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To My Mother and The Memory of My Father, and to My Family and Friends
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CHAPTER I

INTRODUCTION

"Effective research scarcely begins before a scientific community thinks it has acquired firm answers to questions like the following: What are the fundamental entities of which the universe is composed? How do these interact with each other and with the senses? What questions may legitimately be asked about such entities and what techniques employed in seeking solutions?"

Kuhn, 1970

1.1 Background

Many organizational decisions are made in groups. Information technology that supports group work has been defined as groupware. Decision aids in Group Decision Support Systems (GDSS) are designed to improve group decision processes and outcomes. However, empirical research examining the benefits of GDSS have identified both positive [Adelman, 1984], [Vogel et. al., 1989], [Sharda, Barr, McDonnel, 1988] and
negative results [Watson, DeSanctis, Poole, 1988], [Turoff, Hiltz, 1982], [Beauclair, 1987], [Jarvenpaa, Rao, Huber, 1988], [George et. al., 1990].

Organizations are making substantial investments in information technology to improve the efficiency and effectiveness of their organizational work. However, an MIT report proposed that companies would have achieved a higher return on their investments in the 1980's had they invested, instead, in manufacturing technology. Some practitioners believe that many CEO's in the 1980's invested blindly in information technology without understanding the full impact of such technology on work processes. Thus, the topic of "reengineering through information technology" was born.

Information technology can be used to reengineer organizational work, improving its efficiency and effectiveness. Information technology is the "enabler" of the reengineering process by designing information technology to support group work (Groupware) within organizations.

Organizations have reported both positive and negative experiences with the implementation of groupware into their group work processes. For example, Lotus Notes (Commercial groupware product of Lotus corporation) has been found to have a return on investment of four hundred percent in some companies [Vizard, 1993]. In other cases it has been very hard to implement [Rooney, 1993], [Faden, 1993]; the reasons for this difficulty have been attributed to structural and cultural variables within the companies.

To understand why GDSS is effective in some companies and a hindrance in others, one has to consider fundamental questions regarding group decision making and understand their impacts on group processes and outcomes in a GDSS environment. The
penetration of computers into workplaces has changed the nature of jobs in organizations [Zuboff, 1988], and management is being asked to identify and evaluate traditional organizational variables such as the need for group leadership and different types of incentive mechanisms which provide a match for the requirements of the new organizational realities. New organization realities are manifestations of stiff competition, work specialization promoting group activities, information byproduct of work processes, and because "time" has become an important determinant of organizational success. The new organizational realities coupled with the progressive ideas of designing virtual organizations create new challenges to understand the effect of traditional organizational variables which affect group work.

To study the effect of traditional variables on group processes and outcomes, research should study groups which closely resemble groups within organizations. In most organizational settings, group members have asymmetric information, groups have group history, problems are complex, group members have different incentives, and frequently a leader protects organizational stakes in decision outcomes. As stakes are high for group members in most organizational settings and decision makers have to live with the consequences of their decisions, the multiple participants of a decision making group frequently utilize negotiation as a strategy for problem solving. Most of the previous research on GDSS supported settings have considered idea generation tasks [Applegate, 1986], [George et. al., 1990], [Connolly, Jessup, Valacich, 1990], the problems have typically been simple [Bui, Sivasankaran, 1990], [Easton et. al.,1990], [Connolly, Jessup, Valacich, 1990], [Dennis, 1990], [Gallupe, McKeen, 1990], [Lim,
Raman, Wei, 1990], [Watson, DeSanctis, Poole, 1988] and the decision makers have not had significant stakes in decision outcomes [Payne, 1976], [Henderson, Nutt, 1980], [Gallupe, Bastianutti, Cooper, 1991], [Bui, Sivasankaran, 1990], [Connoly, Jessup, Valacich, 1990], [Dennis, 1990]. In addition, many of previous laboratory experiments have dealt with groups that were formed just prior to the experiment, and thus had no group history [Bui, Sivasankaran, 1990], [Connoly, Jessup, Valacich, 1990], [Easton et. al., 1990], [Gallupe, DeSanctis, Dickson, 1988], [Gallupe, McKeen, 1990], [Steeb, Johnson, 1981]. McGrath has warned against using groups with zero group history [McGrath, 1976]. Thus, a study of the impact of independent variables on group processes and outcomes in a GDSS supported setting should utilize groups where group members have a working history together, are faced with a complex task, have high stakes in decision outcomes, have asymmetric information, and have a leader in charge of protecting organizational stakes.

New advancements in computer-supported communication capabilities allow members to engage in problem solving when they are geographically distributed. Time-based organizations would prefer distributed members to solve problems when they are geographically distributed rather than flying them to meet face-to-face. The members in these groups do not have to meet at the same place and the same time if they can solve problems as effectively and efficiently as when they are in close proximity. Previous research on proximity has mostly considered idea generation tasks [Connolly, Jessup, 1990].

---

1 For a comparison of laboratory and field research in the study of electronic meeting systems the reader is referred to [Dennis, Nunamaker, Vogel, 1991].
Valacich, 1990], [Jessup, Tansik, 1991]. Many organizational tasks require negotiation as group members have different stakes in decision outcomes. Thus, the members have mixed motives to both cooperate as well as to compete. Few studies have considered mixed-motive tasks [Arunachalam, 1991], [Rhee, 1993] without a leader, and choice tasks with a leader [George et al., 1990], [Lim, Raman, Wei, 1990], [Hiltz, Johnson, Turoff, 1991]. GDSS studies that consider a complex mixed-motive task to examine the effect of group leader, incentive mechanism, and proximity on decision processes and outcomes seem to have been overlooked.

As groups become a structural unit within organizations and computer systems become a significant component of the fabric of organizations, management is being asked to equip groups with computer support to create a paradigm for effective and efficient organizational decision making. To do this, management has to identify and evaluate organizational structures and processes that can hinder or improve group functioning [Applegate, 1993], and understand the effect of such processes on the group decision making and problem solving outcomes [Hackman, 1976], [McGrath, 1984]. Groups are a means of building a cross-functional perspective into a work process [Davenport, 1993]. Specific benefits from adopting a group as a structural unit of work include: flexibility, efficiency, cross-functional skills, and improved quality of work life.

The need to evaluate organizational structures and processes which enable or hinder group decision making is intensified as new computer supported group decision aids, GDSS, penetrate into workplaces to create time-based competition. GDSS has been
advocated to improve the outcome of group tasks by improving group processes to facilitate cooperative work.

Standard features of GDSS include communication support, structured and unstructured information sharing capabilities, and task specific decision support aids such as modeling and solver capabilities. The modeling and solver subsystems of a GDSS assist decision makers when they are faced with complex tasks, and there are subtasks which can be modeled and solved to optimality. Usually, the complexity of a task is attributed to the size of the search space (the larger the search space, the more complex is the problem), and the number and types of interactions between subtasks. Modeling deals with problem formulation, and the solver subsystem tries to efficiently scan through the search space for the optimal solution. The communication support subsystem provides additional communication channels to facilitate interaction between decision makers within a group. It has been shown [Nunamaker et. al., 1993] that computer supported communication improves equal air-time, prevents production blocking, and promotes parallel and simultaneous communication. "What If" capability allows users to query their solutions with sensitivity analysis. This feature tests the robustness of a solution to changes in the underlying assumptions. "Historical feedback" or "Group memory" provides a means for looking at the sequence of potential intermediate solutions on the way to converge to the final group solution. "Information exchange" capability facilitates the sharing of relevant information between group members and may reduce the effect of "isolated decision islands". In addition to GDSS features, other variables
such as group structures (i.e. composition, incentives, proximity) seem to impact group decisions. However, much of the GDSS literature has considered GDSS features.

Group structures depend on such variables as size, goals, presence of leader, and channels of communication. In "leader-directed" (autocratic) groups, the group leader oversees the overall task, coordinates the activities of the members, provides the "final word", and decides on rewards. In self-managing (democratic) groups, the group members share decision making power equally and collectively (i.e. by voting) arrive at an answer to the group problem. Self-organizing or self-managing groups may have positive effects on motivation, but could cause ambiguities regarding who really manages the group activities [Davenport, 1993]. Davenport reports: "Though there is no research to support conjectures on groupware use in group-based processes, we would suspect that the more structured the process, the more likely groupware use will lead to measurable

---

2 Self-managing groups (also known as semiautonomous work groups, or self-regulating work groups) are a type of organizational structure which came from the socio-technical systems movement during the 1950's [Davis, Trist, 1979]. Self-managing groups are characterized by such things as: tasks which require multiple skills, group control of work task assignments, and coordination of group maintenance functions [Pearce, Ravlin, 1987]. In such groups, members are jointly accountable for group functioning, members are interdependent, and cooperative interaction is encouraged as members share the rewards equally. In a study conducted in a coal mine, the violations of health and safety rules, number of accidents, and wasted time all decreased in self-managing groups [Trist, Susman, Brown, 1977]. Further analysis of the interview data showed that workers liked the system. Job satisfaction, involvement in decision making, and intrinsic job characteristics were increased in self-managing groups [Kemp et. al., 1983]. Group skill requirements can be categorized into: problem-solving and decision-making skills, technical or functional expertise, and interpersonal skills [Katzenbach, Smith, 1993].
time reductions or other benefits", and that "....excessive use of computer controls could easily neutralize the motivational advantages of self-managing groups".

This research will study the effect of a group leader, incentive mechanism, and geographic proximity on group decision making process and outcomes for a mixed-motive task in a GDSS supported setting. The groups have group history as they have worked together before and will work together again. The decision makers have high stakes in decision outcomes, and the task is complex enough to require a GDSS. The GDSS is designed to have specific features to support the particular task type.

1.2 Purpose of Research

The purpose of this research is to study the impact of leader, incentive structure, and geographic proximity of decision makers on group decision making processes and outcomes for a mixed-motive task. As companies attempt to utilize computer and communication capabilities to make decisions in distributed decision making environments, we need to gain more understanding about how traditional factors, such as the need for group leadership and incentives, affect distributed decisions. The underlying hypothesis is that traditional variables such as group leadership and different types of incentive structures (i.e. individual versus group based) affect group decisions differently in distributed environments than in a face-to-face decision making situation.

Such decisions as assigning a leader to a decision making group or not, and prescribing incentives based on individual contributions or group achievement are variables which are controllable by organizational designers. Unless a good
understanding of the impact of such variables on decisions is obtained, managers do not have clear guidelines to design organizations which function effectively when decision making groups operate in a distributed decision making environment. The contribution of this research is to gain such an understanding as well as to show that organizations should be cautious about the differences that exist between face-to-face and distributed decision settings. As a result of this study, managers should study the impact of their organizational variables on distributed decisions and modify traditional variables appropriately before they heavily invest in information technology hoping that the distributed environment will provide measurable benefits.

1.3 Task and GDSS

The task is a mixed-motive multiple objective problem with pareto optimal answers. The task was developed for this study since there were no tasks found in the literature which had the desired characteristics for this research in terms of complexity, localized view of organizational information, and incentive mechanisms tied to performance representative of those used in organizations.

The GDSS designed for this experiment was one that had features to specifically support the underlying task, was easy to learn and use, and could capture user responses in real-time for post experimental analysis. The GDSS was developed and tested for the purposes of this study. It was then given to nine pilot groups for beta testing (testing the initial version) and was modified based on their suggestions.
1.4 Research Methodology

The research methodology is an experimental study. A laboratory experiment was conducted to test the impact of leader, incentive structure, and proximity on problem solving and negotiation process and outcomes in groups supported by a GDSS. The study forms a set of testable hypothesis based on prior research and theories, and tests each experimentally. The major theories used to explain the hypotheses were drawn from communication theories, economic game theory, and utility theory. After running the experiments and collecting the data, statistical analyses were performed to test each hypothesis.

1.5 Structure of Dissertation

The remainder of this dissertation is organized as follows. Chapter 2 provides a literature review and summarizes previous findings related to this study. Chapter 3 presents the framework and defines the theory, the task, and the research methodology. Chapter 4 presents the experimental task as given to subjects in the form of a case study. The GDSS (StriveLink) will also be explained in this chapter. Chapter 5 presents the research questions and forms the set of research hypotheses. Chapter 6 will present the experimental results and statistical analyses. Chapter 7 summarizes the research findings and discusses the results and implications. Limitations of the research and directions for future research are also presented.
CHAPTER II

LITERATURE REVIEW

2.1 Introduction

This chapter will review prior research involving task types, GDSS studies on leader, incentives, and communication channels. Section 2.2 provides a background on task types. Section 2.3 summarizes the motivations for having groups as structural units of work in organizations. Section 2.4 surveys MIS studies on small groups. Section 2.5 reviews studies on GDSS. Sections 2.6 to 2.8 review the GDSS studies on Leader, Incentive Structures, and Communication channels.

