. Three of the periods are significant at the 85% level (3,5,6), two at the 65% level (4,7) and one at the 50% level (2).

Given these levels of confidence, a downward trend was observed for both groups in the number of alternatives considered, with the DSS groups considering more than their counterparts each period until the last period (see Figure 12). It is presumed that both groups gained confidence in their ability to narrow down worthwhile alternatives to consider as the game wore on, resulting in the downward trend. It is possible that the non-DSS group became concerned about their performance in period 7 and made an effort to improve it at that time by considering more alternatives, resulting in the upward spike which occurred for that group at that time. Excluding period 7, the DSS group consistently considered more alternatives.

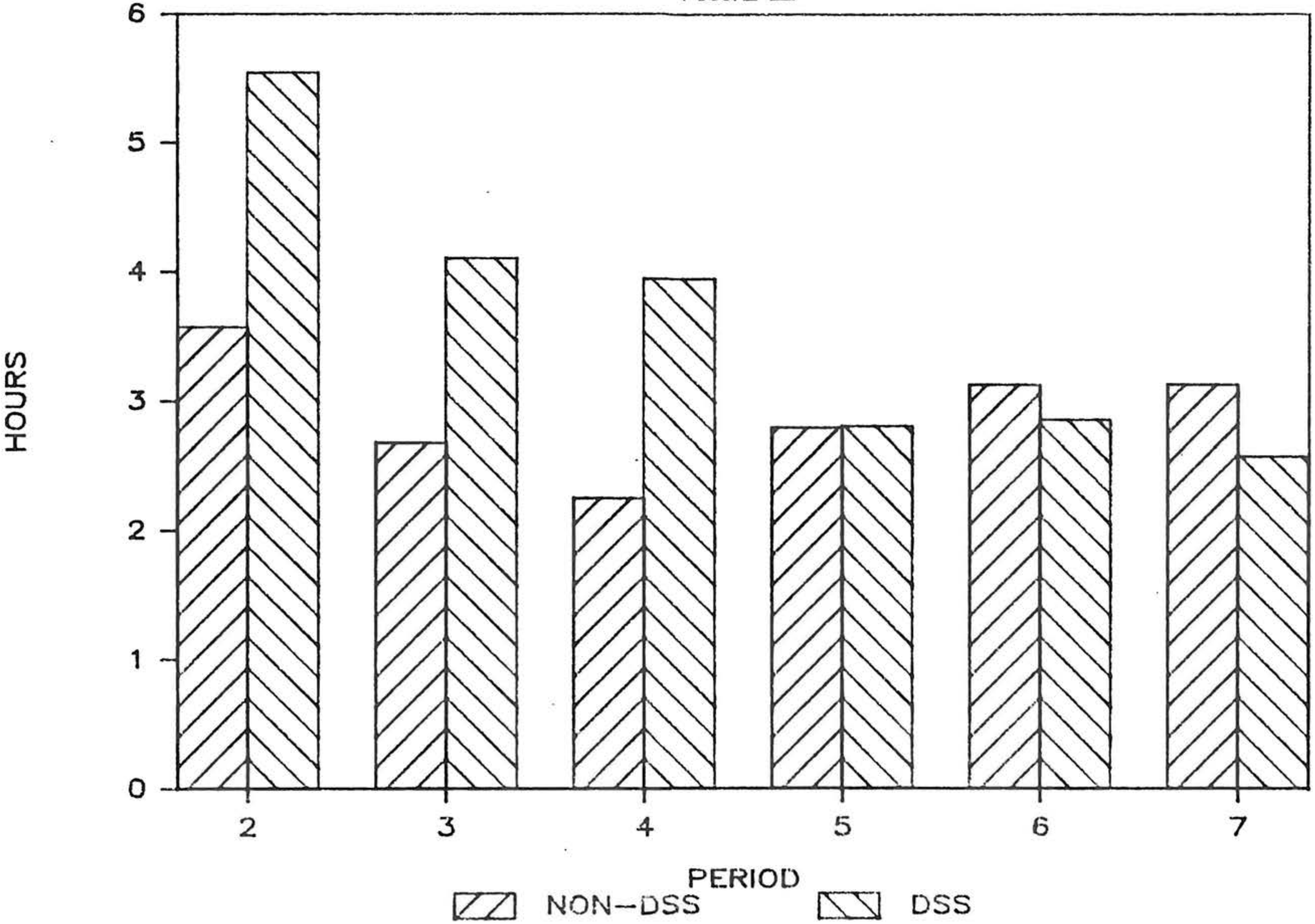
3.1.2.2c) Confidence in decision

The significance level for the reported level of confidence in decisions made is as follows. 85% for one period (4), 65% for one period (6), 55% for three periods (2,3,5) and less than 50% for one period (7).

Given these levels of significance, an upward trend was observed for both groups in their confidence in their decisions over time. The DSS groups were consistently more confident except in period 7 (see Figure 13). As was discussed earlier, the non-DSS group considered more alternatives in that period and

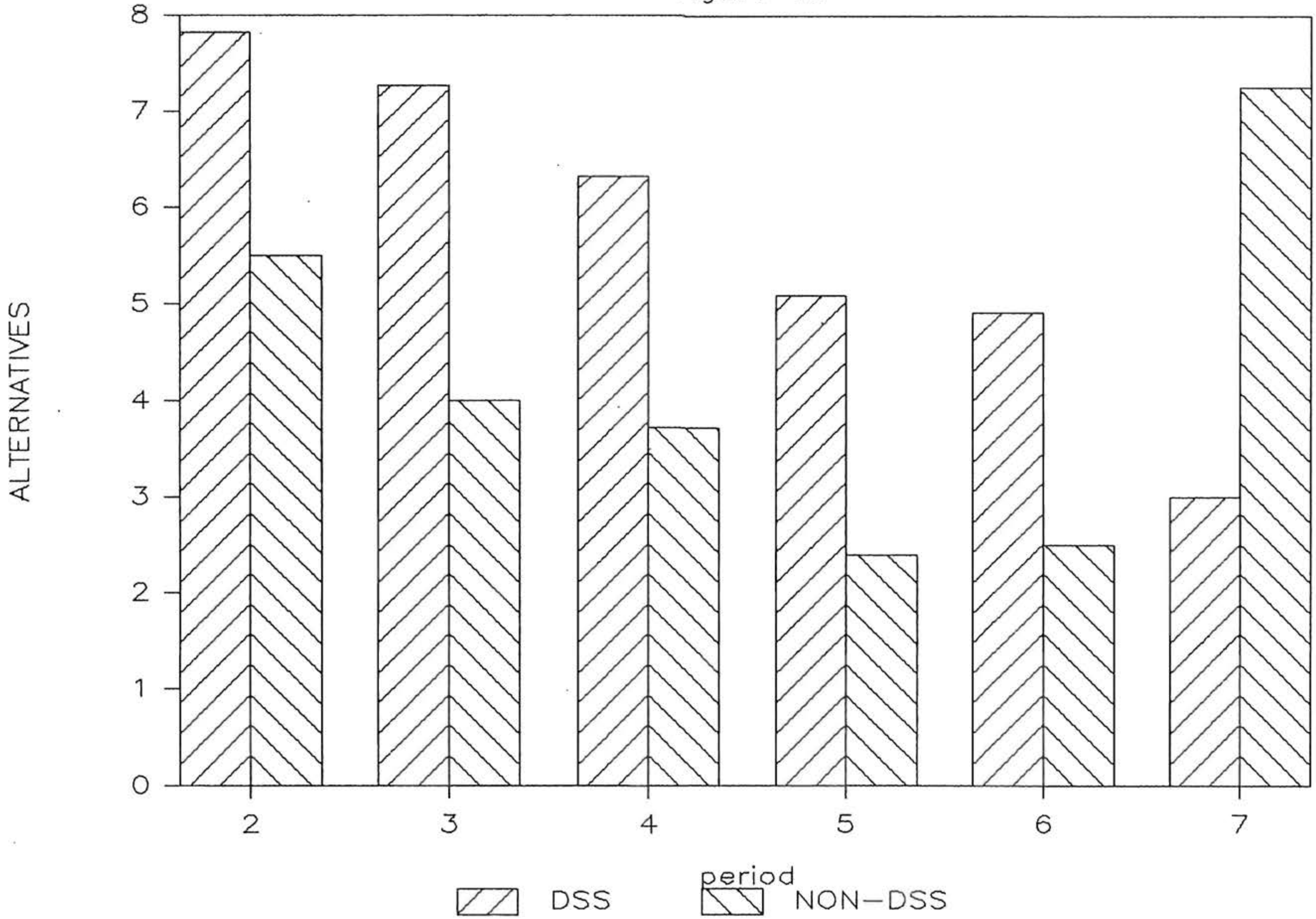
TIME SPENT IN DECISION MAKING

FIGURE 11



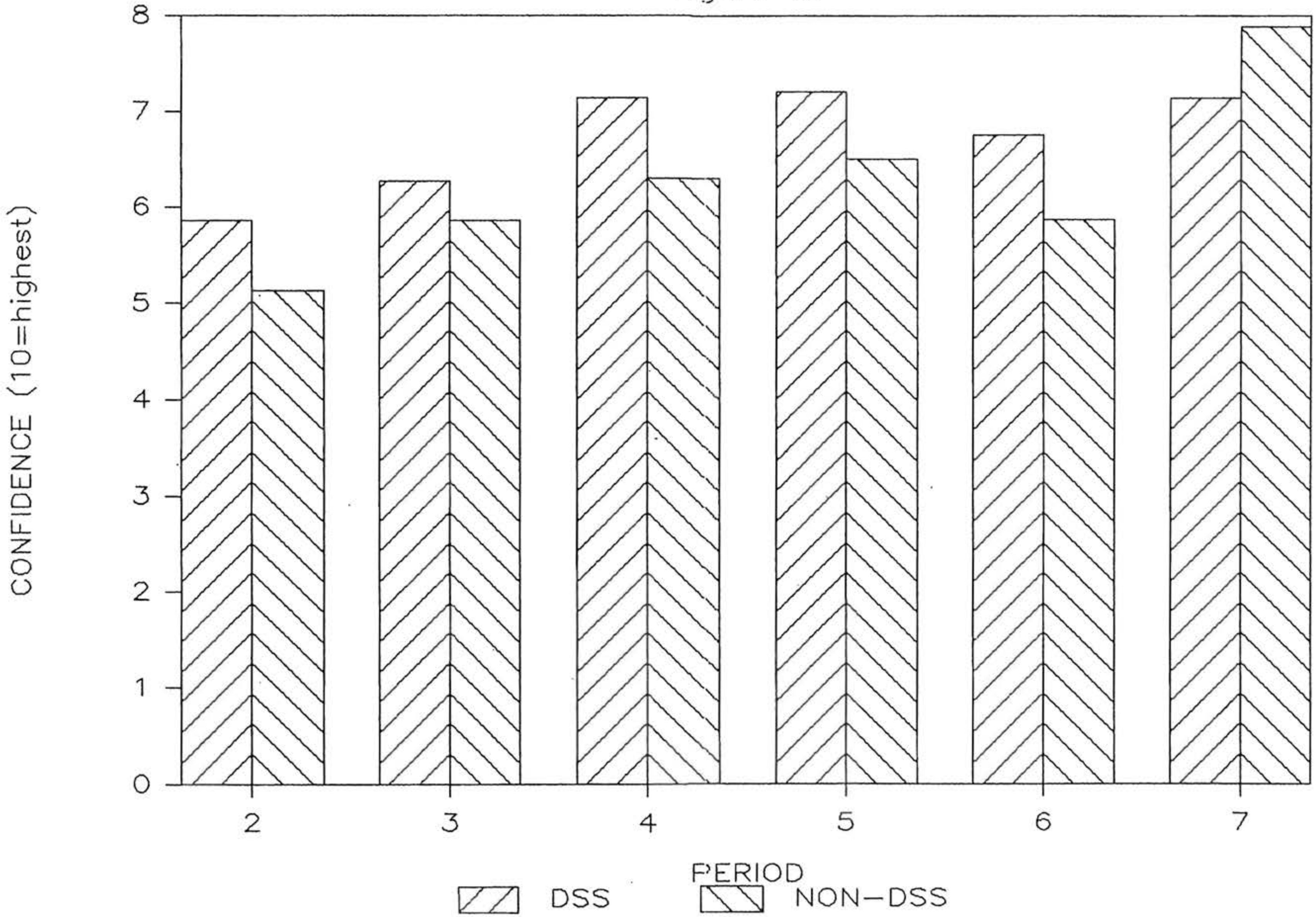
NUMBER OF ALTERNATIVES CONSIDERED

Figure 12



CONFIDENCE IN DECISION

Figure 13



perhaps their confidence was higher at that time as a result of that. But, given the low level of significance for that period, that conclusion is tentative at best.

3.2 CONTROL

In order to control for students majors and grades, several analyses were performed.

3.2.1 t-TEST, GPA

First a t-test was conducted to ensure that neither of the treatment groups contained academically superior students as measured by their GPA. The following hypotheses were proposed:

Ho: $\mu_{GPA,DSS} - \mu_{GPA,non\text{-}DSS} = 0$

Ha: $\mu_{GPA,DSS} - \mu_{GPA,non\text{-}DSS} = 0$

Rejecting Ho would say that there is a significant difference between the GPAs by treatment. The non-DSS group had a mean GPA of 2.936 with a standard deviation of o.435 while the DSS group had a mean GPA of 2.931 with a standard deviation of 0.443. Thus,

$$\bar{x}_{DSS} - \bar{x}_{non\text{-}DSS} = 2.931-2.936 = -0.005$$

In order to check whether this difference is significant, the t-statistic is calculated as follows:

$$t = \frac{\overline{X}_{DSS} - \overline{X}_{non-DSS}}{\frac{S^2_{DSS}}{n_{DSS}} + \frac{S^2_{non-DSS}}{n_{non-DSS}}}$$

This calculated t-statistic is 0.0522 which compares with a critical value of 1.67 at the 95 percent confidence level. We thus fail to reject Ho and conclude that there is no significant difference between the mean GPAs by treatment.

3.2.2 CHI-SQUARE - MAJORS FINELY DIVIDED

The students were grouped according to their majors as follows:

MAJOR	DSS	NON-DSS
0=Uncertain	5	0
1=Marketing	9	6
2=Accounting	14	11
3=Finance	3	9
4=Economics	1	0
5=Management Science/Computer Systems	5	4
6=Information Processing	2	0
7=Business Education	0	0
8=Executive Secretary	1	2
9=Organizational Administration	1	2
10=Psychology	0	0
11=Management	5	3
12=Personnel	1	0

13=International Management	0	0
14=MBA	0	2

The null hypothesis tested was that the percentage of students in both the DSS group and the non-DSS group was the same for every major, or:

Ho: $\mu_{DSS} = \mu_{non-DSS}$; for each major.

or stated another way:

Ho: The two methods of classifying students (by major and by DSS or no DSS) are independent.

Rejection of Ho indicates that there IS a relationship between a student's major and which group he was in - DSS or non-DSS.

Next, the chi-square statistic was calculated as follows:

$$\chi^2 = \frac{(f_o - f_e)^2}{f_e}$$

where f_o = observed frequency.

f_e = expected frequency

Note that the statistic will be higher if the observed frequencies differ more from the expected frequencies. A small statistic (resulting from small differences) indicates that the two classifications are independent. The hypothesis is thus a one tailed test to the right since rejection will occur with a large statistic and will not occur with a small statistic.

Degrees of freedom were calculated as follows:

$$d.f. = (r-1)(c-1)$$

where r = number of rows.

c = number of columns

In the preceding table, note that the majors are divided very finely causing many of the cells to be sparsely filled. I fa t, over twenty percent of the cells have expected counts less than five students, resulting in a somewhat suspect chi-square test. The computed chi-square statistic is 11.1 with 10 degrees of freedom. This compares with a critical value of 15.99 at the 90% confidence level. Thus we fail to reject Ho and conclude that the classifications are independent.

Although the test is suspect, inspection of the chi-square table reveals that, overall, there are no major differences between the two treatment groups in terms of major.

Both treatment groups have, within two, the same number of students from each major except in three cases. The DSS group has three more marketing majors and three more accounting majors, while the non-DSS group has six more finance majors.

3.2.3 CHI-SQUARE - MAJORS MORE CLOSELY DIVIDED

Next, the majors were grouped more closely as follows:

MAJOR	DSS	NON-DSS
0=Uncertain	0	5
1=Marketing	9	6

2=Accounting	14	11
3=Finance Economics	14	9
4=Management Science/Computers Information Processing	7	4
5=Business Education Executive Secretary Organizational Administration	2	4
6=Psychology Management Personnel International Management	6	3
7=MBA	0	2

Again, over 20 percent of the cells have counts less than 5 so the test is suspect. The calculated chi-square statistic is 7.3 with 6 degrees of freedom. This compares with a critical value of 10.64 at the 90% confidence level. Thus we fail to reject the null hypothesis and conclude that the classifications are independent.

Although this test is also suspect, casual inspection reveals that both treatment groups have within three, the same number of students from each major classification. The only noticeable change resulting from this regrouping is that the non-DSS group has nine finance/economics majors versus four for the DSS group.

3.2.4 CHI-SQUARE - TECHNICAL VERSUS NON-TECHNICAL MAJORS

Lastly, the majors were grouped as being either technical or non-technical.

	MAJOR	DSS	NON-DSS
	0=Uncertain	0	5
Non-technical	1=Marketing	17	13
	Business Education		
	Executive Secretary		
	Organizational Administration		
	Psychology		
	Management		
	Personnel		
	International Management		
Technical	2=Accounting	25	26
	Finance		
	Economics		
	Management Science/Computers		
	Information Processing		
	MBA		

The computed chi-square statistic is 0.442 with one degree of freedom versus a critical value of 2.71 at the 90% confidence level. This test is not suspect and inspection of the chi-square table confirms that there are no major biases. Technical majors are virtually evenly spread across treatments (26 non-DSS versus 25 DSS) and non-technical majors nearly so (13 non-DSS versus 17 DSS).

3.2.5 CHI-SQUARE - GRADES RECEIVED

In addition to majors, the students were grouped according to the grade they recieved as shown below.