2.2 Task Types

The group task is a significant variable that affects the group's decision making process and outcomes. Studies in GDSS literature make the point that the group task is one of the most important variables that affects the group's task performance [Gallupe,
McGrath developed an integrative topology [McGrath, 1984], the group task circumplex (see Figure 2.1). He categorized group tasks based on the classification schemes developed by Hackman [Hackman, 1969], and Steiner [Steiner, 1974]. He divided group tasks based on four general processes: to Generate (alternatives), to Choose (alternative), to Negotiate, and to Execute.

There are two task types which involve 'Negotiate' process: Cognitive conflict and Mixed-motive tasks. Cognitive conflict tasks require resolving conflicts of viewpoints between group members and mixed-motive tasks require resolving pay-off conflicts. Pay-off conflicts mean that conflicts are caused by conflicting payment schemes between negotiators which could be induced by different incentive structures. "Mixed-motive" implies that participants are motivated to both cooperate and to compete with one another. Competition is induced by different outcomes desired by each party. Cooperation is required due to the interdependence of decisions. A decision maker can not achieve its goals unilaterally, and thus, has to resolve interest (payoff) conflicts with others. The group processes in negotiation tasks differ from those involved in planning tasks, creativity task, or other types of cooperative decision making tasks. Social and emotional aspects of negotiation [Faure, LeDong, Shakun, 1990] differ from those for other types of tasks. The computer support used for negotiation tasks may, thus, differ from those used for other types of tasks. Anson and Jelassi [1990] provide a development framework for computer-supported conflict resolution.
Figure 2.1: The Group Task Circumplex
(Source: McGrath, 1984)
2.3 Motivation: Groups as Structural Units of Work in Organizations

In a bureaucracy, all problems are processed through a fixed set of relationships; however, in network organizations\(^1\), the network molds itself to each problem [Baker, 1992]. Various methods for breaking bureaucratic hindrance to successful business operations have been attempted by different organizations. Edwards Deming, credited for having made substantial contributions to the success of Japanese industry, has advocated fourteen points which organizations should follow to improve their business by improving the quality of all aspects of work [Gitlow, Gitlow, 1987]. One of these points is: "break down barriers between departments" (point nine). Matrix organizations and group structures are two ways of breaking barriers between departments in hierarchically rigid organizational structures.

Matrix organizations cope with environmental uncertainty by superimposing a project structure over a functional structure [Szilagyi, Wallace, 1983]. Since projects are typically performed by groups, the matrix organization is a virtual organization consisting of groups which are formed by individuals from within a hierarchical organization. "A group is a small number of people with complementary skills who are committed to a common purpose, performance goals, and approach for which they hold themselves accountable" [Katzenbach, Smith, 1993].

---

\(^1\) A network organization adapts itself by the interactions of problems, people, and resources; a network organization has also been called "self-designing" organization [Eccles, Crane, 1988].
Groups are formed to create a cooperative environment where every member is empowered and the members share the rewards equally. Groups bring cross functional skills in a single unit, increase coordination across functions, and produce a wealth of information when individuals are members of more than one group. Groups have certain process gains, relative to individual work, such as: more information, synergy, more objective evaluation, stimulation of work, and learning. Group process losses include: coordination problems, constrained air time, production blocking, failure to remember, conformance pressure, evaluation apprehension, free riding, cognitive inertia, socializing, domination, information overload, incomplete use of information, and incomplete task analysis [Nunamaker et. al., 1993]. Table 2.1 provides the GDSS features, or the capabilities that such features provide, for reducing the effects of group process losses. Group matters could be handled by a leader or collectively by the members. Ketchup reports that safety and maintenance coordination, information security, and scheduling are among the group matters which are more appropriate to be handled by a single individual [Ketchup, Trist, 1992]. In leader-directed or autocratic groups, the leader acts as the coordinator, has the responsibility of the whole task, and decides on how to reward members. This is counter to the individual empowerment, but perhaps simplifies the convergence of the solution synthesis. There is no research to clearly identify the effect of a leader in solution synthesis under different incentive structures in a GDSS environment.
Table 2.1: Group process losses & GDSS features/user capabilities

<table>
<thead>
<tr>
<th>Group process losses</th>
<th>GDSS features &amp; user options</th>
</tr>
</thead>
<tbody>
<tr>
<td>Information exchange</td>
<td>Shared MIS</td>
</tr>
<tr>
<td>Constrained air time</td>
<td>Simultaneous typing</td>
</tr>
<tr>
<td>Production blocking</td>
<td>Communication support</td>
</tr>
<tr>
<td>Failure to remember</td>
<td>Recording and retrieval</td>
</tr>
<tr>
<td>Conformance Pressure</td>
<td>Anonymity</td>
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<tr>
<td>Evaluation apprehension</td>
<td>Equal reward set by system</td>
</tr>
<tr>
<td>Free riding</td>
<td>Build history of user contributions</td>
</tr>
<tr>
<td>Socializing</td>
<td>Monitor behavior</td>
</tr>
<tr>
<td>Domination</td>
<td>Voting mechanism</td>
</tr>
<tr>
<td>Information overload</td>
<td>Record for later use</td>
</tr>
<tr>
<td>Incomplete use of information</td>
<td>Data analysis tools</td>
</tr>
<tr>
<td>Incomplete task analysis</td>
<td>Modeling tools</td>
</tr>
</tbody>
</table>

Many proponents of democratic groups and GDSS support would hypothesize that if an appropriately designed GDSS can simplify the synthesis by providing some of the routine and programmed leader functions, then empowered members can operate more efficiently in a democratic group by escaping the costs and inefficiencies associated with having a group leader. Another argument for democratic groups when GDSS is available is that the communication between the members and the group leader in leader-directed groups requires abstraction of information. This is frequently an attempt to reduce the information overload on the group leader. Information overload was shown to negatively affect decision quality, confidence in decision quality, and time taken to reach decisions [Chervany, Dickson, 1974].
Abstraction of information may, however, filter the relevant information\(^2\) at the price of preventing information overload, causing the tip-of-the-iceberg phenomena (leader unaware of relevant information).

In democratic groups, targeted messages between group members with no power differences seem to lead to more effective and efficient communication compared to broadcasting a message to every other group member. Targeted message passing is an example of a GDSS feature which could improve the efficiency of group communication.

Section 2.4 reviews the studies on groups and information technology. The research on information technology has been motivated by the potential of information technology to support decision making. Most of such studies were exploratory in nature where the researchers were interested in identifying specific MIS attributes [Mackay, Barr, Kletke, 1992], individual differences [Benbasat, Dexter, 1982], [Zmud, 1979], group size differences [Dennis, Valacich, Nunamaker, 1990], [Gallupe et. al., 1992] and presentation formats [Lusk, Kersnick, 1979], [Moore, 1979], [Jarvenpaa, 1989] most appropriate to support specific decision making tasks.

2.4 Studies on Information Technology


\(^2\) The relevance of information for decision making depends on such attributes as: level of aggregation, timeliness, completeness, reliability, accuracy, validity, currentness, and frequency [Gorry, Scott Morton, 1971], [Zmud, 1978].
success in terms of individual differences by reviewing the empirical research in the area. He classifies MIS attributes into three groups: information needs, decision aids, and delivery system components. Users seem to prefer reports which could be modified compared to unalterable reports [Eason, 1976]. Quantitative decision models are reported to improve performance [Benbasat, Schroeder, 1977], [Chervany, Dickson, 1974], but decrease user confidence in the quality of the decisions [Chervany, Dickson, 1974]. Getting users involved in the design of the MIS is positively related to their level of satisfaction [Edstrom, 1977], [Maish, 1979], [Swanson, 1974], and attitudes toward the MIS [Lucas, 1975]. Subjects with higher risk-taking propensities used MIS less that their lower risk-taking counterparts [Taylor, Dunnette, 1975]. More education, longer organizational tenure, and organizational success have been found to be negatively related to MIS usage [Lucas, 1975], [Werner, 1974]. Professionals and decision makers with high task domain knowledge used MIS more than their counterparts [Werner, 1974].

Prior exploratory studies on information technologies have identified some features that in general aid individual decision makers. Information technologies to support groups provide services such as: member access rights to group resources, group problem solving support, brainstorming (solicitation of ideas), group communications, scheduling of meetings, setting agendas, identifying problems, selecting among alternatives, negotiating options, and analysis of group processes.

Recent developments in information technologies to support groups provide facilities to effectively collect, organize, and share information across networks (LAN and WAN) and dial-up lines. For example, "Lotus Notes", a product of Lotus
Corporation, supports the following major categories of applications: Tracking (i.e. project status report), broadcast, reference, discussion, and workflow automation [Lotus, 1993]. "MeetingRight", a product of QSoft Solutions Corporation, encourages proper preparation for meeting, provides a brainstorming tool, has a tool to record agenda summary screen, keeps meetings on track by utilizing a timer, keeps members on track by reminding them of the desired outcomes for each agenda topic, provides screens for the information needed to achieve closure on each topic, helps in assigning tasks to people, aids in establishing timetables, and provides a pop-up calendar and a pull-down menu of names to ease person-task assignment.

Recent developments in information technology have created a new stream of research which is more specific than the studies on MIS reported above. This stream studies groupware and GDSS. Groupware is the information technology to support information-related activities of groups. A groupware used to support group problem solving with task specific features is called GDSS. Section 2.5 will outline the research on GDSS.

2.5 Research on GDSS

A GDSS is an interactive, computer-based system that facilitates the solution of unstructured problems by a set of decision-makers working together as a group [DeSanctis, Gallupe, 1987]. DeSanctis and Gallupe define three levels of GDSS. Level 1 GDSSs provide technical features to remove common communication barriers such as large screens for instantaneous display of ideas, voting solicitation and compilation,
anonymous input of ideas, and electronic message exchange. Level 2 GDSSs provide
decision modeling and group decision techniques. Level 3 GDSSs are characterized by
machine-induced group communication patterns and can include expert advice in
selecting and arranging of rules to be applied during a meeting. Prior GDSS research has
extensively studied idea generation tasks [Applegate, 1986], [George et. al., 1990],
[Connolly, Jessup, Valacich, 1990].

GDSS use was found [Dennis, 1991] to enhance the following six capabilities
thus improving strategic management outcomes: 1) idea generation, 2) identification of
key problem areas, 3) innovation, 4) communication of line manager concerns to top
management, 5) fostering organizational learning, and 6) integrating diverse functions
and operations. GDSS helped reduce product development time in Balcor (real estate
investment management firm) by thirty percent [Opper, Fersko-Weiss, 1992].

The prominent managerial time wasters are: lack of planning, lack of priorities,
lack of delegation, over commitment, management by crisis, meetings, haste, routine and
trivia, paperwork and reading, visitors (open door), indecision and procrastination,
telephone (message machine) [Patten, 1981], and lack of coordination. The presence of a
coordinator was found to positively affect network communication [Hiltz, Turoff, 1978].
Floyd [1982] found that the use of GDSS (Facilitator) improved decision quality,
increased number of alternatives per decision, and reduced domination by a single group
member. Kull [1982] used MINDSIGHT from Execucom to determine the effect of
GDSS on group decision making and concluded that GDSS must promote group
interaction, allow user to weigh and rank alternative solutions, and support voting.
Ruble [1984], using a management game, found no difference between the groups which used the GDSS and those which did not; he explained that the lack of difference could have been due to the unavailability of specific features to properly support the group decision making process. The nature of the task could also have attributed to the lack of the difference between groups. In her dissertation, Applegate [1986] used a GDSS (Plexsys) to examine its effect on idea generation for strategic planning groups; user perception of the system was reported as positive and anonymity and the ability to work in parallel were mentioned as features which contributed to success. Watson, DeSanctis, and Poole [1988] found that small groups with GDSS performed allocation tasks with poorer quality than did non-GDSS groups and that there was no difference in the degree of consensus formation between members in GDSS groups and those in non-GDSS groups.

The interaction between task complexity and GDSS usage was empirically tested [Bui, Sivasankaran, 1990] using three-member groups; the authors found that GDSS groups made higher quality decisions than did non-GDSS groups, but the decision quality did not differ for low-complexity tasks. Specific GDSS features also impacted decision quality. For example, feedback was found to improve decision quality in three-member GDSS groups working on a choice task [Sengupta, Te'eni, 1991].

The presence of an active process facilitator in allocation tasks was found to enhance consensus compared to when there was no active facilitator or computer mediated facilitator in three to five member groups [Dickson, Robinson, Heath, 1989]. Another study [Anson, 1990] to test the effect of an active process facilitator and GDSS
(GroupSystem) found that the groups with facilitator and GDSS had the highest cohesiveness and process perceptions; the groups with no support ranked lowest on task performance, cohesiveness, and process perceptions. A subsequent study [Anson, Heminger, 1990] confirmed the positive effect of an active process facilitator on GDSS groups.

The next three sections will review the literature on leader, incentives, and proximity in GDSS supported groups.

2.6 GDSS and Leader

In most organizational decision contexts where decisions are made by groups, a group leader is in charge of the final group solution. A group leader performs tasks such as providing technical guidance\(^3\) to members, chairing meetings, maintaining the agendas, assessing the need for agenda changes, and improving group interaction by providing process structure in coordinating verbal discussion [Nunamaker et. al., 1993]. Some studies have examined the relationship between the leader and individual differences on group performance, but the results show no significant relationships in general [Morgan, Lassiter, 1992]. Zmud [1979] categorizes individual differences into: cognitive style\(^4\),

\(^3\) Projects with large software budget as a percentage of total budget are found to be successful projects when the project manager has prior software experience [Williams, 1989].

\(^4\) Simple versus complex [Schroeder, Driver, Streufert, 1967]; low analytic versus high analytic [Witkin, et. al., 1971]; systematic versus heuristic [Huysmans, 1970]; thinking, feeling, sensation, intuition [Jung, 1976].
personality\(^5\), and demographic/situational\(^6\) differences. The GDSS research on cognitive style lost much steam after Huber's Management Science article "Cognitive style as a basis for MIS and DSS designs: Much Ado about nothing?" [Huber, 1983].

Orientation of leader (task oriented versus person oriented), and leader ability were found not to be related to group performance [Hewett, O'Brian, Hornik, 1974], [O'Brian, Owens, 1969]. Leader intelligence is positively related to group performance, but this relationship weakens as leader's level of stress is increased [Fiedler, Leister, 1977].

Much of the non-GDSS research on leadership style compare autocratic and democratic leadership styles [Morse, Reimer, 1956], [Shaw, 1955]. Most of small group research on non-GDSS groups have shown that groups with autocratic leadership styles perform better than groups with democratic leadership styles, but members react more positively to their groups with democratic styles. For research and development groups, studies of non-GDSS groups have shown that the project performance is impaired when only one or a few members are responsible for communication [Allen, Lee, Tushman, 1980], [Tushman, Katz, 1980].

The success of managing projects was positively related to the managers' achieving styles, professional background, and use of legitimate power [Williams, 1989].

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\(^5\) Such as locus of control, dogmatism, ambiguity tolerance, extroversion/introversion, anxiety level, need for achievement, evaluative defensiveness, and risk taking propensity [Klauss, Jewett, 1974].

\(^6\) Such as sex, age, education, organizational level, experience, and professional orientation [Zmud, 1979].
A topology was developed from a field research study [Perkins, 1983] which suggested that the most successful groups had the following characteristics: members with longer term tenure, effective communication, ability to determine problem-solving methods internally, reception of help when needed, and a leader who facilitated the process.

GDSS group meetings seem to benefit from having a facilitator\(^7\) to improve meeting processes and outcomes [Dennis, 1991]. Kahan et. al. [1985] propose that "in operational settings, where leadership is relatively enduring and the leader possesses the authority to actually control group processes, the effects of the leader's personality tends to have a greater influence on group performance"; this claim requires empirical verification.

Lim, Raman, and Wei [1990] used Watson's allocation task with five-member groups; half of the experimental groups had a group-elected leader, and the other half did not have a leader. The major findings were that the GDSS group with no-leader had a more even distribution of influence, and that the dominant group member in GDSS groups had less influence than the dominant member of the non-GDSS groups (with and without leaders). Zigurs, Poole, and DeSanctis [1988] using a GDSS with features including collection and display of ideas, rating, ranking, and voting, found that the

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\(^7\) In most studies a facilitator is not equivalent to a leader; the basic and general functions of a facilitator are to help members with the sophisticated technology, oversee smooth and trouble free operating of the meeting room facilities, and sometimes help members structure meeting agendas using the software tools available. In this study we distinguish between this definition of facilitator and leader.
members in GDSS groups had a more even distribution of influence; the study recommended further GDSS research on the effects of group leader\(^8\).

In an experiment with six-member groups with a generate-and-choose task, George et. al. [George et. al., 1990] found that differences in decision quality, effects of anonymity\(^9\), and the presence of a randomly selected group leader did not significantly differ between GDSS and non-GDSS groups; GDSS groups with leaders participated more equally, and satisfaction was highest in anonymous GDSS groups with leaders and nonanonymously groups without leaders. Anonymity was shown to be less important in groups of peers compared to hierarchically structured groups [Dennis, 1991]. Gallupe [1990] studied the effect of "best member" on the performance of GDSS and non-GDSS groups; the GDSS groups did not do as well as the best member of their group, but many non-GDSS groups did as well or better than their best member. This implies that it is harder for a member to influence other members in GDSS groups than in non-GDSS groups; thus, for tasks such as functional coordination which should promote equal influence by all members, GDSS seems to provide a valuable tool.

\(^8\) Leadership is multidimensional and thus hard to study rigorously without reducing the dimensions. One method of reducing the dimensionality of the study of leadership is to focus on specific attributes of leadership and define concrete measures for such attributes. This study focuses on the synthesis of sub-solutions, and the effect of the over-riding authority of the leader. For a good review of leadership, the reader is referred to Bass and Stogdill [1990].

\(^9\) For other studies on the effects of anonymity the reader is referred to [Licker, 1993], and [Jessup, Tansik, 1991]. Most studies on anonymity have considered idea generation tasks.
In an experimental setting with student subjects, it was found that influence was more evenly distributed in no-leader groups with GDSS relative to no-leader groups without a GDSS, however, GDSS could not stop the leader from exercising influence [Lim, Raman, Wei, 1990]. The task involved ranking competing projects for allocation of funds. The subjects of the study were students in the National University of Singapore who received partial course credit for their participation. The effect of GDSS on influence distribution was insignificant in groups with elected leaders, but GDSS reduced individual domination in groups. The final conclusion was that GDSS promoted democracy in group discussion in the absence of an elected group leader. The surrogate measures for democracy were influence imbalance and dominance significance. In this study, the groups met face-to-face. The research did not specifically address the authority of the leader or the incentives of members. Without incentives tied to performance and leadership authority to override a solution, the results of this study on the effect of leadership lack some important dimensions. The study, however, is interesting in that it analyzes leadership from a narrow definition of leadership; because leadership is a multi-faceted role with many dimensions, it seems only feasible to study just a few dimensions at a time in each single experimental setting.

Group member personality traits can be used to construct homogeneous or heterogeneous groups. Heterogeneous non-GDSS groups tend to produce better solutions for problem-solving tasks [Hoffman, 1959], [Hoffman, Maier, 1961] than their homogeneous counterparts. Another non-GDSS study of three-person groups with heterogeneous versus homogeneous abilities has revealed that the group with
heterogeneous abilities performed better [Laughlin, Branch, Johnson, 1969]. Groups with
homogeneous personalities, attitudes, and abilities tend to make better decisions when
smooth and timely member intergroup interactions are important to group performance.
Less time is invested on interpersonal issues in homogeneous groups relative to
heterogeneous groups [Byrne, 1971]. However, heterogeneous groups perform better on
creative tasks [Bass, Ryterband, 1979].

Higher levels of task interdependence are found to be positively related to helping
behavior, learning from group members, interacting quality among members, and
strength of cooperation norms [Wageman, 1993]. Task uncertainty is negatively related
to discretion [Kowatha, 1993], and goal clarity has been found to improve productivity
and encourage cooperative effort [Drucker, 1964]. Majority rule is more effective than
veto and consensus when groups make judgements [Burnberg, Pondy, Davis, 1970].

Results of studies [Somers, 1965], [Howell, Becker, 1962] on spacial
arrangement show that round tables should stimulate discussion by everyone more than
rectangular tables; however, for groups of three to five the spatial arrangements seem to
have no effect [Cummings, Huber, Adndt, 1974]. The existence of formal leaders also
reduce the effect of spatial arrangements [Hearn, 1957].

Most of the studies on leader have taken place in non-GDSS environments. Very
few studies investigate the effect of leader in a GDSS environment. As GDSS penetrates
into organizations, further research is required to understand the impact of leader on
problem solving in GDSS environments before one can advocate democratic or
autocratic GDSS groups.
2.7 Groups and Reward Structures

Current reward structures which support individual performance to a very high degree are said to discourage groupwork [Doyle, 1992], and the label "autonomous" in autonomous groups, a misnomer, suggests that groups are independent. This label should be replaced by "coordinated" to express the need for cooperation in today's organizations. Major inhibitors of effective groupwork include: compensation systems which emphasize individual performance, command leadership with rugged individualism, and a tendency for quick fix solution methods [Vaughen, 1991].

Group incentives are appropriate when: 1) there exists strong interdependence between individual group member tasks, 2) it is hard to evaluate individual contributions to overall achievement, and 3) management desires to promote group activities [Nickel, O'Neal, 1990]. A gainsharing plan which replaced group-based compensation system with the traditional individual-based program has brought many advantages to BFGoodrich [Masternak, 1993].

Compensation strategies which achieve cross-functional integration in organizations include: rewarding based on performance of cross functional groups, evaluating the coordinated outcome of the cross-functional group instead of functional outcomes, and offering ownership to those in all functional areas [Coombs, Gomez-Mejia, 1991]. Integration and interaction of talents, group collective orientation, a reward
system which reinforces entrepreneurial behavior\textsuperscript{10}, are among the group-focused issues which promote innovation in companies.

It has been shown [Wageman, 1993] that reward system design influences motivation and the strength of groups' norms regulating member effort. Task visibility was found to be positively related to personal monitoring\textsuperscript{11} and outcome-based rewards [Kowatha, 1993]. In a field study with five non-union companies institutionalizing quality circles, it was found [Brennan, 1990] that quality circles can not be easily implemented into the existing organizational power structures because their presence may threaten some middle managers.

In an experiment using high school seniors [Miles, 1993], three independent variables: 1) group composition (self-selected groupmates, or randomly assigned groupmates), 2) reward structure (individual, group, relative performance compared to other member), and 3) task structure (work together, work independently) were used to study productivity and effectiveness of the groups. In this experiment, productivity was found to be highest in groups with randomly selected groupmates with competitive goals working apart from each other; effectiveness, however, was found to be highest in groups with sociometrically selected groupmates with cooperative goals working apart from each other.

\begin{flushright}
\textsuperscript{10} Other factors include: calculated risk taking, management commitment to entrepreneurial activities, and innovation [Saleh, 1993].
\end{flushright}

\begin{flushright}
\textsuperscript{11} Dimensions of control are described as: situational control (monitoring), discretion, outcome-based rewards, professional control (enforcement), and inclusion (residual rights).
\end{flushright}
Incentives could promote cooperative or competitive behavior. For example, for a task of constructing towers from wooden blocks [Cooke, 1981], the productivity and efficiency of groups with intragroup competition-intergroup independence were the poorest; these groups produced least turn-taking behavior, had most tower falls, and engaged in most sabotage attempts. Intergroup equity motive characterized intergroup cooperation and resulted in attempts to ensure that towers did not fall.

Culture seems to impact the effect of incentives. The relationship between culture and rewards was empirically tested by comparing performance and satisfaction on managerial employees in the U.S. and Japanese local governments; the study [Peng, 1991] did not support the culture-free nature of rewards and punishments.

Incentives may impact learning behavior. Cooperative versus individual reward structures12 were shown to have the same effects on the learning ability of undergraduate student subjects to visualize multi-view orthographic projections [Lauderbach, 1986]. The difference between cooperative learning and individual learning [Kassem, 1990] was found not to be significantly different, but the students in the individualistic condition reported more positive attitudes toward the classroom learning experience compared to cooperative students.

Conformity of group decisions was not affected by group or individual reward structures [Miller, 1982] for a task of agreeing or disagreeing on factual or opinion items.

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12 Students in the cooperative group were encouraged to work together by using a cooperative reward structure; they received the same grade based on the average of their individual performance.
In this experiment with six graders, intelligence was found to be negatively related to conformity, gender was found to be unrelated to conformity, and peer pressure significantly influenced the conforming behavior of subjects. A study considering individual and group goals in relation to types of task interdependence - pooled, sequential, and reciprocal- among group members showed [Gowen, 1981] that performance increased for sequential groups with group goals and decreased for reciprocal groups with individual goals.

Section 2.8 will review the literature as it relates to communication channels in GDSS settings.