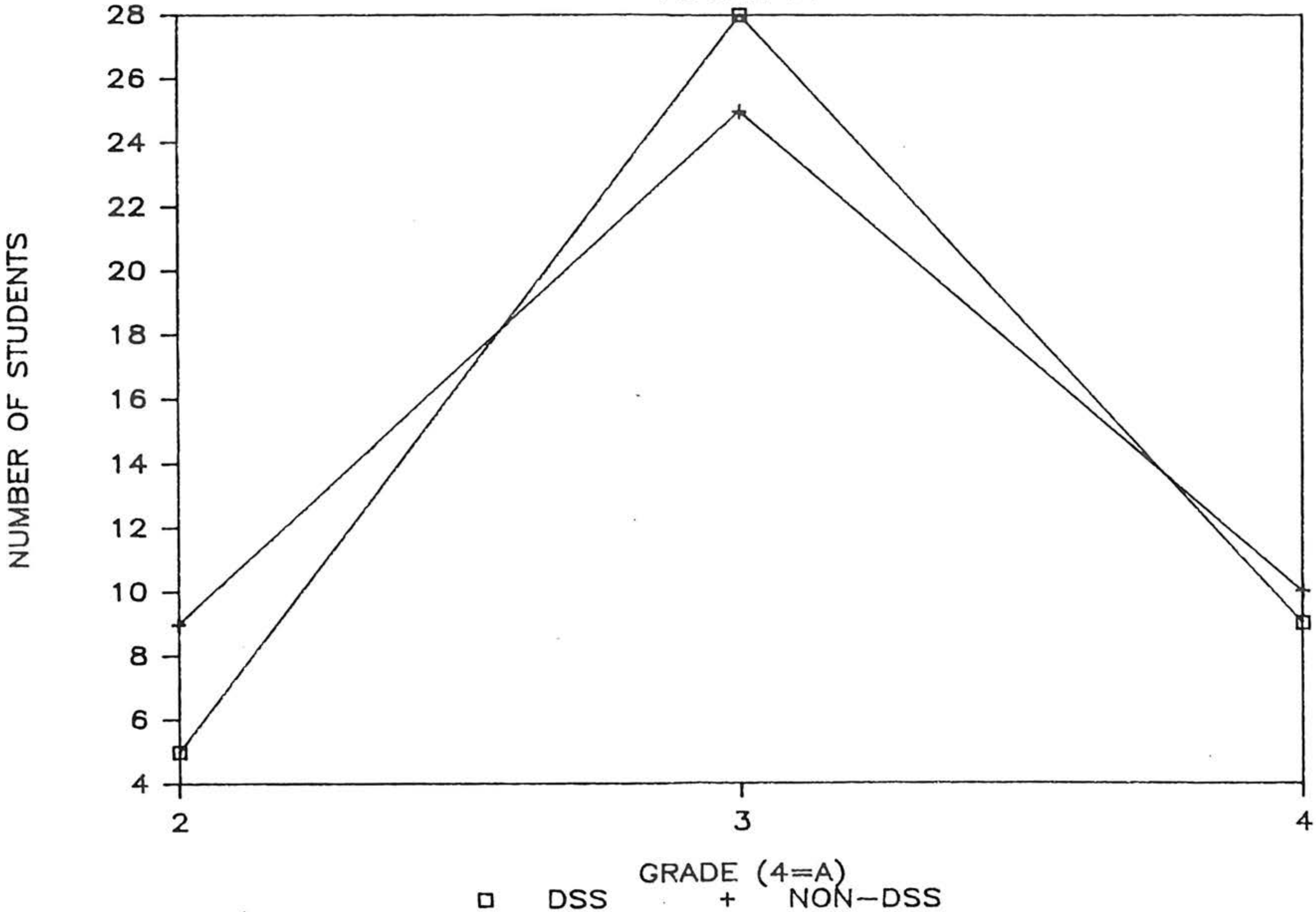
GRADE	DSS	NON-DSS
C	5	9
B	28	25
A	9	10

The computed chi-square value is 1.32 with 2 degrees of freedom versus a 4.61 critical value at the 90% level. Inspection confirms though that there were no major biases.

The non-DSS group recieved slightly more A's and C's, while the DSS group received slightly more B's. Figure 14 shows that the distribution of grades for the DSS group exhibits a little more certainty, centered around a grade of B, but the difference is not great.

DISTRIBUTION OF GRADES RECIEVED

FIGURE 14



3.3 DISCUSSION

In sum, we found that in this experiment, a DSS allowed for the treatment group to make both more effective and more efficient decisions. Important relationships between this and other studies will now be examined.

Many research frameworks for the information systems area have been proposed and examined (Section 1.2). As has been previously stated, none of these frameworks explicitly consider the macro case of DSS versus no-DSS. This experiment thus does not fit directly into any of the frameworks.

Gentry et al (1983) and Courtney et al (1983) have discussed experimental gaming as a research tool. It is hoped that the advantages of experimental gaming, as they have outlined them, have been maximized while the disadvantages have been minimized.

Mixed results have been found concerning experimental gaming and its effects on learning (Fritzche 1974; Sietz and Thornton 1974; Wolfe and Guth 1975). This study did not specifically address this issue and speculation will not be made.

Concerning internal validity, mixed results have been found concerning academic ability and game performance (Dill 1961; Potter 1965; McKenney & Dill 1966; Seginer 1980 and Niebuhr & Norris 1980). Wolfe (1978) suggests that these mixed results are due to the individual nature of academic achievement ratings and the collective nature of game performance ratings. He found in his study a positive relationship between subjects' grades and aptitude scores, and performance by a firm of which they were in sole control. We did not assign individual students to individual firms because in the business world, people perform in teams of several members. More importantly though, our analysis for academic ability indicates that there is no reason to believe that the treatment group performed better because its subjects were better academic achievers. A group size of three was chosen because it was believed that this size would be the easiest for students to work in. Gentry's study (1980) in which he found that smaller groups (two or three members) work better in simulation games supports this design.

Evidence concerning the external validity of experimental gaming is also mixed. The game played in this experiment was much more complex and life-like than most others examined and also was played over a much longer time span. It is believed that the simulation, though far from completely realistic, was at least satisfactorily so and certainly more realistic than most of the other studies examined.

Assuming internal and external validity considerations have been satisfied, attention will now be turned to how this study relates to other specific studies that have been conducted in the information systems area.

As has been mentioned, the Minnesota Experiments examined individual aspects of an information system. As such it is difficult to compare them directly with the study at hand. The exception to this is Benbasat and Schroeder (1977) in which they found that subjects with decision aids performed better. They also found that they took longer to make their decisions. Both of these findings coincide with our findings.

Aldag and Power (1984) found no difference in performance between cases prepared by students with access to a DSS and those without access. It should be noted that performance was judged by independent raters. Given the "soft" nature of the study, its findings do not necessarily conflict with those found here.

The studies by Lucas and Nielsen (1980), Peters (1984) and Gentry (1985) were also focused and will not be discussed.

Barkin's study (1974), though focused, warrants attention here. He found that the amount of data selected by subjects varied by cognitive style. Lucas (1981) found cognitive style an important variable influencing the performance of an individual and their reaction to an information system. Aldag and Power (1984), in a behaviorally based study on the other hand, found that subjects' responses to a DSS and their performance were not significantly affected by cognitive style.

Both the treatment and control groups in this experiment have been shown to be formed independently of the student's major, GPA and amount of technical training. Thus, there is no reason to believe that any of these influenced the superior performance of the DSS group. In any case, the evidence on their effect on the performances is mixed.

Overall, we found that a decision support system allowed for those with access to it to make significantly more effective and efficient decisions in a business simulation game. For virtually every measure of decision effectiveness examined the DSS group outperformed their non-DSS counterparts. Concerning decision efficiency, the DSS group considered more alternatives, took longer to make their decisions and were more confident in the decisions they made.

4. SUMMARY AND CONCLUSIONS

There have been many claims of increased decision efficiency and effectiveness resulting from the use of decision support systems. But skeptics note that these claims have been based on anecdotal evidence with no laboratory tests. Until it can be shown that decision support systems can make a difference, most practitioners will not convert to computer-aided decision making.

The specific objective of this study was to test the general hypothesis that a decision support system improves effectiveness and efficiency of decision making. It was designed to test in a laboratory setting the claims in favor of decision support systems. An executive decision game was played in a senior level policy course. One section was exposed to a DSS while another section played the game in the normal way. Various measures of the quality of decisions were recorded.

Overall, we found that a decision support system allowed for those with access to it to make significantly more effective and efficient decisions in a business simulation game. For virtually every measure of decision quality examined the DSS group outperformed their non-DSS counterparts. Concerning decision efficiency, the DSS group considered more alternatives, took longer to make their decisions and were more confident in the decisions they made.

5. SUGGESTIONS FOR FUTURE RESEARCH

We did not keep track of the actual usage of the DSS and the teams were not charged for this usage. Future studies should monitor the actual usage to ensure that any increases in decision quality are actually the result of the use of a DSS and not some external influence. In the real world information is not free and future studies should reflect this in order to gain more external validity. External validity would also be enhanced by using executives as subjects rather than students.

To further test the general hypothesis that DSSs increase decision quality, DSS generators other than IFPS should be used to build support systems. Further, these systems should be applied to other decision situations (other games). Ideally, ones even more strategic in nature. The UCLA Executive Game is far from simulating completely unstructured decisions. It is with unstructured decisions that DSSs are claimed to be most helpful.

Lastly, it was thought that perhaps the subjects should be allowed to build their models themselves. Letting subjects build their own models may allow us to examine another usage of DSS.

6. REFERENCES

ALDAG, R.J. and D.J. POWER, "An Empirical Assessment of Computer-Assisted Decision Making," Proceedings of the National AIDS Meeting, (November 1984).

ALTER, S.L., Decision Support Systems: Current Practice and Continuing Challenges, Addison-Wesley, Reading, Massachusetts, 1980.

BARKIN, S., "An Investigation Into Some Factors Affecting Information System Utilization," unpublished Ph.D. thesis, University of Minnesota (1974).

BENBASAT, I. and R.G. SCHROEDER, "An Experimental Investigation of Some MIS Design Variables," The Management Information Systems Quarterly, 1 (March 1977).

CHANDLER, J.S., "A Multiple Criteria Approach for Evaluating Information Systems," MIS Quarterly, (March 1982), 61-74.

CHERVANY, N.L., and G.W. DICKSON, "An Experimental Evaluation of Information Overload in a Production Environment," Management Science, (June 1974), 1335-1344.

CHERVANY, N.L., G.W. DICKSON and K.A. KOZAR, "An Experimental Gaming Framework for Investigating the Influence of Management Information Systems on Decision Effectiveness," Management Information Systems Research Center, working paper 71-12, University of Minnesota, (1971).

CHERVANY, N.L. and R.F. SAUTER, "Analysis and Design of Computer-Based Management Information Systems: An Evaluation of Risk Analysis Decision Aids," Management Information Research Center, Monograph 5, University of Minnesota, Minneapolis, Minnesota.

COURTNEY, J.F., G. DESANCTIS, and G.M. KASPER, "Continuity in MIS/DSS Laboratory Research: The Case for a Common Gaming Simulator," Decision Sciences, 14 (1983), 419-439.

DICKSON, G.W., J.A. SENN and N.L. CHERVANY, "Research in Management Information Systems: The Minnesota Experiments," Management Science, 23, 9 (May 1977), 913-923.

DILL, W.R., "The Educational Effects of Management Games," Proceedings of the Conference on Business Games, New Orleans: Tulane University, (1961).

FELLINGHAM, J.C., T.J. MOCK, and M.A. VASARHELYI, "Simulation of Information Choice," Decision Sciences, 7, 2 (April 1976), 219-234.

FRITZCHE, D.J., "The Lecture Versus the Game," ABSEL Proceedings, (1974), 41-46.

GENTRY, J.W., "Group Size and Attitudes Toward the Simulation Experience," Simulation and Games, 11, 4 (December 1980), 451-460.

GENTRY, J.W., "The Influence of the Information Presentation Format on Effectiveness of a Retail Information System," (unpublished research proposal), Oklahoma State University, (January 1985).

GENTRY, J.W., T.F. TICE, C.W. ROBERTSON and M.J. GENTRY, "Simulation Gaming as a Means of Researching Substantive Issues: Another Look," (working paper 83-9), Office of Business and Economic Research, Oklahoma State University, (August 1983).

GORRY, G.A. and M.S. SCOTT MORTON, "A Framework for Management Information Systems," Sloan Management Review, 13, 1 (1971), 55-70.

GOSENPUD, J.,P. MIESSING and C.J. MILTON, "A Research Study on Strategic Decisions in a Business Simulation," ABSEL Proceedings, (January 1984),161-165.

HENSHAW,R.C. and J.R. JACKSON, The Executive Game, Richard D. Irwin, Inc., Homewood, Illinois, 1983.

IVES, B., S. HAMILTON and G.B. DAVIS, "A Framework for Research in Computer-Based Management Information Systems," Management Science, 26, 9 (September 1980), 910-934.

JAUCH, L.R. and J.W. GENTRY, "Interactive Simulation as a Supplementary Instructional Tool: Its Relation to Performance in a Business Simulation," ABSEL Proceedings, (April 1976), 435-447.

JENKINS, A.M., "A Framework for MIS Research," Proceedings of the Ninth Annual Conference: American Institute for Decision Sciences, Chicago, Illinois (October 1977). 573.

KEEN, P.G.W and M.S. SCOTT MORTON, Decision Support Systems: An Organizational Perspective, Addison-Wesley, Reading, Massachusetts, 1978.

KOZAR, K.A., "Decision Making in a Simulated Environment: A Comparative Analysis of Computer Display Media," unpublished Ph.D. thesis, University of Minnesota (1972).

LUCAS, H.C., "A Descriptive Model of Information Systems in the Context of the Organization," Database, 5, 2 (1973), 27-36.

LUCAS,H.C., "An Experimental Investigation of the Use of Computer-Based Graphics in Decision Making," Management Science, 27, 7 (July 1981), 757-768.

LUCAS, H.C. and N.R. NIELSEN, "The Impact of the Mode of Information Presentation on Learning and Performance," Management Science, 26, 10 (October 1980), 982-993.

MASON, R.O. and I.I. MITROFF, "A Program for Research on Management Information Systems," Management Science, 19, 5 (January 1973), 475-487.

McKENNEY, J.L. and W.R. DILL, "Influences on Learning in Simulation Games," American Behavioral Scientist, 10,2 (October 1966), 28-32.

MOCK, T.J., "A Longitudinal Study of Some Information Structure Alternatives," Database, 5, 2 (1973), 40-45.

NAPIER, H.S. and W.C. HOUSE, "Individual Self-Report vs. Group Consensus in Small Decision-Making Groups," ABSEL Proceedings, (1979), 66-67.

NIEBUHR, R.E. and D.R. NORRIS, "Gaming Performance: The Influence of Quantitative Training and Environmental Conditions," Journal of Experiential Learning and Simulation, (1980), 65-73.

NIEBUHR, R.E., R.A. POPE and D.R. NORRIS, "The Impact of Individual Differences on Performance in a Business Game Simulation," paper presented at the Joint National Meetings of the Operations Research Society of America and the Institute of Management Sciences, Los Angeles, California (1978).

NOLAN, R.L. and J.C. WETHERBE, "Toward a Comprehensive Framework for MIS Research," MIS Quarterly, (June 1980), 1-19.

NORRIS, D.R. and C.A. SNYDER, "External Validation of Simulation Games," Simulation and Games, 13, (1982), 73-85.

PETERS, M.H., "Use of Simulation Administration to Achieve Pedagogical Objectives," ABSEL Proceedings, 11, (1984), 21-22.

POTTER, G.B., "An Exploratory Study of Psychological Factors in Business Simulation Games," Master's thesis, University of Illinois (1965).

REMUS, W. and S. JENNER, "Playing Business Games: Attitudinal Differences Between Students Playing Singly and as Teams," Simulation and Games, 10 (March 1979), 75-86.

SCHROEDER, R.G. and I. BENBASAT, "An Experimental Evaluation of the Relationship of Uncertainty in the Environment to Information Used by Decision Makers," Decision Sciences, 6 (July 1975), 556-567.

SEGINER, R., "Game Ability and Academic Ability: Dependence on SES and Psychological Mediators," Simulation and Games, 11, 4, (1980), 403-421.

SEITZ, N.E. and B.M. THORNTON, "The Use of Simulation in a Financial Planning Course," ABSEL Proceedings, (1974), 248-255.

SENN, J.A., "Information System Structure and Purchasing Decision Effectiveness: An Experimental Study," unpublished Ph.D.-thesis, University of Minnesota, (1973).

SHAW, M.E., Group Dynamics: The Psychology of Small Group Behavior, McGraw-Hill, New York (1971).

SMITH, H.R., "Experimental Comparison of Database Inquiry Techniques," unpublished Ph.D. thesis, University of Minnesota, (1975).

WILSON, H.K., "Administration: The Key to a Successful Gaming Experience," ABSEL Proceedings, (1974), 174-181.

WOLFE, J., "Correlations Between Academic Achievement, Aptitude, and Business Game Performance," ABSEL Proceedings, (April 1978), 316-324.

WOLFE, J. and G. GUTH, "The Case Approach Versus Gaming in the Teaching of Business Policy: An Experimental Evaluation," Journal of Business, 48 (July 1975), 349-364.

WOLFE, J. and C.R. ROBERTS, "A Longitudinal Study of the External Validity of a Business Management Game," ABSEL Proceedings, (February 1983), 9-12.

WYNNE, B. and G.W. DICKSON, "Experienced Managers' Performance in Experimental Man-Machine Decision System Simulation," Academy of Management Journal, 18 (March 1975), 25-40.

APPENDIX A

TABLES

TABLE 1
COMPARISON OF TOTAL REVENUES BETWEEN DSS AND NON-DSS GROUPS

WEEK	N	DSS	NON-DSS	P-VALUE
2	32	2237037	2196300	.7481
3	32	2506940	2543212	.8991
4	32	2752516	2357640	.1528
5	31	2212586	1892035	.0550
6	32	2583000	2146351	.0282
7	32	3094284	2490405	.0257
8	19	2634350	2157734	.1705
9	21	1965427	1661868	.1473
10	32	2348674	2182010	.1932
OVERALL	263	2479188	2228555	.0016

TABLE 2
COMPARISON OF TOTAL EXPENSES BETWEEN DSS AND NON-DSS GROUPS

WEEK	N	DSS	NON-DSS	P-VALUE
2	32	2012798	2030402	.8340
3	32	2188566	2246784	.7370
4	32	2395071	2209677	.2151
5	31	2143622	1988750	.1905
6	32	2309446	2085724	.0802
7	32	2617630	2264898	.0553
8	19	2405946	2219747	.2504
9	21	2076476	1985968	.4258
10	32	2257064	2245081	.9017
OVERALL	263	2264306	2150074	.0188

TABLE 3
COMPARISON OF NET EARNINGS BETWEEN DSS AND NON-DSS GROUPS

WEEK	N	DSS	NON-DSS	P-VALUE
2	32	161172	132489	.2401
3	32	205585	193692	.8404
4	32	225488	120596	.1376
5	31	84666	1833	.0223
6	32	182379	76019	.0170
7	32	278939	153486	.0564
8	19	157416	11881	.1621
9	21	-3720	-100401	.4269
10	32	94190	14031	.1203
OVERALL	263	154184	85932	.0008

TABLE 4
COMPARISON OF NET CASH INFLOW BETWEEN DSS AND NON-DSS GROUPS

WEEK	N	DSS	NON-DSS	P-VALUE
2	32	256090	13732	.1877
3	32	365482	238078	.6310
4	32	187316	42915	.5928
5	31	-658424	-348793	.4078
6	32	-267631	-319773	.8696
7	32	368696	126694	.4009
8	19	-292049	-137192	.6862
9	21	-551413	-683344	.7844
10	32	-278848	-295362	.9449
OVERALL	263	-87093	-105300	.8589

TABLE 5
COMPARISON OF NET ASSETS BETWEEN DSS AND THE NON-DSS GROUPS

WEEK	N	DSS	NON-DSS	P-VALUE
2	32	17214511	17150210	.0428
3	32	17420497	17344167	.3338
4	32	17644532	17464971	.1973
5	31	17755334	17466973	.0826
6	32	17911388	17543297	.0714
7	32	18190756	17697641	.0559
8	19	18348250	17514432	.1501
9	21	18346670	17229515	.1871
10	32	18416334	17735478	.0572
OVERALL	263	17905209	17477358	.0001

TABLE 6
COMPARISON OF THE NUMBER OF ALTERNATIVES EXAMINED
BEFORE ARRIVING AT A DECISION BETWEEN DSS AND NON-DSS GROUPS

WEEK	N	DSS	NON-DSS	P-VALUE
2	23	7.82	5.50	.4860
3	21	7.27	4.00	.1192
4	22	6.33	3.71	.3242
5	15	5.10	2.40	.1200
6	16	4.92	2.50	.1329
7	11	3.00	7.25	.3465
OVERALL	108	5.94	4.36	.1546

TABLE 7
COMPARISON OF TIME SPENT IN DECISION MAKING
BETWEEN DSS AND NON-DSS GROUPS

WEEK	N	DSS	NON-DSS	P-VALUE
2	22	5.55	3.58	.004
3	22	4.11	2.68	.0550
4	22	3.95	2.26	.0236
5	15	2.81	2.80	.9887
6	16	2.86	3.13	.6623
7	10	2.58	3.13	.5795
OVERALL	107	3.72	2.96	.0012

TABLE 8
COMPARISON OF CONFIDENCE IN DECISION
BETWEEN DSS AND NON-DSS GROUPS

WEEK	N	DSS	NON-DSS	P-VALUE
2	23	5.86	5.13	.4462
3	22	6.27	5.86	.4367
4	21	7.14	6.29	.1378
5	15	7.20	6.50	.4342
6	16	6.75	5.88	.3232
7	11	7.14	7.87	.5685
OVERALL	108	6.72	5.99	.0441

TABLE 9
COMPARISON OF PRICE, PRODUCT 1 BETWEEN DSS AND NON-DSS GROUPS

WEEK	N	DSS	NON-DSS	P-VALUE
2	32	4.61	4.54	.2715
3	32	4.62	4.53	.2913
4	32	4.65	4.45	.2446
5	32	4.66	4.36	.1352
6	32	4.64	4.32	.1028
7	32	4.65	4.33	.0877
8	19	4.58	4.15	.2686
9	21	4.61	4.14	.3998
10	32	4.61	4.40	.1952
OVERALL	264	4.63	4.39	.0001