2.8 GDSS and Communication Channels

The research on communication channels has been motivated by the fact that today's computer capabilities allow organizational members to engage in real-time communication and information exchange when they are geographically distributed. Changing communication channel characteristics has the potential of changing the nature of work in organizations [Zuboff, 1988]. Previous GDSS studies on communication channels have generally compared the efficiency and effectiveness of computer-mediated communication (CMC) with the Face-to-Face (FTF) communication mode. Most studies on computer mediated communication have reported findings in terms of communication efficiency, equality of member participation, and decision quality. For a review see [Rice, 1984].
Communication efficiency is usually captured by the time it takes to reach a solution, and it has been found that CMC groups take longer to reach consensus than FTF groups [Kiesler, Zubrow, Moses, 1985], [Siegel et. al., 1986], [Dubroski, Kiesler, Sehna, 1991], and [Hiltz, Johnson, Turoff, 1986]. FTF communication is shown to be more intimate and immediate than Computer-mediated communication, and thus, CMC creates feelings of de-personalization [Johansen, Vallee, Spangler, 1979], [Kerr, Hiltz, 1982]. The feeling of de-personalization causes group members to focus on the task rather than personal issues [Poole, Holmes, DeSanctis, 1991]. Consensus building was found to be more efficient in FTF groups [Hiltz et. al., 1980] among student subjects, and computer supported groups were found to concentrate more on achieving high quality decisions than engaging in social-emotional types of communication [Hiltz, Johnson, Turoff, 1981] in a group of managers. FTF groups participated more equally [Siegel et. al., 1986] in group activities. The general findings of many studies imply that electronic communication channels reduce media richness [Trevino, Lengel, Daft, 1987].

The research question: "How does GDSS affect group decision making for choice tasks where group members are either face-to-face or remote?" was investigated by Gallupe, and McKeen [1990]. In this study, the task was to rank causes for declining profits of a simulated company, and the decision quality was measured using a benchmark decision made by three experts. The results indicated no difference between any of the experimental conditions, and one reason for that, as pointed out by the authors, was perhaps the task was not difficult enough to require a GDSS. This research
confirmed previous research that FTF groups were more satisfied than computer supported groups.

In another study, the effect of GDSS on communication medium was tested for two types of tasks, intellective and preference tasks [Raman, Tan, Wei, 1993]. The outcome variables included decision satisfaction, a surrogate for decision confidence, and consensus change (a measure for the ability of a group to resolve conflicts and reach a decision). The results of this study showed that for intellective tasks, there was no difference in outcome variables between face-to-face versus distributed groups; however, the face-to-face groups performing the preference task reported higher decision satisfaction and confidence and showed higher consensus change than their distributed counterparts. The authors defined Intellective tasks as tasks which are usually solved through cooperation, and preference tasks as tasks which involve conflict resolution. The group size in this experiment was five. The intellective task required group members to rank a list of competing applicants based on a set of applicant attributes. The preference task required groups to allocate funds to a list of competing projects. The subjects were given course credit for their participation (not clear if tied to performance). The outcome variables in this research did not include any measures of decision quality, and the tasks defined as intellective and preference did not really differ much as they both required subjects to score items given limited resources, just like the Knapsack problem. The intellective task in this research did not seem to have an obvious "correct" answer, and consequently, the authors did not use it as a benchmark for evaluating the quality of the group solution. Comparing tasks which require different mental activities from the
perspective of the perceptions of the subjects may result in erroneous conclusions. In addition to task type, a measure of complexity of the tasks of different types may be required before two tasks may be compared.

Participation of group members refers to the degree to which group members contribute to the problem solving activities. There is evidence to believe that there is a higher equalization of member participation in CMC groups relative to that in FTF groups [Gallupe, DeSanctis, Dickson, 1988], [Johansen Vallee, Spangler, 1979], [Rice, 1984], [Siegel et. al., 1986], [Kiesler, Zubrow, Moses, 1985], [Dubroski Kiesler, Serhna, 1991], [Hiltz, Johnson, Turoff, 1986]. Communication mode has not been found to significantly impact decision quality [Turoff, Hiltz, 1982], [Hiltz, Johnson, Turoff, 1986].

Based on previous research, mostly on idea generation tasks, CMC mode is characterized as having 'low communication efficiency', 'de-individuation', and 'equal participation'. How these characteristics affect groups performing a complex mixed-motive task when groups are equipped with a level 2 GDSS remains an open question requiring further research, which is the subject of current study.

2.9 Experimental Research

No study was found which considered a complex problem facing leader directed groups when the GDSS was specific to the task and the participants had significant stakes in the decision outcomes. Our study is the first to experimentally evaluate the effect of communication channel, group leader, and different incentive mechanisms for groups
with prior group history. The group members in this study have significant stakes in
decision outcomes.

We had to design our own GDSS to control the features available to subjects in an
attempt to assure that differences in treatments were not due to different features that
subjects used or the levels at which these features were used. Systems like Lotus Notes,
and Qsoft have too many general features and not enough specific ones. Thus, it would
not have been possible to utilize them for this specific task and answer research questions
about the effect of leader, incentive structures, and proximity without having results being
biased by GDSS usage characteristics.

Like any other laboratory experiment, the use of student subjects pose potential
threats to external validity and one should be careful in generalizing the findings of this
research beyond the scopes of this study. It has been claimed [McGrath, 1976], however,
that if the students have significant stakes in decision outcomes and are familiar with the
task, then they make reasonable surrogates for actual decision makers.

The subjects of our study were familiar with the task as it was introduced in
conjunction with course topics. They had significant stakes in decision outcomes and had
developed group history before undertaking this experiment.
CHAPTER III

RESEARCH FRAMEWORK, TASK, THEORY, AND EXPERIMENT

3.1 Introduction

It is important to establish a conceptual and theoretical basis for an exploratory study to understand the relation of a particular study within the overall context [Dubin, 1976]. Thus, this chapter proposes a hybrid research framework based on those proposed by Pinsonneault and Kreamer [Pinsonneault, Kreamer, 1989], [Applegate, 1991], and [Hackman, 1983] to study the effect of leader, incentive structure, and proximity on groups solving a mixed-motive task in a GDSS setting.

The chapter will present the framework, task, research methodology and design of the experiment.

3.2 Research Framework

Pinsonneault and Kreamer's conceptual model (see Figure 3.1) for the study of technological impact on group process is the underlying framework for this study
Figure 3.1: Framework for analyzing the impacts of GDSS on group dynamics
(Source: Pinsonneault and Kreamer 1989)
The framework is also based on that given by Applegate [1991] for GDSS supported groups and on the normative model of Hackman [Hackman, 1983] for studying groups.

In Hackman's model, group effectiveness is dependent upon the sufficiency of the material resources and the process criteria of effectiveness; the process criteria of effectiveness is, in turn, dependent upon the match of organizational context and group design and the resulting level of group synergy. Successful implementation and effective use of GDSS requires an awareness of group, technology, and task characteristics. In this study, we keep the task and GDSS features constant and vary the incentive structure (individual versus group), group composition (leader versus no leader), and group member geographic proximity (face-to-face versus distributed).

Applegate proposes that close monitoring of the incremental changes in alignment of the new work processes as the members become assimilated with the technology is also critical; thus, we provided GDSS access and training for group members to aid them through the assimilation with the new technology. Environmental and organizational contextual variables further complicate the implementation of GDSS in organizations. We simulated a case where the environmental and organizational contextual variables remained constant to isolate the effects of our research variables from those attributed to environmental and organizational contextual variables.

In this framework, effectiveness is measured by both outcome variables (performance, satisfaction with the solution, and confidence in the solution) and process variables (frustration with the process, time taken to finish the process, and number of
messages exchanged during the process). The concepts of global optimal solution\(^1\), the efficient frontier, and integrative solution will be used as a benchmark to measure the group solution to determine decision quality and evaluate group performance. A post experiment questionnaire recorded some important measures as perceived by the user.

### 3.3 GDSS Theory

The theoretical planes upon which we build this research are the *Contingency Theory* [Lawrence, Lorsch, 1967], [Kast, Rosenzweig, 1973], *Communication Theory* [Hiltz, Johnson, 1990], [Watson, DeSanctis, Poole, 1988], [George et. al., 1990], [Desanctis, Poole, 1991], *Utility Theory*, and *Economic Game Theory*. Contingency theory tries to understand the interrelationships among organizational subsystems. Communication theory concentrates on communication media characteristics and their effects on decisions. Utility theory proposes that decision makers make decisions to maximize their utility. In Game theory, decision makers may select the dominant strategy or the nash strategy. In the dominant strategy, each member tries to do the best he or she can regardless of what others are doing. In the nash strategy, each member will try to do the best he or she can do, given what others are likely to do.

Other GDSS theories in literature include: 1) Decision making theories where emphasis is on aiding a group of decision makers [Bui, Jarke, 1986], [Dickson, DeSanctis, Poole, 1991], 2) Group process theories where rational practice is overcome

\(^1\) The best possible solution utilizing all data and optimizing accordingly.
by conventional practice and political concerns [Nutt, 1984], [Noel, Wynne, 1991],
[Watson, DeSanctis, Poole, 1988], 3) Institutional theories where emphasis is on the
effects of GDSS on groups, organizations, and the society from a more social rather than
technical perspective (GDSS is viewed as a part of a larger system) [Fulk, Schmitz,
Steinfield, 1990], [Poole, DeSanctis, 1990], and 4) Coordination theory where
coordination is seen as managing dependencies between activities\(^2\) [Malone, Crawston,
1994].

To study group problem solving in a GDSS environment, we wanted a rich task
which captured important characteristics of organizational problem solving tasks.
Section 3.4 will discuss such characteristics of the desired task.

### 3.4 The General Task Characteristics

The task we consider is an example of a *mixed-motive* task. Decision makers have
to resolve conflicts of pay-off by coordinating their decision making. Coordination is
usually required when knowledge and other resources are distributed. Examples of
problems where knowledge and other resources are distributed are product distribution
and supply, organizational coordination and control, and resource allocation and
distribution.

\(^2\) Coordination theory considers the interaction between group members, goals,
activities, computer support systems and other organizational elements from a systems
perspective. The system attempts to achieve coordination for accomplishing complex
tasks [Malone, 1987].
Distribution is inherent in the way work in organizations is accomplished. Pheysey gives a categorization of the division of work for a hospital [Pheysey, 1993], and we modify it for a manufacturing organization. Divisions could be made by: 1) function (i.e. marketing, manufacturing, finance, engineering), 2) customer type (i.e. one-time versus frequent, residential versus industrial), 3) serial stages in the work (i.e. design, manufacturing, marketing), 4) territory (i.e. regions, districts), 5) time (i.e. short-term projects versus long-term projects), 6) stability or variability of workload (i.e. rush orders, make-to-order, make-to-stock), and 7) status or seniority (i.e. top management, middle management, clerical, manual workers).

By constructing groups with the "right" mix of skills, abilities, and resources, organizations frequently convert distributed problems into group problems. A group problem is a problem which requires more than one person to solve it either cooperatively or noncooperatively (competitively). An example of a cooperative problem is coordination for mutual gain, and an example of a competitive problem is the transfer pricing problem.

In this research, we construct a group problem where the group members represent different functional areas\(^3\) (i.e. purchasing, marketing, and production)

---

\(^3\) The degree of differences between departments as well as the degree of interdependence between departments impose different structure and information requirements for coordination. High interdependence requires large amounts of information to handle interdependence; high difference requires rich media structure; formal information systems, update data bases, project scheduling models (i.e. pert charts) are given as examples of tools for coordinating activities for the departments with low on difference, and high on interdependence dimensions [Daft, Lengel, 1984], [Daft, Lengel, 1986].
distributed within a simulated organization, and their activities require coordination. Whenever there is some form of interdependency between agents, there needs to be a coordination mechanism to coordinate the activities of agents to integrate their individual efforts. Different forms of interdependencies include: pooled (sharing of common resources), sequential (activities can begin only after some others have completed), reciprocal (output of some are inputs to others) [Thompson, 1967].

Interdependencies could be managed by: standardization (predetermined rules), direct supervision and organizational hierarchies (one actor manages interdependencies), mutual adjustment (each actor makes adjustments) [Malone, Crawston, 1994], or by bureaucratic means, by clans (direct contact, overlapping memberships, task forces, liaison units), and by markets (i.e. transfer pricing) [Pheysey, 1993]. When problems involve interdependencies, members may engage in gaming behavior. A game could be cooperative or noncooperative. In a cooperative game, players may negotiate binding contracts for joint strategies, whereas, in a noncooperative game, players normally do not have to behave within any contract guidelines [Pindyck, Rubinfeld, 1989].

3.5 The Experimental Task

The company makes $k$ products, and each customer order specifies the quantity of each of the products requested. Consider $n$ customer orders with differential profit impacts and product quantity requirements. The problem is to decide which subset of these $n$ orders to fill to maximize reward without violating product capacity constraints. The best solution can be found by formulating and solving a knapsack problem. The
problem is an example of a \( k \) constraint Knapsack problem, where \( K = \{k: k \text{ is a product}\} \).

To select a subset of orders among the set \( S = \{i: i \text{ is an incoming order}\} \), \(|S| = n\) without violating the product capacity constraints in order to maximize reward, we formulate the following model\(^4\):

\[
\begin{align*}
\text{Max} & \quad f(S,E) \\
\text{S.t.} & \quad g_k(S) < \text{Capacity}_k \quad \text{for all } k
\end{align*}
\]

In the above model, the objective function represents the leader reward (directly proportional to organizational profit) as a result of filling orders \( O \subseteq S \), when departments exert effort levels specified by the second argument. Leader reward is an increasing function of member efforts. The function \( g_k \) represents product \( k \)'s accumulated quantity requirements of filling orders in subset \( O \). \( O \) is a row vector with a one in the column \( i \) when order \( i \) is to be filled, and a zero otherwise.

The organizational objective is to maximize profit, and due to the need for specialized skills, different departments will perform specialized subtasks. Each department \( d \) is rewarded for its work based on the function \( f_d(O,E) \), where \( O \) is the orders that are filled and \( E \) is the set of efforts expended to fill these orders. \( E \) is a row vector with values corresponding to the level of effort associated with each order \( i \). Let \( D = \{d: d \text{ is a department}\} \), then the departmental problem is modeled as follows:

\(^4\)Even though there could be substitution between products, to simplify the analysis we assumed that no such substitution exists.
\[ \text{Max } f(S,E) \] 
\[ \text{S.t. } g_k(S) < \text{Capacity}_k \text{ for product } k \]

More information regarding this function will be provided after we specify member incentives and efforts. Each department is responsible for performing a portion of the overall task of filling an order, and thus, the outcome of the group process is a set of orders that are picked to be filled.

To operationalize a specific working incentive structure based on the above concepts, we introduce the following terms:

\[ PC_{id} = \text{Projected Cost of filling order } i \text{ at department } d. \text{ This is the best estimate the organization has regarding how much it should cost the department to fill an order.} \]

\[ ADC_{ijd} = \text{Actual Departmental Cost of filling order } i \text{ expending effort level } j \text{ at department } d. \text{ For varied levels of effort, the ADC differs and this information is internal to each department.} \]

\[ UDEC_{ijd} = \text{Uncompensated Departmental Effort Cost is the cost that the department } d \text{ incurs for filling order } i \text{ for effort level } j. \text{ This information is internal to each department.} \]

\[ Rev_i = \text{The Revenue generated by filling order } i. \]
The specific problems faced by each member and leader will be operationalized, using the above terms, after incentives are explained.

3.6 Member Incentive and Effort

In this research we operationalize the two different incentive mechanisms for department managers. The first incentive mechanism rewards departments based on how well they perform individually, and the second rewards them based on how well they perform as a group. The surrogate measure for departmental performance in many organizations is how well the departments control their costs compared to some projected standard cost. The corresponding surrogate for departmental contribution to the organizational profit is often a bonus that is tied to organizational profit. If $f_d(O, E)$ is the departmental reward function which is based on the orders selected ($O$) and departmental resource and effort levels ($E$), then finding the optimal set of orders to fill and the optimal resource and effort level to expend to maximize the reward is the departmental objective. The two incentive mechanisms (local and global) for the members are explained in sections 3.6.1 and 3.6.2

3.6.1 Local Incentive

Typical of many organizational incentive mechanisms, member bonus is based on how well each department controls its Actual Departmental Costs ($ADC$) compared to Projected Costs ($PC$). A department receives a bonus, for our example without loss of generality, equal to 60% of the difference between the $ADC$'s and $PC$'s. To lower the
In an attempt to maximize bonus, each department incurs some *Uncompensated Departmental Effort and Resource Costs (UDEC)*. The UDEC is the monetary equivalent estimate to model such intangible costs as the costs due to higher pressure on departmental employees, costs associated with meeting tighter schedules, and costs due to higher stress levels. For each order selected, the internalized reward for each departmental manager is equal to the bonus he or she receives (this is a proxy for the compensation of the department) minus the costs the department incurs for increased effort. Figure 3.2 represents the relationships between different costs, bonuses, and rewards. The figures show that from the perspective of each member, there exists an optimal effort level for each order. The optimal effort level occurs either at the point where the slope of the concave reward curve is zero or at one of the extremes of effort levels. The reward due to selecting order *i* and expending effort and resource level *j* at department *d* is:

\[
\beta_{id} = UDEC_{id} - UDEC_{id}
\]

where,

\[
\beta_{id} = \text{Bonus department } d \text{ receives for filling order } i \text{ at effort level } j \times (PC_{id} - ADC_{id}) \times 60\%
\]
A formulation of the problem is given below:

\[
\begin{align*}
\text{Max} & \sum_{n \in S} \sum_{n \in E} [(PC_{n} - ADC_{n}) \times 60\% - \text{UDEC}_{n}] \times X_{ij} \\
\text{S.t.} & \sum_{n \in S} Q_{nk} Y_{i} < \text{Capacity}_{k} \quad \text{for all product } k \\
& \sum_{n \in S} X_{y} = Y_{i} \quad \text{forall } i \in S
\end{align*}
\]

where,

\[Q_{nk} = \text{Quantity of product } k \in K \text{ requested by order } i \in S\]  

\[X_{y} = \begin{cases} 
1 & \text{if order } i \text{ taken at effort level } j \\
0 & \text{otherwise}
\end{cases}\]

\[Y_{i} = \begin{cases} 
1 & \text{if order } i \text{ taken} \\
0 & \text{otherwise}
\end{cases}\]
Figure 3.2: Relationship between cost, bonus, and reward: Local incentive
With this incentive mechanism, Utility theory predicts that each member will select effort at a level where the marginal increase in bonus is equal to the marginal cost of extra effort. Each member, in addition to deciding on the effort levels, has to select a subset of orders to fill to maximize his or her reward. The problem faced by the members to select effort levels and orders can be divided into two separate sub-problems. The first problem is to select optimal effort levels for each order. Once optimal effort levels are selected, the optimal ADC (ADC’) and UDEC (UDEC’) will be used to solve the following problem and find the optimal set of orders.

\[
\sum_{t} \sum_{k} \left[ (PC_{i,t} - ADC_{i,t})^{0.60 \%} - UDEC_{i,t} \right] Y_{i,t}
\]

\[
\text{S.t.} \sum_{t} Q_{ik} Y_{i,t} < \text{Capacity}_k \quad \text{for all product } k
\]

where,

\[ ADC_{i,t}^{*} = \text{ADC for optimal effort level } j \]

\[ UDEC_{i,t}^{*} = \text{UDEC for optimal effort level } j \]

The experiment was operationalized by each group member receiving a case that provides the relevant data needed to make local decisions; this creates some ambiguity as each member, does not know how the other members are perceiving the problem. When a department solves its local problem (departmental sub-problem), the local solution

---

5 *Ambiguity* confronting managers in organizations seems important to decisions regarding structural design and information processing [Daft, Lengel, 1986].
(departmental sub-solution) may not be acceptable to other departments or the leader because of the interdependency⁶ between the decisions.

Information pertaining to different departments' cost information was deliberately kept out of the case descriptions to simulate the typical organizations where departmental cost information is local to each department. Both face-to-face and distributed GDSS groups had tools which aided them to optimally solve their departmental problems. However, the final choice needed the concurrence of the leader. The problem faced by the leader is explained next.

3.6.2 Global Incentive

The global incentive is based on departmental contribution to the organizational profit. Without loss of generality, 60% of the profit is allocated to be given out as bonuses. Each member will receive 25% of this total allocated pool, and the rest of the profit goes back to the organization. The bonus each member receives depends on the costs of other members as well as his or her own. If costs of other members are assumed constant, then each member is faced with a problem of finding optimal effort level for filling each order, and this information is available locally at the department. Due to the interaction between a member's bonus and other member's costs, isolated local decisions do not necessarily result in the best global reward for all members simultaneously. A standard projected cost is assigned to each order, and this is the best

⁶ Interdependency between decisions implies that choosing a specific order necessitates giving up another order.
estimate a member has regarding other member costs of filling each order. Each member can update the default projected costs if he or she wishes to communicate actual cost information to other members.

The GDSS feature which supports this task is the "Global Cost Exchange" menu option. The GDSS uses these reported actual costs, as the costs incurred at other departments, to calculate order rewards for each member. If these costs are under-reported, then the bonus for that particular order is perceived to be higher than it really is; if these costs are inflated, then the bonus per order is perceived to be lower than what it actually would be. The reward for each order is the bonus minus the Uncompensated Departmental Effort Cost (UDEC). Figure 3.3 shows the relationship between member rewards, bonuses, and costs. Assuming other departmental costs to be constant, each department could find the optimal effort level for each order.

Reward for order $i$ is thus calculated as:

\[
\beta_{iyd} \cdot UDEC_{yd}
\]

where,

\[
\beta_{iy} = 15\% \cdot [(Rev_i - \sum_{dD} ADC_{iyd})]
\]

define $X_{ij}$ and $Y_i$ as we did before for local incentive. The problem is modeled as follows:

\[
\begin{align*}
\text{Max} \sum_{iS} [(Rev_i - \sum_{dD} ADC_{iyd}) 15\% \cdot UDEC_{yd}] X_{iy} \\
\text{S.t.} \\
\sum_{iS} Q_{ik} Y_i < \text{Capacity}_k \quad \text{for all product } k \\
\sum_{iE} X_{iy} = Y_i \quad \text{forall } i \in S
\end{align*}
\]
3.7 Implications of Member Incentives

The first incentive structure should promote competition, whereas the second one should promote cooperation [Graham-Moore, Ross, 1990]. Local incentive is tied to departmental performance, and the global incentive is tied to organizational performance. When group member bonuses are tied to the organizational profit, there is no incentive for any department to knowingly make decisions that will have a negative total contribution (the sum of gains and losses to the organization being
negative). In other words, if the optimal profit of the group solution is represented as a circular pie, then there are \( n \) equal slices (bonuses) for each of the \( n \) members of the group. The total bonus to be allocated among the group members will always be a pie, sharing the same center as and being inside of (equal if the group achieves optimality) the optimal pie as depicted pictorially in Figure 3.4.

A case study problem setting with an inherently group problem (no one can singly solve the overall problem optimally) where each member has a partial view of the overall problem will be given to subjects to solve collectively. Each group member will be given a different case representative of the local problem (based on his or her partial view). This constitutes a decomposed sub-problem. Each agent will solve the sub-problem by utilizing the GDSS features. These features include: modeling, structured information exchange, coordinated what-if capability, solution generation and evaluation capabilities, and the group memory which is a historical representation of the proposed solution.

Once each member solves his or her local problem, each will have a local sub-solution. If he or she belongs to a One-member-synthesis group then the sub-solution is sent to the synthesizer agent (the leader). If he or she belongs to a collective-synthesis group (groups with no leader), then the agent collectively along with other group members attempts to synthesize the global solution from the local sub-solutions. The inherently distributed nature of the group problem will make it impossible for a single member to solve the overall group problem in isolation. It is as if every member sees a portion of a large elephant and they are trying to figure out that the object is an elephant.
3.8 Leader Incentive

The leader tries to maximize the organizational profit as his or her reward is directly tied to organizational profit. Sixty percent of organizational profit is allocated for reward, and the leader will get fifteen percent of this allocated pool. The leader's problem is captured by the following model:

$$\begin{align*}
    \text{Max} & \quad \sum_{i \in S} \left[ 9\% \left( \text{Rev}_i - \sum_{d \in D} \text{ADC}_d \right) \right] Y_i \\
    \text{S.t.} & \quad \sum_{i \in S} Q_k Y_i < \text{Capacity}_k \quad \text{for all product } k
\end{align*}$$

where,

$$\text{Rev}_i = \text{Revenue generated by filling order } i$$

The leader has to select a set of orders to ship to customers and has the authority to impose his or her solution on the managers. The leader may also let the members negotiate a commonly acceptable set of orders. The leader's reward depends on the ADC's incurred at each department for the orders which will be filled. The ADC's are local information at the departmental level, and the leader originally has information about Projected Costs (PC) which are best estimates of the departmental costs of filling an order. The department managers may send the leader updated information about their ADC's through predefined templates of the structured message exchange support sub-component of the GDSS.
3.9 Research Methodology

The research methodology was an experimental study. Each group was randomly assigned to one of the eight treatment conditions. The eight treatments were the result of the three research variables each having two conditions. The research variables were:

I) Group composition:
   1) collective-synthesis (democratic),
   2) One-person-synthesis (leader-directed),

II) Proximity:
   1) Face-to-Face (FTF),
   2) Distributed (DIST),

III) Member Incentive Structure:
   1) Local (group member bonus is tied to departmental performance),
   2) Global (group members bonus is tied to organizational performance).