TABLE 10
COMPARISON OF REVENUE, PRODUCT 1 BETWEEN DSS AND NON-DSS GROUPS

WEEK	N	DSS	NON-DSS	P-VALUE
2	32	965879	939799	.6434
3	32	1108577	1033153	.5984
4	32	1182739	1021722	.2200
5	32	911749	845506	.4387
6	32	1059933	953521	.2572
7	32	1291819	1077789	.0884
8	19	1142960	1001151	.4359
9	21	863920	766256	.5686
10	32	1009806	977754	.6245
OVERALL	264	1057331	971187	.0226

TABLE 11
COMPARISON OF OPERATING PROFIT, PRODUCT 1
BETWEEN DSS AND NON-DSS GROUPS

WEEK	N	DSS	NON-DSS	P-VALUE
2	32	127991	104575	.3360
3	32	171227	69497	.3837
4	32	197907	80898	.0902
5	31	60764	805	.0677
6	32	146708	71267	.0560
7	32	252779	138522	.0594
8	19	165556	47894	.1729
9	21	13506	-66185	.2967
10	32	94666	46289	.1756
OVERALL	263	136508	66080	.0012

TABLE 12
COMPARISON OF MARKET SHARE, PRODUCT 1
BETWEEN DSS AND NON-DSS GROUPS

WEEK	N	DSS	NON-DSS	P-VALUE
2	32	6.38	6.44	.8757
3	32	6.69	6.00	.4886
4	32	6.81	6.12	.3640
5	32	6.50	6.18	.5744
6	32	6.63	6.18	.3824
7	32	6.88	5.88	.1309
8	19	6.58	6.43	.8553
9	21	6.63	6.20	.6294
10	32	6.50	6.50	1.0
OVERALL	264	6.62	6.20	.0495

TABLE 13

COMPARISON OF PRICE, PRODUCT 2 BETWEEN DSS AND NON-DSS GROUPS

WEEK	N	DSS	NON-DSS	P-VALUE
2	32	5.96	5.93	.5873
3	32	5.98	5.97	26574
4	32	5.98	5.72	.2934
5	32	5.98	5.62	.1788
6	32	5.97	5.63	.2057
7	32	6.02	5.62	.1420
8	19	5.92	5.22	.2224
9	21	5.96	5.17	.3515
10	32	5.96	5.67	.2552
OVERALL	264	5.97	5.69	.0007

TABLE 14

COMPARISON OF REVENUE, PRODUCT 2 BETWEEN DSS AND NON-DSS GROUPS

WEEK	N	DSS	NON-DSS	P-VALUE
2	32	705034	667664	.4765
3	32	756545	825901	.4647
4	32	844632	748544	.3131
5	32	674737	568357	.0819
6	32	801960	642017	.0276
7	32	964213	769865	.0496
8	19	845793	627810	.0657
9	21	626252	508330	.1590
10	32	748910	653194	.0682
OVERALL	264	772186	685040	.0019

TABLE 15
COMPARISON OF OPERATING PROFIT, PRODUCT 2
BETWEEN DSS AND NON-DSS GROUPS

WEEK	N	DSS	NON-DSS	P-VALUE
2	32	78579	63504	.3034
3	32	94604	114814	.6236
4	32	106277	81864	.5126
5	31	9982	-27375	.1267
6	32	81505	15680	.0228
7	32	140208	86705	.2492
8	19	73405	-14754	.2294
9	21	-33241	-90871	.5415
10	32	31982	-28713	.1191
OVERALL	263	64958	35049	.0309

TABLE 16
COMPARISON OF MARKET SHARE, PRODUCT 2
BETWEEN DSS AND NON-DSS GROUPS

WEEK	N	DSS	NON-DSS	P-VALUE
2	32	3.56	3.37	.5195
3	32	3.50	3.94	.3001
4	32	3.94	3.44	.2157
5	32	3.69	3.38	.4094
6	32	3.88	3.25	.0638
7	32	4.00	3.31	.0770
8	19	3.92	3.14	.0466
9	21	3.80	3.63	.8101
10	32	3.75	3.44	.2748
OVERALL	264	3.76	3.44	.0113

TABLE 17
COMPARISON OF PRICE, PRODUCT 3 BETWEEN DSS AND NON-DSS GROUPS

WEEK	N	DSS	NON-DSS	P-VALUE
2	32	7.66	7.72	.7864
3	32	7.58	7.80	.2444
4	32	7.62	7.30	.3689
5	32	7.64	7.19	.2350
6	32	7.58	7.26	.3957
7	32	7.71	7.19	.1574
8	19	7.64	6.64	.2103
9	21	7.62	6.41	.2966
10	32	7.62	7.17	.1878
OVERALL	264	7.63	7.30	.0058

TABLE 18
COMPARISON OF REVENUE, PRODUCT 3 BETWEEN DSS AND NON-DSS GROUPS

WEEK	N	DSS	NON-DSS	P-VALUE
2	32	566124	588837	.6867
3	32	641818	684158	.6097
4	32	725144	587375	.0726
5	32	596759	478305	.0137
6	32	721076	550812	.0086
7	32	838252	642750	.0172
8	19	645598	528774	.1755
9	21	475255	387281	.1737
10	32	589957	551061	.3524
OVERALL	264	644410	572343	.0026

TABLE 19
COMPARISON OF OPERATING PROFIT, PRODUCT 3
BETWEEN DSS AND NON-DSS GROUPS

WEEK	N	DSS	NON-DSS	P-VALUE
2	32	17668	-2181	.3271
3	32	44043	113241	.3121
4	32	53260	-14173	.1597
5	31	-12427	-69984	.0125
6	32	45372	-26322	.0132
7	32	83667	280	.0468
8	19	-10556	-95154	.2529
9	21	-85689	-167045	.4314
10	32	-35038	-80643	.2614
OVERALL	263	11938	-22402	.0314

TABLE 20
COMPARISON OF MARKET SHARE, PRODUCT 3
BETWEEN DSS AND NON-DSS GROUPS

WEEK	N	DSS	NON-DSS	P-VALUE
2	32	2.31	2.31	1.0
3	32	2.31	2.25	.8619
4	32	2.56	2.25	.3778
5	32	2.69	2.44	.4512
6	32	2.75	2.31	.1470
7	32	2.69	2.12	.0576
8	19	2.25	2.43	.7527
9	21	2.13	2.60	.6174
10	32	2.25	2.50	.3813
OVERALL	264	2.44	2.33	.3099