Thus we had a 2 X 2 X 2 experiment. Define,

\[ x_1 = \begin{cases} 
FTF & \text{Face To Face with GDSS} \\
DIS & \text{Distributed with GDSS} 
\end{cases} \]

\[ x_2 = \begin{cases} 
GLOBAL & \text{Bonus tied to organizational performance} \\
LOCAL & \text{Bonus tied to departmental performance} 
\end{cases} \]

\[ x_3 = \begin{cases} 
NO LEADER & \text{No Leader, Collective Synthesis} \\
LEADER & \text{Leader, One-member synthesis} 
\end{cases} \]
Table 3.1 presents the complete factorial design:

<table>
<thead>
<tr>
<th>Proximity</th>
<th>Composition</th>
<th>Incentive</th>
</tr>
</thead>
<tbody>
<tr>
<td>Face-to-face</td>
<td>Democratic</td>
<td>Global</td>
</tr>
<tr>
<td>Distributed</td>
<td>Democratic</td>
<td>Global</td>
</tr>
<tr>
<td>Face-to-face</td>
<td>Leader-directed</td>
<td>Global</td>
</tr>
<tr>
<td>Distributed</td>
<td>Leader-directed</td>
<td>Global</td>
</tr>
<tr>
<td>Face-to-face</td>
<td>Democratic</td>
<td>Local</td>
</tr>
<tr>
<td>Distributed</td>
<td>Democratic</td>
<td>Local</td>
</tr>
<tr>
<td>Face-to-face</td>
<td>Leader-directed</td>
<td>Local</td>
</tr>
<tr>
<td>Distributed</td>
<td>Leader-directed</td>
<td>Local</td>
</tr>
</tbody>
</table>

It has been shown that groups performed best when their reward and tasks were pure group-based or pure individual-based and worst when either tasks or rewards were hybrid [Wageman, 1993]. Hybrid rewards involve rewarding partly based on group performance and partly based on individual performance. Thus, we rely on this finding to test only group and individual based rewards instead of any convex combination of these extremes.

In this study, we keep the task and GDSS features constant. Close monitoring of the incremental changes in alignment of the new work processes as the members become assimilated with the technology is critical. Thus, we provided GDSS access and training for subjects to aid them through the assimilation with the new technology.

The FTF group discussions were video-taped, and the computer communication, along with the timing of computer activities, was recorded in a database file.
3.10 Subjects

Participants in this study were 176 higher level undergraduate business students enrolled in a business decision making course at The Ohio State University. An integral part of the course required students to work in "management groups" to make decisions for their departments within their firm. Three sections of this course were selected for the study, and all sections were taught by the same instructor (the author) in an attempt to provide homogeneous information to all groups. Each student within the decision making group was randomly assigned to a group of three and so represented a manager of either marketing, production, or purchasing department. Some groups had four members, one being the group leader. We randomly assigned groups to each of the cells in Table 3.2. The groups were formed the first day of class and were given multiple group assignments before they were given this case. Thus, groups had developed some group history prior to solving this case.

<table>
<thead>
<tr>
<th>Global Incentive</th>
<th>Leader-directed</th>
<th>Democratic</th>
</tr>
</thead>
<tbody>
<tr>
<td>FTF</td>
<td>FTF</td>
<td></td>
</tr>
<tr>
<td>DIST</td>
<td>DIST</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Local Incentive</th>
<th>Leader-directed</th>
<th>Democratic</th>
</tr>
</thead>
<tbody>
<tr>
<td>FTF</td>
<td>FTF</td>
<td></td>
</tr>
<tr>
<td>DIST</td>
<td>DIST</td>
<td></td>
</tr>
</tbody>
</table>

The College administering the course felt that this would be an excellent exercise for the students as it utilized a number of concepts they were being taught. Based on their suggestion the experiment was made an integral part of the course.
Each participant was given a case study describing the problem to be solved without the cost information prior to the experiment, and each was also presented with a presentation on the general GDSS features and the case problem. It was shown to them how the case fit into the topics covered in the course. The students were asked to read the case and ask any questions they had. Each group member, during the experiment, was provided with local cost information. These cost sheets did not include information about costs of other departments, and this information was deliberately kept out of the case descriptions to simulate the real environments in departments within organizations where cost information is local to each department.

Both FTF and distributed GDSS groups had tools which aided them in optimally solving their departmental problems. The case was required for the course and was worth ten percent of the course grade. Participation in the experiment, however, was voluntary. The students who volunteered to participate in this study earned up to 5 extra credit points based on their performance. All students in the class voluntarily agreed to participate in the experiment, so the project was essentially worth fifteen percent of their grade. Students were told that their grades were directly proportional to the reward points they achieved.

To alleviate the problem of unfair comparisons across treatment conditions and roles, each role was compared to the same role in the same treatment condition. Student grades were determined with respect to how well others with comparable roles and treatment conditions performed. An analysis of the videotapes indicated that each student tried very hard to achieve as high a reward as possible as fifteen percent of the course
grade provided significant stakes. The experiment was approved by the Human Subjects Review Committee at The Ohio State University.

The Face-to-Face GDSS group interactions were video-taped, and the interaction of all groups (Face-to-Face and distributed) were recorded by the computer in a database for post experimental in-depth analysis.

To become acquainted with the system, a training session was held, and a sample problem was solved. The actual experiment started only when it was known that the subjects fully understood the problem and the GDSS features. The author remained on-site during the experiment to answer any questions at any time. On the average, each experiment lasted approximately two hours, but there were no explicit time limits.

3.11 Measures

In this study we evaluate decisions from the perspective of both process and outcome variables. The outcome variables included measures of performance as related to decision quality and satisfaction with the solution. The process variables included time taken to finish the negotiation process, frustration with the process, and the number of different types of messages exchanged during the negotiation process. The measures of performance were operationalized by comparing the solutions with the theoretical efficient frontier.
3.11.1 Theoretical Efficient Frontier

In multiple objective problems, the notion of optimality is replaced by pareto optimality, efficient frontier, or nondominated solution set. The notion of optimality should be dropped because a solution which optimizes one objective, in general, will not optimize other objectives [Cohon, 1978], [Stuer, 1989]. The efficient frontier consists of all solutions which can not be dominated by another solution. That is, one can not find a solution which improves at least one objective without degrading one or more of the other objectives.

For our problem, we found the theoretical efficient frontier for the objectives of leader and members by formulating and solving a two objective problem. The problem then was iteratively solved using the weighting method of multiple objectives [Cohon, 1978]. In this method, one parametrically keeps changing the weights assigned to each objective to find the break-points in the efficient frontier. Once we found the efficient frontier, the experimental points were compared against the efficient frontier. We represented the leader objective on the vertical axis and that of the members on the horizontal axis. The deviation from the efficient frontier was found by measuring the vertical and horizontal distances between the efficient frontier and the points obtained from the experiment. This provides a measure of leader and member performance with respect to the best outcome they could achieve given the other parties' outcomes. This became a measure which we utilized in forming some of the hypotheses on performance. Figure 3.5 provides a graphical representation of the efficient frontier when member
incentive is local, and the LINDO program for finding the efficient frontier is presented in Appendix A.

Figure 3.5: The Theoretical efficient frontier for local incentive
3.11.2 Integrative Solution

In negotiation situations where multiple parties with different objectives have to negotiate with each other to arrive at a solution, a good solution may be defined as a solution which simultaneously makes everyone as well off as possible. That is, no one receives an extremely high payoff at the expense of others.

To find the Integrative solution for our problem, we will solve the problem as a goal programming problem. The goals would be to achieve as high a percentage of everyone's optimal solution as possible simultaneously. To find the optimal reward for each member and leader, four single objective problems were formulated and solved. Once the optimal solution for each member and leader was identified, a new model with four extra constraints (assuring that each member received a reward higher than a fixed percentage of his/her optimal reward) was formulated and solved. We parametrically varied the percentages until no further improvements could be made.

The deviation from the integrative solution was a measure used to form a set of testable hypotheses. An integrative solution is the objective of an "integrative" approach to negotiation. An integrative approach to negotiation is characterized by a coordinative behavior [Magenau, Pruitt, 1979] or "soft negotiation" [Fisher, Ury, 1981], where the parties collaborate with the other parties in the search of a commonly acceptable solution. Integrative bargaining enhances organizational effectiveness in intra-organizational negotiation [Pruitt, 1981] and, thus, is a relevant measure to form hypotheses on performance. Figure 3.6 provides a graphical representation of nondominated solutions
and the Integrative solution using Value paths developed by [Schilling, Revelle, Cohon, 1983], and Appendix A provides a LINDO code we used to find these.

Figure 3.6: The Nondominated solutions and the integrative Solution
CHAPTER IV

StriveCo CASE & GDSS

4.1 Introduction

This chapter presents the StriveCo manufacturing case. Every participant in the experiment received the StriveCo Manufacturing case as depicted in section 4.2.1. Each subject, also depending on his or her role received the appropriate handout as depicted in sections 4.2.2 to 4.2.5.

4.2 The Case description

The structure of this section is as follows. The general problem handout which was given to students prior to the experiment is depicted in 4.2.1. The cases which were provided to the subjects right before the experiment appear in sections 4.2.2 to 4.2.5. The reward handouts for local and global incentive structures are provided in sections 4.2.6 and 4.2.7. The GDSS will be explained in section 4.3.
4.2.1 StriveCo Manufacturing Case

StriveCo manufacturing company, established in 1920, was one of the pioneering companies in producing products that improve office productivity. The company used to sell typewriters, customized business forms, and other tools to improve the efficiency and effectiveness of office communication. New developments in technology have always created new possibilities for the company to convert the new technological possibilities into innovative office and factory productivity tools. Currently, the company markets specialized hardware and software tools for the office. This market is expected to grow substantially in the 1990's. The four main products within this category, which StriveCo produces and sells, are:

1) Product 1
2) Product 2
3) Product 3
4) Product 4

Although each product has a set of basic characteristics, they differ in some features depending on customer requirements and specific orders. Thus, the products are basically make-to-order. The customer specifications fall into a class of modifications that the company uses as guidelines for setting the prices competitively; thus each order is assigned a revenue which depends on the number of products and the complexity of modifying the products to satisfy customer specific requirements.
StriveCo is an autonomous subsidiary of OfficeTech Corporation. OfficeTech owns other subsidiaries similar to StriveCo, and each of these subsidiaries specialize in one set of office technology product category. StriveCo has three functional divisions (departments) which are in charge of coordinating their activities as they each perform a task associated with each order to be filled. These departments are:

1) Marketing
2) Production
3) Purchasing

The operation of each functional division is loosely coupled with those of other functional divisions. That is, they make their local decisions and then coordinate their activities to fill customer orders in the most efficient manner. The task for each functional manager is to determine which of the customer orders to fill, and how much departmental effort to expend for filling each order. A customer order is considered to be some combination of all four products made by StriveCo. If an order is filled, it has to be filled completely and no partial orders are shipped. A listing of current customer orders are depicted in Table 4.1, and you have to determine which subset of these orders to fill.

The department managers will meet to decide which orders to fill. The departments start their work as soon as they agree on the set of orders to be filled from among the incoming orders. Each group member has to maximize his or her reward. Each department has capacity product constraints and may not violated. The products within each order, although basically similar, differ slightly due to specific customer
requirements and specifications. These special modifications to the basic products may affect departmental costs.

Each order is assigned a standard cost based on several general characteristics of orders which the cost accountants have classified and built into an expert system. The expert system determines the standard cost for each order for each department, and assigns a selling price to each order. The customers are charged based on the selling prices assigned by the expert system. The departments can control departmental costs by exerting different levels of departmental effort and resources. As each department increases its effort and resource level, Actual Departmental Costs (ADC) which are used to calculate departmental bonuses may go down (resulting in higher bonuses), but the departmental hidden costs may go up.

When the meeting starts, each of you will be given information regarding the costs of filling each order for your department. You will use a Group Decision Support System which is a menu-driven system to aid you in your decision making task.