APPENDIX B

DSS-EXEC PROGRAM

```
**** TSO FOREGROUND HARDCOPY ****
DSNAME=U13977A.RECOO.TEXT

 INPUT: MODEL GAME
 READY FOR EDIT, LAST LINE IS 10000
 INPUT: LIST
1
 MODEL GAME  VERSION OF  02/14/84  17:36
 1 COLUMNS 1
 17 SIMULTANEOUS AUTO
 18 *
 99 *$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
 100 *
 102 *      GIVEN AND ESTIMATED VALUES
 103 *
 104 PRIOR PLANT CAPACITY=413517
 106 *
 108 PRIOR CASH BALANCE=1516590
 110 *
 112 PRIOR SECURITIES=8000000
 114 *
 116 PRIOR PRODUCTION VOLUME1=175000
 118 PRIOR PRODUCTION VOLUME2=95000
 120 PRIOR PRODUCTION VOLUME3=50000
 122 *
 124 PRIOR INVENTORY VALUE1=0
 126 PRIOR INVENTORY VALUE2=9600
 128 PRIOR INVENTORY VALUE3=23625
 130 *
 132 PRIOR INVENTORY UNITS1=0
 134 PRIOR INVENTORY UNITS2=4354
 136 PRIOR INVENTORY UNITS3=7499
 138 *
 142 *
 144 DEMAND1=200000
 146 DEMAND2=75000
 148 DEMAND3=57000
 150 *
 152 PRIOR PLANT AND EQUIPMENT PURCHASE=0
 154 PRIOR2 PLANT AND EQUIPMENT PURCHASE=0
 156*
 499 *$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
 500 *
 502 *      DECISION VARIABLES
 504 *
 506 *
 508 *         FOR THE FIRM AS A WHOLE
 510 *
 512 PLANT AND EQUIPMENT PURCHASE=0
 514 *
 516 SECURITIES PURCHASE=0
 518 *
 700 *
 702 *         FOR EACH PRODUCT OF THE FIRM
 704 *
 706 *
 708 PRICE1=4.58
 710 PRICE2=5.97
 712 PRICE3=7.49
 714 *
 722 *
 724 MARKETING BUDGET1=140000
```

```
726 MARKETING BUDGET2=130000
728 MARKETING BUDGET3=125000
730 *
732 DESIGN AND STYLE BUDGET1=25000
734 DESIGN AND STYLE BUDGET2=25000
736 DESIGN AND STYLE BUDGET3=25000
738 *
740 PRODUCTION VOLUME1=175000
742 PRODUCTION VOLUME2=99000
744 PRODUCTION VOLUME3=57000
746 *
748 PRODUCTION BUDGET1=1.65
750 PRODUCTION BUDGET2=2.20
752 PRODUCTION BUDGET3=3.15
754 *
999 *$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
1000 *
1010 *     INCOME AND EXPENSES, PRODUCT 1
1020 *
1030 *
1040 REVENUE1=PRICE1*DEMAND1
1050 *
1060 LABOR AND MATERIALS1=(PRODUCTION BUDGET1*PRODUCTION VOLUME1)+'
1070 (1*OT PRODUCTION VOLUME1)
1080 *
1090 INVENTORY VALUE ADJ1=PRIOR INVENTORY VALUE1-'
1100 CURRENT INVENTORY VALUE1
1110 *
1120 DIRECT COGS1=L1060+L1090
1130 *
1140 GROSS PROFIT1=L1040-L1120
1150 *
1160 *
1170 MARKETING EXPENSE1=MARKETING BUDGET1
1180 *
1190 DESIGN AND STYLE EXPENSE1=DESIGN AND STYLE BUDGET1
1200 *
1210 PACKING AND SHIPPING1=.10*DEMAND1
1220 *
1230 INVENTORY CARRYING COSTS1=(.03*CURRENT INVENTORY UNITS1)+'
1240 (.01*CURRENT INVENTORY VALUE1)+30000
1250 *
1260 WAREHOUSING AND SHIPPING COST1=L1210+L1230
1270 *
1280 DEPRECIATION1=(DEPRECIATION*(PRODUCTION VOLUME1/'
1290 TOTAL PRODUCTION VOLUME))
1300 *
1310 ADM CHANGE1=(REVENUE1/TOTAL SALES REVENUE)*ADM CHANGE
1320 *
1330 ADM SIDE1=IF (PRODUCTION VOLUME1-PRIOR PRODUCTION VOLUME1) '
1340 .NE. 0 THEN (.10*(PRODUCTION VOLUME1-'
1350 PRIOR PRODUCTION VOLUME1)) ELSE 0
1360 *
1370 ADM PLANT AND EQUIPMENT1=(.01*PLANT AND EQUIPMENT VALUE)*'
1380 (REVENUE1/TOTAL SALES REVENUE)
1390 *
1400 ADM PURCHASE1=ADM PURCHASE PLANT AND EQUIPMENT*'
1402 (REVENUE1/TOTAL SALES REVENUE)
1430 *
1460 *
1470 ADM CASH1=ADM NEGATIVE CASH BALANCE*'
1472 (REVENUE1/TOTAL SALES REVENUE)
1500 *
1520 ADM BURDEN1=(.07*(L1060+L1170+L1190+L1260))+30000
1530 *
1540 ALLOCATED ADMINISTRATION1=L1310+L1330+L1370+L1400+'
```

```
1550 ADM CASH1+ADM BURDEN1
1560 *
1570 INDIRECT EXPENSE1=L1170+L1190+L1260+L1280+L1540
1580 *
1590 TOTAL EXPENSES1=L1060+L1090+L1570
1600 *
1610 OPERATING PROFIT1=L1040-L1590
1999 *$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
2000 *
2010 *      INCOME AND EXPENSES, PRODUCT 2
2020 *
2030 *
2040 REVENUE2=PRICE2*DEMAND2
2050 *
2060 LABOR AND MATERIALS2=(PRODUCTION BUDGET2*PRODUCTION VOLUME2)+'
2070 (1*OT PRODUCTION VOLUME2)
2080 *
2090 INVENTORY VALUE ADJ2=PRIOR INVENTORY VALUE2-'
2100 CURRENT INVENTORY VALUE2
2110 *
2120 DIRECT COGS2=L2060+L2090
2130 *
2140 GROSS PROFIT2=L2040-L2120
2150 *
2160 *
2170 MARKETING EXPENSE2=MARKETING BUDGET2
2180 *
2190 DESIGN AND STYLE EXPENSE2=DESIGN AND STYLE BUDGET2
2200 *
2210 PACKING AND SHIPPING2=.10*DEMAND2
2220 *
2230 INVENTORY CARRYING COSTS2=(.03*CURRENT INVENTORY UNITS2)+'
2240 (.01*CURRENT INVENTORY VALUE2)+30000
2250 *
2260 WAREHOUSING AND SHIPPING COST2=L2210+L2230
2270 *
2280 DEPRECIATION2=(DEPRECIATION*(PRODUCTION VOLUME2/'
2290 TOTAL PRODUCTION VOLUME))
2300 *
2310 ADM CHANGE2=(REVENUE2/TOTAL SALES REVENUE)*ADM CHANGE
2320 *
2330 ADM SIDE2=IF (PRODUCTION VOLUME2-PRIOR PRODUCTION VOLUME2) '
2340 .NE. O THEN (.10*(PRODUCTION VOLUME2-'
2350 PRIOR PRODUCTION VOLUME2)) ELSE O
2360 *
2370 ADM PLANT AND EQUIPMENT2=(.01*PLANT AND EQUIPMENT VALUE)*'
2380 (REVENUE2/TOTAL SALES REVENUE)
2390 *
2400 ADM PURCHASE2=ADM PURCHASE PLANT AND EQUIPMENT*'
2402 (REVENUE2/TOTAL SALES REVENUE)
2430 *
2460 *
2470 ADM CASH2=ADM NEGATIVE CASH BALANCE*'
2472 (REVENUE2/TOTAL SALES REVENUE)
2500 *
2520 ADM BURDEN2=(.07*(L2060+L2170+L2190+L2260))+30000
2530 *
2540 ALLOCATED ADMINISTRATION2=L2310+L2330+L2370+L2400+'
2550 ADM CASH2+ADM BURDEN2
2560 *
2570 INDIRECT EXPENSE2=L2170+L2190+L2260+L2280+L2540
2580 *
2590 TOTAL EXPENSES2=L2060+L2090+L2570
2600 *
2610 OPERATING PROFIT2=L2040-L2590
2999 *$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
```

```
3000 *
3010 *       INCOME AND EXPENSES, PRODUCT3
3020 *
3030 *
3040 REVENUE3=PRICE3*DEMAND3
3050 *
3060 LABOR AND MATERIALS3=(PRODUCTION BUDGET3*PRODUCTION VOLUME3)+'
3070 (1*OT PRODUCTION VOLUME3)
3080 *
3090 INVENTORY VALUE ADJ3=PRIOR INVENTORY VALUE3-'
3100 CURRENT INVENTORY VALUE3
3110 *
3120 DIRECT COGS3=L3060+L3090
3130 *
3140 GROSS PROFIT3=L3040-L3120
3150 *
3160 *
3170 MARKETING EXPENSE3=MARKETING BUDGET3
3180 *
3190 DESIGN AND STYLE EXPENSE3=DESIGN AND STYLE BUDGET3
3200 *
3210 PACKING AND SHIPPING3=.10*DEMAND3
3220 *
3230 INVENTORY CARRYING COSTS3=(.03*CURRENT INVENTORY UNITS3)+'
3240 (.01*CURRENT INVENTORY VALUE3)+30000
3250 *
3260 WAREHOUSING AND SHIPPING COST3=L3210+L3230
3270 *
3280 DEPRECIATION3=(DEPRECIATION*(PRODUCTION VOLUME3/'
3290 TOTAL PRODUCTION VOLUME))
3300 *
3310 ADM CHANGE3=(REVENUE3/TOTAL SALES REVENUE)*ADM CHANGE
3320 *
3330 ADM SIDE3=IF (PRODUCTION VOLUME3-PRIOR PRODUCTION VOLUME3) '
3340 .NE. O THEN (.10*(PRODUCTION VOLUME3-'
3350 PRIOR PRODUCTION VOLUME3)) ELSE O
3360 *
3370 ADM PLANT AND EQUIPMENT3=(.01*PLANT AND EQUIPMENT VALUE)*'
3380 (REVENUE3/TOTAL SALES REVENUE)
3390 *
3400 ADM PURCHASE3=ADM PURCHASE PLANT AND EQUIPMENT*'
3402 (REVENUE3/TOTAL SALES REVENUE)
3430 *
3460 *
3470 ADM CASH3=ADM NEGATIVE CASH BALANCE*'
3472 (REVENUE3/TOTAL SALES REVENUE)
3500 *
3520 ADM BURDEN3=(.07*(L3060+L3170+L3190+L3260))+30000
3530 *
3540 ALLOCATED ADMINISTRATION3=L3310+L3330+L3370+L3400+'
3550 ADM CASH3+ADM BURDEN3
3560 *
3570 INDIRECT EXPENSE3=L3170+L3190+L3260+L3280+L3540
3580 *
3590 TOTAL EXPENSES3=L3060+L3090+L3570
3600 *
3610 OPERATING PROFIT3=L3040-L3590
3999 *$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
4000 *
4010 *
4020 *       CONSOLIDATED REPORT
4030 *
4040 *
4050 TOTAL SALES REVENUE=REVENUE1+REVENUE2+REVENUE3
4060 *
4070 TOTAL LABOR AND MATERIALS COSTS=LABOR AND MATERIALS1+'
```

```
4080 LABOR AND MATERIALS2+LABOR AND MATERIALS3
4090 *
4100 COMBINED INVENTORY VALUE ADJUSTMENT=INVENTORY VALUE ADJ1+'
4110 INVENTORY VALUE ADJ2+INVENTORY VALUE ADJ3
4120 *
4130 TOTAL MARKETING EXPENDITURES=MARKETING EXPENSE1+'
4140 MARKETING EXPENSE2+MARKETING EXPENSE3
4145 *
4150 TOTAL DESIGN AND STYLING EXPENDITURES='
4160 DESIGN AND STYLE EXPENSE1+DESIGN AND STYLE EXPENSE2+'
4165 DESIGN AND STYLE EXPENSE3
4170 *
4180 TOTAL WAREHOUSING AND SHIPPING COSTS='
4190 WAREHOUSING AND SHIPPING COST1+'
4200 WAREHOUSING AND SHIPPING COST2+'
4210 WAREHOUSING AND SHIPPING COST3
4220 *
4230 DEPRECIATION=.025*PLANT AND EQUIPMENT VALUE
4240 *
4250 ADMINISTRATION ETC=ALLOCATED ADMINISTRATION1+'
4260 ALLOCATED ADMINISTRATION2+'
4270 ALLOCATED ADMINISTRATION3+'
4272 ADM SECURITIES SALE
4280 *
4290 TOTAL INDIRECT EXPENSES=L4130+L4150+L4180+L4230+L4250
4300 *
4310 TOTAL EXPENSES=L4070+L4100+L4290
4320 *
4330 TOTAL OPERATING PROFIT=L4050-L4310
4340 *
4350 INCOME FROM SECURITIES=(.015*'
4351 (PRIOR SECURITIES+SECURITIES PURCHASE))
4360 *
4370 TOTAL TAXABLE INCOME=L4330+L4350
4380 *
4390 TAX ON CURRENT INCOME=.52*L4370
4400 *
4410 NET EARNINGS=L4370-L4390
4420 *
4421 *$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
4430 *
4440 *
4450 *      CASH FLOW
4460 *
4470 *
4480 TOTAL RECEIPTS=L4050+L4350
4490 *
4500 TOTAL DISBURSEMENTS=(L4310-L4100-L4230)+'
4510 (L152+L516+L4390)
4530 *
4540 NET CASH INFLOW=L4480-L4500
4550 *
4552 *$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
4560 *
4570 *
4580 *      FINANCIAL CONDITION
4590 *
4600 *
4610 NET CASH ASSETS=CASH BALANCE
4620 *
4630 INVENTORY VALUE=TOTAL CURRENT INVENTORY VALUE
4640 *
4650 PLANT AND EQUIPMENT VALUE=(20*PLANT CAPACITY CURRENT)
4670 *
4680 SECURITIES=PRIOR SECURITIES+SECURITIES PURCHASE
4690 *
```

```
4700 NET ASSETS=L4610+L4630+L4650+L4680
4710 *
4712 *$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
4720 *
4730 *
4740 *      PLANT REPORT
4750 *
4760 *
4770 PLANT CAPACITY PRIOR=L104
4780 *
4790 LOSS FROM DEPRECIATION=DEPRECIATION/20
4800 *
4810 GAIN FROM NEW INVESTMENT=PRIOR2 PLANT AND EQUIPMENT PURCHASE
4820 *
4830 PLANT CAPACITY CURRENT=L4770-L4790+L4810
4840 *
4850 *
4860 *
5999 *$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
6000 *
6002 *
6004 *      MISCELLANEOUS
6006 *
6008 *
6010 TOTAL PRODUCTION VOLUME=L740+L742+L744
6012 *
6014 OT PRODUCTION VOLUME=IF (L6010-L4830) .GT. 0 THEN
6016 (L6010-L4830) ELSE 0
6018 *
6020 OT PRODUCTION VOLUME1=L6014*(L740/L6010)
6022 OT PRODUCTION VOLUME2=L6014*(L742/L6010)
6024 OT PRODUCTION VOLUME3=L6014*(L744/L6010)
6026 *
6028 TOTAL CURRENT INVENTRY VALUE=CURRENT INVENTORY VALUE1+'
6030 CURRENT INVENTORY VALUE2+CURRENT INVENTORY VALUE3
6032 *
6034 TOTAL PRIOR INVENTORY VALUE=PRIOR INVENTORY VALUE1+'
6036 PRIOR INVENTORY VALUE2+PRIOR INVENTORY VALUE3
6038 *
6040 TOTAL CURRENT INVENTORY VALUE=CURRENT INVENTORY VALUE1+'
6042 CURRENT INVENTORY VALUE2+CURRENT INVENTORY VALUE3
6044 *
6046 TOTAL PRIOR PRODUCTION VOLUME=L116+L118+L120
6048 *
6050 PRODUCTION INCREASE COST=IF (L6010-L6046) .GT. 0 THEN '
6052 (.40*(L6010-L6046)) ELSE 0
6054 *
6056 PRODUCTION DECREASE COST=IF (L6010-L6046) .LE. 0 THEN '
6058 (.20*(L6046-L6010)) ELSE 0
6060 *
6062 ADM CHANGE=L6050+L6056
6064 *
6066 ADM SECURITIES SALE=IF SECURITIES PURCHASE .LT. 0 THEN '
6068 (.04*ABS(SECURITIES PURCHASE)) ELSE 0
6070 *
6072 CASH BALANCE=PRIOR CASH BALANCE+NET CASH INFLOW
6074 *
6076 ADM PURCHASE PLANT AND EQUIPMENT='
6078 INTERPOLATION ON(L152,0,0,'
6080 250000,7000,500000,20000,1000000,60000,2000000,250000)
6082 *
6084 ADM NEGATIVE CASH BALANCE=IF (CASH BALANCE .LE. 0) THEN '
6086 (INTERPOLATION ON(CASH BALANCE,0,0,-200000,2000,'
6088 -400000,6000,-800000,22000,-1600000,84000)) ELSE 0
6090 *
6092 UNIT COST1=L1060/L740
```

```
6094 UNIT COST2=L2060/L742
6096 UNIT COST3=L3060/L744
6098 *
7000 CURRENT INVENTORY VALUE1=IF ((.9*L124)+(L6092*(L740-L144)))'
7001  .GT. 0 THEN ((.9*L124)+(L6092*(L740-L144))) ELSE 0
7002 CURRENT INVENTORY VALUE2=IF ((.9*L126)+(L6094*(L742-L146)))'
7003  .GT. 0 THEN ((.9*L126)+(L6094*(L742-L146))) ELSE 0
7004 CURRENT INVENTORY VALUE3=IF ((.9*L128)+(L6096*(L744-L148)))'
7005  .GT. 0 THEN ((.9*L128)+(L6096*(L744-L148))) ELSE 0
7006 *
7008 CURRENT INVENTORY UNITS1=IF (L132+L740-L144) '
7009 .GT. 0 THEN (L132+L740-L144) ELSE 0
7010 CURRENT INVENTORY UNITS2=IF (L134+L742-L146) '
7011 .GT. 0 THEN (L134+L742-L146) ELSE 0
7012 CURRENT INVENTORY UNITS3=IF (L136+L744-L148) '
7013 .GT. 0 THEN (L136+L744-L148) ELSE 0
7014 *
7016 PRIOR UNIT COST1=L124/L132
7018 PRIOR UNIT COST2=L126/L134
7020 PRIOR UNIT COST3=L128/L136
7022 *
7050 GOODS AVAILABLE1=L132+L740
7052 GOODS AVAILABLE2=L134+L742
7054 GOODS AVAILABLE3=L136+L744
7056 *
7058 SHORTAGES1=IF (L7050 .LT. L144) THEN (L144-L7050) ELSE 0
7060 SHORTAGES2=IF (L7052 .LT. L146) THEN (L146-L7052) ELSE 0
7062 SHORTAGES3=IF (L7054 .LT. L148) THEN (L148-L7054) ELSE 0
7064 *
7066 SALES VOLUME1=L144-L7058
7068 SALES VOLUME2=L146-L7060
7070 SALES VOLUME3=L148-L7062
7072 *
7074 TEN PERCENT FLAG1=IF L7050 .GE. (1.1*L144) THEN 1 ELSE 0
7076 TEN PERCENT FLAG2=IF L7052 .GE. (1.1*L146) THEN 1 ELSE 0
7078 TEN PERCENT FLAG3=IF L7054 .GE. (1.1*L148) THEN 1 ELSE 0
7080 *
7083 TOTAL EXPENSES LESS INV ADJ DEPR=L4310-L4100-L4230
7084 *
10000 *$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
END OF MODEL
```