Each department manager will receive a case which contains that department's cost information.
### Table 4.1: Listing of the Twenty Customer Orders

<table>
<thead>
<tr>
<th>Customer Number</th>
<th>Product 1 Quantity</th>
<th>Product 2 Quantity</th>
<th>Product 3 Quantity</th>
<th>Product 4 Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>200</td>
<td>450</td>
<td>200</td>
<td>400</td>
</tr>
<tr>
<td>2</td>
<td>50</td>
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<td>100</td>
<td>800</td>
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<tr>
<td>3</td>
<td>100</td>
<td>0</td>
<td>50</td>
<td>400</td>
</tr>
<tr>
<td>4</td>
<td>400</td>
<td>100</td>
<td>150</td>
<td>650</td>
</tr>
<tr>
<td>5</td>
<td>350</td>
<td>1100</td>
<td>550</td>
<td>950</td>
</tr>
<tr>
<td>6</td>
<td>400</td>
<td>55</td>
<td>420</td>
<td>155</td>
</tr>
<tr>
<td>7</td>
<td>150</td>
<td>50</td>
<td>250</td>
<td>80</td>
</tr>
<tr>
<td>8</td>
<td>200</td>
<td>1100</td>
<td>300</td>
<td>700</td>
</tr>
<tr>
<td>9</td>
<td>300</td>
<td>0</td>
<td>455</td>
<td>0</td>
</tr>
<tr>
<td>10</td>
<td>100</td>
<td>0</td>
<td>300</td>
<td>300</td>
</tr>
<tr>
<td>11</td>
<td>600</td>
<td>1100</td>
<td>300</td>
<td>300</td>
</tr>
<tr>
<td>12</td>
<td>800</td>
<td>950</td>
<td>300</td>
<td>300</td>
</tr>
<tr>
<td>13</td>
<td>100</td>
<td>400</td>
<td>250</td>
<td>450</td>
</tr>
<tr>
<td>14</td>
<td>300</td>
<td>100</td>
<td>700</td>
<td></td>
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<tr>
<td>15</td>
<td>500</td>
<td>100</td>
<td></td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>450</td>
<td>1000</td>
<td>835</td>
<td>2250</td>
</tr>
<tr>
<td>17</td>
<td>210</td>
<td>210</td>
<td>315</td>
<td>255</td>
</tr>
<tr>
<td>18</td>
<td>200</td>
<td>300</td>
<td>310</td>
<td>350</td>
</tr>
<tr>
<td>19</td>
<td>150</td>
<td>310</td>
<td>400</td>
<td>450</td>
</tr>
<tr>
<td>20</td>
<td>250</td>
<td>55</td>
<td>520</td>
<td>110</td>
</tr>
</tbody>
</table>

### Table 4.2: Order revenue information

<table>
<thead>
<tr>
<th>Order</th>
<th>Revenue</th>
<th>Order</th>
<th>Revenue</th>
<th>Order</th>
<th>Revenue</th>
<th>Order</th>
<th>Revenue</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>$865.00</td>
<td>6</td>
<td>$1,120.00</td>
<td>11</td>
<td>$1,990.00</td>
<td>16</td>
<td>$3,870.00</td>
</tr>
<tr>
<td>2</td>
<td>$1,195.00</td>
<td>7</td>
<td>$740.00</td>
<td>12</td>
<td>$860.00</td>
<td>17</td>
<td>$1,010.00</td>
</tr>
<tr>
<td>3</td>
<td>$510.00</td>
<td>8</td>
<td>$1,520.00</td>
<td>13</td>
<td>$1,195.00</td>
<td>18</td>
<td>$1,120.00</td>
</tr>
<tr>
<td>4</td>
<td>$790.00</td>
<td>9</td>
<td>$840.00</td>
<td>14</td>
<td>$830.00</td>
<td>19</td>
<td>$1,750.00</td>
</tr>
<tr>
<td>5</td>
<td>$2,340.00</td>
<td>10</td>
<td>$1,340.00</td>
<td>15</td>
<td>$1,450.00</td>
<td>20</td>
<td>$970.00</td>
</tr>
</tbody>
</table>
4.2.2 Marketing Department

You are the manager of Marketing department of StriveCo which performs the customer relation activities, on-site user installation, and training. Each order is associated a projected cost, the best estimate the organization has regarding your departmental cost of filling that order. The projected costs are representative of, and are not equivalent to actual departmental costs for each order. As you increase your effort and resource levels, Actual Departmental Costs (ADC) may drop. Your department's extra effort is not directly compensated by the organization and it may include such costs as increased pressure on departmental employees, faster pace of work in the department, and basically any costs associated with the loss of moving from the comfortable work load to more intense working conditions. The following Tables provide information on the pair of Uncompensated Departmental Cost (UDEC) due to increased effort and resources, and the Actual Departmental Cost (ADC) for each order. The four rows within each order represent effort levels from 1 (top row) to 4 (bottom row).

Table 4.3: Marketing cost information for orders 1 to 4

<table>
<thead>
<tr>
<th>Order: 1</th>
<th>Order: 2</th>
<th>Order: 3</th>
<th>Order: 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>PC: $200</td>
<td>PC: $280</td>
<td>PC: $100</td>
<td>PC: $180</td>
</tr>
<tr>
<td>UDEC</td>
<td>ADC</td>
<td>UDEC</td>
<td>ADC</td>
</tr>
<tr>
<td>$0</td>
<td>$190</td>
<td>$0</td>
<td>$290</td>
</tr>
<tr>
<td>$10</td>
<td>$150</td>
<td>$10</td>
<td>$230</td>
</tr>
<tr>
<td>$20</td>
<td>$140</td>
<td>$20</td>
<td>$200</td>
</tr>
<tr>
<td>$30</td>
<td>$120</td>
<td>$40</td>
<td>$190</td>
</tr>
</tbody>
</table>
Table 4.4: Marketing cost information for orders 5 to 20

<table>
<thead>
<tr>
<th>Order: 5</th>
<th>Order: 6</th>
<th>Order: 7</th>
<th>Order: 8</th>
</tr>
</thead>
<tbody>
<tr>
<td>PC: $600</td>
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<td>PC: $100</td>
<td>PC: $320</td>
</tr>
<tr>
<td>UDEC</td>
<td>ADC</td>
<td>UDEC</td>
<td>ADC</td>
</tr>
<tr>
<td>$0</td>
<td>$650</td>
<td>$0</td>
<td>$240</td>
</tr>
<tr>
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<td>$50</td>
<td>$490</td>
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<th>Order: 11</th>
<th>Order: 12</th>
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<tbody>
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<td>PC: $80</td>
<td>PC: $250</td>
<td>PC: $400</td>
<td>PC: $180</td>
</tr>
<tr>
<td>UDEC</td>
<td>ADC</td>
<td>UDEC</td>
<td>ADC</td>
</tr>
<tr>
<td>$0</td>
<td>$100</td>
<td>$0</td>
<td>$240</td>
</tr>
<tr>
<td>$10</td>
<td>$90</td>
<td>$10</td>
<td>$180</td>
</tr>
<tr>
<td>$20</td>
<td>$85</td>
<td>$20</td>
<td>$170</td>
</tr>
<tr>
<td>$30</td>
<td>$85</td>
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<table>
<thead>
<tr>
<th>Order: 13</th>
<th>Order: 14</th>
<th>Order: 15</th>
<th>Order: 16</th>
</tr>
</thead>
<tbody>
<tr>
<td>PC: $250</td>
<td>PC: $160</td>
<td>PC: $300</td>
<td>PC: $800</td>
</tr>
<tr>
<td>UDEC</td>
<td>ADC</td>
<td>UDEC</td>
<td>ADC</td>
</tr>
<tr>
<td>$0</td>
<td>$220</td>
<td>$0</td>
<td>$160</td>
</tr>
<tr>
<td>$10</td>
<td>$210</td>
<td>$20</td>
<td>$130</td>
</tr>
<tr>
<td>$20</td>
<td>$200</td>
<td>$30</td>
<td>$100</td>
</tr>
<tr>
<td>$30</td>
<td>$190</td>
<td>$40</td>
<td>$70</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Order: 17</th>
<th>Order: 18</th>
<th>Order: 19</th>
<th>Order: 20</th>
</tr>
</thead>
<tbody>
<tr>
<td>PC: $220</td>
<td>PC: $280</td>
<td>PC: $360</td>
<td>PC: $180</td>
</tr>
<tr>
<td>UDEC</td>
<td>ADC</td>
<td>UDEC</td>
<td>ADC</td>
</tr>
<tr>
<td>$0</td>
<td>$260</td>
<td>$0</td>
<td>$320</td>
</tr>
<tr>
<td>$10</td>
<td>$220</td>
<td>$10</td>
<td>$300</td>
</tr>
<tr>
<td>$20</td>
<td>$180</td>
<td>$20</td>
<td>$260</td>
</tr>
<tr>
<td>$30</td>
<td>$150</td>
<td>$30</td>
<td>$210</td>
</tr>
</tbody>
</table>
You have to select a subset of the twenty orders to maximize your reward. Your department has capacity limits of: 1500 for product 1, 1950 for product 2, 3400 for product 3, and 2850 for product 4; you cannot select orders that violate capacity constraints. Your reward is calculated based on the equation explained in the reward handout. If a common set of orders is not adopted by all group members, then the reward is zero for each group member.

You may utilize the Group Decision Support System features, Communication Support System, [request aid from the leader if your group has a leader]¹, and decide on how and what information to share with others. When you begin, you have information regarding other departmental projected costs; other departments also only have information regarding your projected costs for each order. These are the best estimates of how much it should cost other departments to fill each order.

The actual departmental costs and effort costs (Uncompensated Effort Costs) are local to the functional divisions; it is up to you to decide how and what information to share with other departments or the leader if your group has a leader. Each department manager has information regarding it's local costs; departmental data remain the property of each department, and is not directly accessible by other departments or the leader.

¹This information appears in the cases given to groups with a leader only.
4.2.3 Production Department

You are the manager of the production department of StriveCo. You have to determine which of the twenty orders to fill to maximize your reward; you also have to determine how much departmental effort and resources to exert on each order. Normally, as you exert extra effort, your department incurs a cost which is not compensated by the organization (UDEC), but the Actual Departmental Costs (ADC) which are used to calculate your bonus may drop, resulting in a higher bonus. The following Tables provide information on the Uncompensated Departmental Effort Cost (UDEC), and Actual Departmental Cost (ADC) for each order; The Projected Cost (PC) of filling each order, which is the best organizational estimate of the departmental costs, are also given for each order.

<table>
<thead>
<tr>
<th>Order: 1</th>
<th>Order: 2</th>
<th>Order: 3</th>
<th>Order: 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>PC: $400</td>
<td>PC: $430</td>
<td>PC: $200</td>
<td>PC: $300</td>
</tr>
<tr>
<td>UDEC</td>
<td>ADC</td>
<td>UDEC</td>
<td>ADC</td>
</tr>
<tr>
<td>$0</td>
<td>$360</td>
<td>$0</td>
<td>$460</td>
</tr>
<tr>
<td>$20</td>
<td>$330</td>
<td>$20</td>
<td>$400</td>
</tr>
<tr>
<td>$40</td>
<td>$300</td>
<td>$40</td>
<td>$380</td>
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<tr>
<td>$50</td>
<td>$300</td>
<td>$50</td>
<td>$380</td>
</tr>
</tbody>
</table>
Table 4.6: Production cost information for orders 5 to 20

<table>
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<tr>
<th>Order: 5</th>
<th>Order: 6</th>
<th>Order: 7</th>
<th>Order: 8</th>
</tr>
</thead>
<tbody>
<tr>
<td>PC: $1000</td>
<td>PC: $500</td>
<td>PC: $250</td>
<td>PC: $650</td>
</tr>
<tr>
<td>UDEC ADC</td>
<td>UDEC ADC</td>
<td>UDEC ADC</td>
<td>UDEC ADC</td>
</tr>
<tr>
<td>$0 $1000</td>
<td>$0 $330</td>
<td>$0 $280</td>
<td>$0 $700</td>
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<tr>
<td>$20 $950</td>
<td>$20 $480</td>
<td>$20 $255</td>
<td>$10 $680</td>
</tr>
<tr>
<td>$40 $900</td>
<td>$30 $430</td>
<td>$30 $240</td>
<td>$20 $660</td>
</tr>
<tr>
<td>$55 $880</td>
<td>$40 $420</td>
<td>$40 $570</td>
<td>$30 $610</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Order: 9</th>
<th>Order: 10</th>
<th>Order: 11</th>
<th>Order: 12</th>
</tr>
</thead>
<tbody>
<tr>
<td>PC: $400</td>
<td>PC: $550</td>
<td>PC: $800</td>
<td>PC: $450</td>
</tr>
<tr>
<td>UDEC ADC</td>
<td>UDEC ADC</td>
<td>UDEC ADC</td>
<td>UDEC ADC</td>
</tr>
<tr>
<td>$0 $380</td>
<td>$0 $560</td>
<td>$0 $860</td>
<td>$0 $480</td>
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<tr>
<td>$10 $300</td>
<td>$10 $550</td>
<td>$10 $800</td>
<td>$10 $420</td>
</tr>
<tr>
<td>$20 $290</td>
<td>$20 $540</td>
<td>$20 $775</td>
<td>$20 $410</td>
</tr>
<tr>
<td>$30 $280</td>
<td>$30 $500</td>
<td>$30 $700</td>
<td>$30 $370</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Order: 13</th>
<th>Order: 14</th>
<th>Order: 15</th>
<th>Order: 16</th>
</tr>
</thead>
<tbody>
<tr>
<td>PC: $500</td>
<td>PC: $350</td>
<td>PC: $650</td>
<td>PC: $1700</td>
</tr>
<tr>
<td>UDEC ADC</td>
<td>UDEC ADC</td>
<td>UDEC ADC</td>
<td>UDEC ADC</td>
</tr>
<tr>
<td>$0 $480</td>
<td>$0 $350</td>
<td>$0 $690</td>
<td>$0 $1650</td>
</tr>
<tr>
<td>$10 $470</td>
<td>$10 $290</td>
<td>$10 $650</td>
<td>$10 $1600</td>
</tr>
<tr>
<td>$20 $450</td>
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<td>$30 $260</td>
<td>$30 $580</td>
<td>$30 $1500</td>
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</table>

<table>
<thead>
<tr>
<th>Order: 17</th>
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<th>Order: 20</th>
</tr>
</thead>
<tbody>
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<td>PC: $710</td>
<td>PC: $450</td>
</tr>
<tr>
<td>UDEC ADC</td>
<td>UDEC ADC</td>
<td>UDEC ADC</td>
<td>UDEC ADC</td>
</tr>
<tr>
<td>$0 $410</td>
<td>$0 $520</td>
<td>$0 $700</td>
<td>$0 $500</td>
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<tr>
<td>$10 $400</td>
<td>$10 $500</td>
<td>$10 $650</td>
<td>$10 $460</td>
</tr>
<tr>
<td>$20 $390</td>
<td>$20 $450</td>
<td>$20 $640</td>
<td>$20 $450</td>
</tr>
<tr>
<td>$30 $380</td>
<td>$30 $410</td>
<td>$30 $620</td>
<td>$30 $420</td>
</tr>
</tbody>
</table>
You have to select a subset of the twenty orders to maximize your reward. Your department has capacity limits of: 1500 for product 1, 1950 for product 2, 3400 for product 3, and 2850 for product 4, and you cannot select orders that violate capacity constraints. Your reward is calculated based on the equation explained in the section on reward. If a mutually agreeable set of orders is not adopted by all group members, then the reward is zero for each.