$$

```
ENTER SOLVE OPTIONS
INPUT: SOLVE
ENTER SOLVE OPTIONS
INPUT: GENREPORT RESULTS
```

REPORT ON PRODUCT 1
==================

INCOME AND EXPENSES

REVENUE		$916,000
LABOR AND MATERIALS		
PLUS DIRECT COST OF OVERTIME	$288,750	
INVENTORY VALUE ADJUSTMENT	$0	
DIRECT COST OF GOODS SOLD		$288,750
GROSS PROFIT		$627,250
MARKETING EXPENDITURE	$140,000	
DESIGN AND STYLING EXPENDITURE	$25,000	
WAREHOUSING AND SHIPPING COST	$50,000	
DEPRECIATION, ALLOCATED	$106,647	
ADMINISTRATION, ETC., ALLOCATED	$108,787	
INDIRECT EXPENSE		$430,435
OPERATING PROFIT		$196,815

PRODUCTION - SALES - INVENTORY

INVENTORY QUANTITY, END OF PRIOR PER.	0	
PRODUCTION VOLUME, CURRENT PER .	175,000	
GOODS AVAILABLE		175,000
ORDERS RECIEVED	200,000	
SALES LOST DUE TO INVENTORY SHORTAGE	25,000	
SALES VOLUME		175,000
INVENTORY QUANTITY, END OF CUR		0
INVENTORY VALUE		0

TEN PERCENT FLAG
----

1 = GOODS AVAILABLE EXCEED ORDERS BY TEN PERCENT 0 = THEY DO NOT	0

REPORT ON PRODUCT 2
===================

INCOME AND EXPENSES

REVENUE		$447,750
LABOR AND MATERIALS PLUS DIRECT COST OF OVERTIME	$217,800	
INVENTORY VALUE ADJUSTMENT	$-51,840	
DIRECT COST OF GOODS SOLD		$165,960
GROSS PROFIT		$281,790
MARKETING EXPENDITURE	$130,000	
DESIGN AND STYLING EXPENDITURE	$25,000	
WAREHOUSING AND SHIPPING COST	$38,965	
DEPRECIATION, ALLOCATED	$60,332	
ADMINISTRATION, ETC., ALLOCATED	$80,499	
INDIRECT EXPENSE		$334,796
OPERATING PROFIT		$-53,006

PRODUCTION - SALES - INVENTORY

INVENTORY QUANTITY, END OF PRIOR PER.	4,354	
PRODUCTION VOLUME, CURRENT PER.	99,000	
GOODS AVAILABLE		103,354
ORDERS RECIEVED	75,000	
SALES LOST DUE TO INVENTORY SHORTAGE	0	
SALES VOLUME		75,000
INVENTORY QUANTITY, END OF CUR		28,354
INVENTORY VALUE		61,440

TEN PERCENT FLAG
----

1 = GOODS AVAILABLE EXCEED
ORDERS BY TEN PERCENT
0 = THEY DO NOT

REPORT ON PRODUCT 3
===================

INCOME AND EXPENSES

REVENUE		$426,930
LABOR AND MATERIALS		
PLUS DIRECT COST OF OVERTIME	$179,550	
INVENTORY VALUE ADJUSTMENT	$2,363	
DIRECT COST OF GOODS SOLD		$181,913
GROSS PROFIT		$245,018
MARKETING EXPENDITURE	$125,000	
DESIGN AND STYLING EXPENDITURE	$25,000	
WAREHOUSING AND SHIPPING COST	$36,138	
DEPRECIATION, ALLOCATED	$34,737	
ADMINISTRATION, ETC., ALLOCATED	$76,584	
INDIRECT EXPENSE		$297,458
OPERATING PROFIT		$-52,441

PRODUCTION - SALES -INVENTORY

INVENTORY QUANTITY, END OF PRIOR PER.	7,499	
PRODUCTION VOLUME, CURRENT PER.	57,000	
GOODS AVAILABLE		64,499
ORDERS RECIEVED	57,000	
SALES LOST DUE TO INVENTORY SHORTAGE	0	
SALES VOLUME		57,000
INVENTORY QUANTITY, END OF CUR		7,499
INVENTORY VALUE		21,263

TEN PERCENT FLAG
----

1 = GOODS AVAILABLE EXCEED
ORDERS BY TEN PERCENT
0 = THEY DO NOT

CONSOLIDATED REPORT
===================

PROFITS AND LOSS

TOTAL SALES REVENUE, ALL PRODUCTS		$1,790,680
TOTAL LABOR AND MATERIAL COST	$686,100	
COMBINED INVENTORY VALUE ADJUSTMENTS	$-49,478	
TOTAL MARKETING EXPENDITURES	395,000	
TOTAL DESIGN AND STYLING EXPENDITURES	75,000	
TOTAL WAREHOUSING AND SHIPPING COSTS	125,103	
DEPRECIATION	201,716	
ADMINISTRATION, ETC	265,870	
TOTAL EXPENSES		$1,699,3,1
TOTAL OPERATING PROFIT		$91,369
INCOME FROM SECURITIES		120,000

```
     TOTAL TAXABLE INCOME                                    $211,369
     TAX ON CURRENT INCOME                                    109,912

     NET EARNINGS                                            $101,457


CASH FLOW
---------

TOTAL SALES REVENUE, ALL PRODUCTS              $1,790,680
INCOME FROM SECURITIES                            120,000
     TOTAL RECEIPTS                                          $1,910,680

TOTAL EXPENSES, LESS INV ADJ, DEPR             $1,547,073
NEW PLANT INVESTMENT                                    0
NEW SECURITIES INVESTMENT                               0
TAX ON CURRENT INCOME                             109,912
     TOTAL DISBURSEMENTS                                      1,656,985

     NET CASH INFLOW                                         $253,695


FINANCIAL CONDITIONS
--------------------

     NET CASH ASSETS                           $1,770,285
     INVENTORY VALUE                               82,703
     PLANT AND EQUIPMENT VALUE                  8,068,624
     SECURITIES                                 8,000,000

     NET ASSETS                               $17,921,612


PLANT REPORT
------------

     PLANT CAPACITY, PRIOR                        413,517
     LOSS FROM DEPRECIATION                        10,086
     GAIN FROM NEW INVESTMENT                           0

     PLANT CAPACITY, CURRENT                      403,431

INPUT: WHAT IF
WHAT IF CASE 1
ENTER STATEMENTS
INPUT: DEMAND1=202000
INPUT: DEMAND2=67500
INPUT: SOLVE
ENTER SOLVE OPTIONS
INPUT: GENREPORT RESULTS


***** WHAT IF CASE 1 *****
2 WHAT IF STATEMENTS PROCESSED


REPORT ON PRODUCT 1
===================
```

INCOME AND EXPENSES

REVENUE		$925,160
LABOR AND MATERIALS		
PLUS DIRECT COST OF OVERTIME	$288,750	
INVENTORY VALUE ADJUSTMENT	$0	
DIRECT COST OF GOODS SOLD		$288,750
GROSS PROFIT		$636,410
MARKETING EXPENDITURE	$140,000	
DESIGN AND STYLING EXPENDITURE	$25,000	
WAREHOUSING AND SHIPPING COST	$50,200	
DEPRECIATION, ALLOCATED	$106,647	
ADMINISTRATION, ETC., ALLOCATED	$110,129	
INDIRECT EXPENSE		$431,976
OPERATING PROFIT		$204,434

PRODUCTION - SALES - INVENTORY

INVENTORY QUANTITY, END OF PRIOR PER.	0	
PRODUCTION VOLUME, CURRENT PER	175,000	
GOODS AVAILABLE		175,000
ORDERS RECIEVED	202,000	
SALES LOST DUE TO INVENTORY SHORTAGE	27,000	
SALES VOLUME		175,000
INVENTORY QUANTITY, END OF CUR		0
INVENTORY VALUE		0

TEN PERCENT FLAG

1 = GOODS AVAILABLE EXCEED ORDERS BY TEN PERCENT	
0 = THEY DO NOT	0

REPORT ON PRODUCT 2

INCOME AND EXPENSES

REVENUE		$402,975
LABOR AND MATERIALS PLUS DIRECT COST OF OVERTIME	$217,800	
INVENTORY VALUE ADJUSTMENT	$-68,340	
DIRECT COST OF GOODS SOLD		$149,460
GROSS PROFIT		$253,515
MARKETING EXPENDITURE	$130,000	
DESIGN AND STYLING EXPENDITURE	$25,000	
WAREHOUSING AND SHIPPING COST	$38,605	
DEPRECIATION, ALLOCATED	$60,332	
ADMINISTRATION, ETC., ALLOCATED	$78,735	
INDIRECT EXPENSE		$332,672
OPERATING PROFIT		$-79,157

PRODUCTION - SALES - INVENTORY

INVENTORY QUANTITY, END OF PRIOR PER.	4,354	
PRODUCTION VOLUME, CURRENT PER.	99,000	
GOODS AVAILABLE		103,354
ORDERS RECIEVED	67,500	
SALES LOST DUE TO INVENTORY SHORTAGE	0	
SALES VOLUME		67,500
INVENTORY QUANTITY, END OF CUR		35,854
INVENTORY VALUE		77,940

TEN PERCENT FLAG

1 = GOODS AVAILABLE EXCEED ORDERS BY TEN PERCENT 0 = THEY DO NOT	1

REPORT ON PRODUCT 3
==================

INCOME AND EXPENSES

REVENUE		$426,930
LABOR AND MATERIALS PLUS DIRECT COST OF OVERTIME	$179,550	
INVENTORY VALUE ADJUSTMENT	$2,363	
DIRECT COST OF GOODS SOLD		$181,913
GROSS PROFIT		$245,018
MARKETING EXPENDITURE	$125,000	
DESIGN AND STYLING EXPENDITURE	$25,000	
WAREHOUSING AND SHIPPING COST	$36,138	
DEPRECIATION, ALLOCATED	$34,737	
ADMINISTRATION, ETC., ALLOCATED	$76,996	
INDIRECT EXPENSE		$297,870
OPERATING PROFIT		$-52,852

PRODUCTION - SALES -INVENTORY

INVENTORY QUANTITY, END OF PRIOR PER.	7,499	
PRODUCTION VOLUME, CURRENT PER.	57,000	
GOODS AVAILABLE		64,499
ORDERS RECIEVED	57,000	
SALES LOST DUE TO INVENTORY SHORTAGE	0	
SALES VOLUME		57,000
INVENTORY QUANTITY, END OF CUR		7,499
INVENTORY VALUE		21,263

TEN PERCENT FLAG
----

1 = GOODS AVAILABLE EXCEED ORDERS BY TEN PERCENT 0 = THEY DO NOT	1

CONSOLIDATED REPORT
==================

PROFITS AND LOSS

TOTAL SALES REVENUE, ALL PRODUCTS		$1,755,065
TOTAL LABOR AND MATERIAL COST	$686,100	
COMBINED INVENTORY VALUE ADJUSTMENTS	$-65,978	
TOTAL MARKETING EXPENDITURES	395,000	
TOTAL DESIGN AND STYLING EXPENDITURES	75,000	
TOTAL WAREHOUSING AND SHIPPING COSTS	124,943	
DEPRECIATION	201,716	
ADMINISTRATION, ETC	265,859	
TOTAL EXPENSES		$1,682,640
TOTAL OPERATING PROFIT		$72,425
INCOME FROM SECURITIES		120,000
TOTAL TAXABLE INCOME		$192,425
TAX ON CURRENT INCOME		100,061
NET EARNINGS		$92,364

CASH FLOW

TOTAL SALES REVENUE, ALL PRODUCTS	$1,755,065	
INCOME FROM SECURITIES	120,000	
TOTAL RECEIPTS		$1,875,065
TOTAL EXPENSES, LESS INV ADJ, DEPR	$1,546,902	
NEW PLANT INVESTMENT	0	
NEW SECURITIES INVESTMENT	0	
TAX ON CURRENT INCOME	100,061	
TOTAL DISBURSEMENTS		1,646,963
NET CASH INFLOW		$228,102

FINANCIAL CONDITIONS

NET CASH ASSETS	$1,744,692
INVENTORY VALUE	99,203
PLANT AND EQUIPMENT VALUE	8,068,624
SECURITIES	8,000,000
NET ASSETS	$17,912,519

```
PLANT REPORT
------------

     PLANT CAPACITY, PRIOR                                 413,517
     LOSS FROM DEPRECIATION                                 10,086
     GAIN FROM NEW INVESTMENT                                    0

     PLANT CAPACITY, CURRENT                               403,431

INPUT: WHAT IF
WHAT IF CASE 2
ENTER STATEMENTS
INPUT: DEMAND1=202000
INPUT: DEMAND2=67500
INPUT: SOLVE
ENTER SOLVE OPTIONS
INPUT: OPERATING PROFIT1,OPERATING PROFIT2,NET EARNINGS

***** WHAT IF CASE 2 *****
2 WHAT IF STATEMENTS PROCESSED

                                 1

OPERATING PROFIT1          204434
OPERATING PROFIT2          -79157
NET EARNINGS                92364

ENTER SOLVE OPTIONS
INPUT: QUIT
```

VITA

James Coyle McDonnell
Candidate for the degree of
Master of Business Administration

Report: EFFICIENCY AND EFFECTIVENESS OF A DECISION SUPPORT SYSTEM: A TEST

Major Field: Management Information Systems

Biographical:

Personal Data: Born in Bryn Mawr, Pennsylvania, May 27, 1957, the son of John J. and Evelyn G. McDonnell; married to Anne Elisa Speciale, May 7, 1983; one beautiful child, Evelyn Anne, born September 13, 1984.

Education: Graduated from Radnor Senior High School, Radnor, Pennsylvania, June 1975; recieved the Bachelor of Science degree from the College of Engineering, Cornell University with a major in Geology, May 1980; currently completing requirements for the Master of Business Administration degree at Oklahoma State University.

Professional Experience: Field Engineer, Dresser Atlas, division of Dresser Industries, Fort Morgan, Colorado, 1980-1982; Field Engineer, Dresser Atlas, division of Dresser Industries, Ventura, California, 1983.

Publications: Sharda, R., McDonnell, J.C., "Efficiency and Effectiveness of a Decision Support System", Proceedings of the National American Institute of Decision Scientists Conference, Toronto, Canada, November 1984.