You may utilize the Group Decision Support System features, Communication Support System, [request aid from the leader], and decide on what and how much information to share with others. The ADC's and UDEC's are local to the departments; it is up to you to decide how and what information to share with others. Each department manager has information regarding it's local costs; departmental data remain the property of each department, and is not directly accessible by others.
4.2.4 Purchasing Department

You are the manager of the Purchasing department of StriveCo. Your department has capacity limits of: 1500 for product 1, 1950 for product 2, 3400 for product 3, and 2850 for product 4, and you cannot select orders that violate capacity constraints. You have to select a subset of the twenty orders to maximize your reward. Your reward is calculated based on the equation explained in the reward handout. If a mutually agreeable set of orders is not adopted by all group members, then the reward is zero for each group member. You also have to determine how much departmental effort and resources to exert on each order you select. Normally, as you exert extra effort, your department incurs an Uncompensated Departmental Effort Cost (UDEC) which is not compensated by the organization, but the Actual Departmental Cost (ADC) for filling that order which is used in the calculation of your bonus may drop, resulting in a higher bonus. The following Tables provide information on UDEC, the ADC's, and the Projected Cost (PC) for each order.

**Table 4.7: Purchasing cost information for orders 1 to 4**

<table>
<thead>
<tr>
<th>Order: 1</th>
<th>Order: 2</th>
<th>Order: 3</th>
<th>Order: 4</th>
</tr>
</thead>
<tbody>
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<td>PC: $150</td>
<td>PC: $220</td>
</tr>
<tr>
<td>UDEC</td>
<td>ADC</td>
<td>UDEC</td>
<td>ADC</td>
</tr>
<tr>
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<td>$0</td>
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<tr>
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Table 4.8: Purchasing cost information for orders 5 to 20

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<tr>
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<td>ADC</td>
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<td>$250</td>
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</tbody>
</table>
You may utilize the Group Decision Support System features, Communication Support System, [request aid from the leader], and decide on what and how much information to share with others.

The departmental costs are local to your department, and it is up to you to decide how and what information to share with others. Each department manager has information regarding its local costs. Departmental data remain the property of each department, and is not directly accessible by other departments. If a mutually agreeable set of orders is not adopted by all members, then the allocated reward is zero for each member.
4.2.5 Group Leader

You are the group leader and have to oversee the activities of the three department managers. The departments are: 1) Marketing, 2) Production, and 3) Purchasing. You have to select a set of orders which maximize organizational profit, and thus your reward. 60% of the gross organizational profit is allocated for reward purposes. You receive 15% of this allocated pool. Organizational gross profit is equal to the revenue minus the sum of actual costs incurred at all departments for the selected set of orders. You may:

1) Synthesize sub-solutions provided to you by the separate departments to obtain the final solution,
2) Request information from division managers
3) Ask managers to consider a solution and report to you it's favorableness,
4) Override a sub-solution\(^2\) and replace it with another feasible sub-solution,

To calculate organizational profit, you need to gather cost information from departments. Your perceived organizational profit is determined by subtracting the self-reported total departmental costs from the globally available information about revenue. The actual organizational profit will be equal to your perceived organizational profit only if you received truthful cost information from all departments. The true organizational profit is different otherwise, and is calculated based on the true departmental costs for the set of orders selected. Sixty percent of true organizational profit generated by the set of selected orders is allocated for reward. The final decision is to determine a subset of the twenty orders to fill to maximize organizational profit, and subsequently your reward.

---

\(^2\) A sub-solution is the solution at the divisional level.
4.2.6 Reward (Local)

Your bonus is based on how well you control your Actual Departmental Costs (ADC) compared to Projected Costs (PC). You receive a bonus equal to 60% of the difference between your ADC's and PC's. To improve the ADC's which are used to calculate your bonus, your department incurs some Uncompensated Departmental Effort and Resource Costs (UDEC) which are due to increased costs for increased pressure on departmental employees, costs associated with meeting tighter schedules, etc. For each order you select, your reward is equal to the bonus you receive due to decreased departmental ADC's, minus the costs your department incurs for increased effort. Thus, the Reward for each order is found by:

\[ \text{Reward} = \text{Bonus} - \text{UDEC} \]

where,

\[ \text{Bonus} = (\text{PC} - \text{ADC}) \times 60\% \]

\[ \text{PC} = \text{Projected Cost for filling the order} \]

\[ \text{ADC} = \text{Actual Departmental Cost of filling the order for a specific effort level} \]

\[ \text{UDEC} = \text{Uncompensated Departmental Effort Cost for filling the order for a specific effort level} \]

and thus, your total reward is equal to the sum of rewards obtained by the selected orders:

\[ \text{Reward} = \sum_{i \in O} \text{Reward}_i \]

where,

\[ O = \{ i/ \text{Order} \text{ } i \text{ is selected} \} \]
4.2.7 Reward (Global)

Your reward is based on your departmental contribution to the organizational profit. 60% of the organizational profit is allocated to be given out as bonuses. Each member will receive 25% of this total allocated pool; your Bonus for each order is thus calculated as:

\[ \text{Bonus} = 25\% \cdot \left[ (\text{Rev} - \sum_{d} (\text{ADC}_d)) \cdot 60\% \right] \]

where,

\[ \text{Rev} = \text{Revenue generated by filling the order} \]

\[ \text{ADC} = \text{Actual Departmental Cost for filling the order for a specific effort level} \]

Your reward for each order is found by subtracting your Uncompensated Departmental Effort Cost of from the given Bonus as follows:

\[ \text{Reward} = \text{Bonus} - \text{UDEC} \]

where,

\[ \text{UDEC} = \text{Uncompensated Departmental Effort Cost for filling the order at a specific effort level.} \]

and thus, your total reward is equal to the sum of rewards obtained by the selected orders:

\[ \text{Reward} = \sum_{i \in O} \text{Reward}_i \]

where,

\[ O=\{ i / \text{Order i is selected}\} \]
4.3 GDSS: StriveLink

A Menu-driven GDSS (StriveLink) was designed to link the decision makers to solve the StriveCo manufacturing case on-line. The system was written to run on Disk Operating System (DOS). It was installed on Novelle Network and could be executed from any computer which had access to this file server. StriveLink supported the problem solving and communication needs of the decision making group. The main engine of the system was coded and compiled in Clipper. The system made external calls to compiled programs written in Pascal. The Pascal programs parsed the output generated by external calls that the Clipper program made to LINDO optimization package when the optimization feature of the GDSS was executed. Users did not need to know how to use LINDO, nor did they need to know how to read output generated by LINDO, as the GDSS automated the optimization process and made it transparent to the user.

The GDSS features include: modeling and optimization capability, structured and unstructured information exchange, what-if capability, and solution evaluation capabilities. The modeling capability automatically creates a mathematical model of the decision problem and solves it to optimality based on the information available at that node. The GDSS consists of three main screens: GDSS Menu, Outgoing Messages, and Public Message Board (Figure 4.1). The unstructured information exchange facility allows users to send textual messages to others (Figure 4.2). The sender of the message can select from a menu the group members who will receive each message. The
structured information exchange involves sending problem specific information such as local costs to others through predefined templates provided by the GDSS (Figure 4.3). Other structured information exchange capabilities include proposing solutions to others, again through predefined templates (Figure 4.4). The optimization capability models and solves the local problem to optimality and presents the optimal set of orders and the corresponding reward (Figure 4.5). The solution evaluation capability allows each person to evaluate other solutions proposed by other group members from his or her perspective (Figure 4.6). The what-if capability allows each person to examine the incremental effect of changes to a solution when he or she changes effort levels of one or more orders of a previously evaluated solution set. The Group History keeps a history of all proposed solutions, thus, providing the negotiators with information about the solutions proposed to date by the various group members (Figure 4.7).

This GDSS tool was designed and then given to nine pilot groups who had volunteered to participate in this project for five percent extra credit in a previous term. Based on their suggestions, the initial version of the GDSS was modified. Some of the pilot group's suggestions were to add specific features and some were to make some features easier to use. The students who did the pilot study were graduating seniors during summer quarter and the experiment was conducted during the autumn quarter. The students used for the pilot study graduated but they also signed a form agreeing not to discuss this experiment with other students.
Figure 4.1: StriveLink Main Screen

Figure 4.2: Unstructured Message Passing
Figure 4.3: Structured Cost Sharing

Figure 4.4: Structured Proposal
Figure 4.5: Optimization

Figure 4.6: Solution Evaluation and What-if
Figure 4.7: Group Memory/History
"A generalization for which there is no apparent scientific explanation is called an empirical generalization, while a generalization that can be explained with reference to other scientific laws or theories is called a law"

Kaplan, 1992

5.1 Introduction

The substantive issue we address in this study is:

The effect of geographic proximity, presence of a leader, and incentive structures (local versus global) on decision process and outcomes when decision makers are faced with a complex mixed-motive task and can use a Level Two GDSS1.

In this chapter, a set of testable hypotheses is constructed that address various aspects of the above issue. The line of reasoning to defend each hypothesis is based on research and theories that draw on work in Communication theory, Utility theory, and

1A Level Two GDSS provides decision modeling capabilities [DeSanctis, Gallupe, 1987].
Game theory. Chapter 6 provides experimental results along with the supporting statistical analysis to support or refute the set of hypotheses posed in this chapter.

5.2 Dependent Variables

The set of hypotheses we form relate to negotiation outcome measures as well as process measures.

5.2.1 Hypothesis about Negotiation Outcomes

Negotiation outcomes refer to the quality of the final solution of the negotiation task. For this study, negotiation outcomes include member and leader performance, and satisfaction with the solution. Performance is measured by comparing rewards, and deviations from the Efficient Frontier. We utilize communication theory, utility theory, and economic game theory, and previous exploratory results in the literature to predict the direction of each hypothesis on outcome measures.

The units of analysis are member and leader within each group. Since the department managers have basically the same tasks and the revenue and cost data are designed in such a way that the member rewards are comparable, we combine the department managers into the category "Members". The leader reward is tied to organizational profit and, thus, each hypothesis on leader rewards is a surrogate measure of the organizational performance (gross profit). Therefore, the set of hypothesis on leader performance could be interpreted as organizational performance, and we will not treat that separately except for democratic groups.
When the objective of decision makers is to maximize their reward, measuring their rewards and comparing them within treatment conditions is a good measure of performance. It reveals information regarding relative performance due to the different treatment conditions. It also, reveals information regarding the impact of the research variables under investigation.

5.2.2 Hypothesis about Negotiation Process

Negotiation process variables should capture how negotiation is conducted. For this study, negotiation process variables include: level of frustration with the process, number of structured and unstructured messages exchanged, the time to complete the negotiation process, and the truthfulness of information exchanged between decision makers. These measures reveal information on how negotiation was conducted under different treatment conditions.

5.3 Main Effects: Proximity, Leader, and Incentive

In general, face-to-face groups are expected to perform better than distributed groups for Mixed-Motive tasks [McGrath, Hollingshead, 1993]. Leader should positively impact organizational payoff, and group incentives should induce a different behavior in members that results in different outcomes compared to individual incentives. In this section, the effect of only one variable is studied on all experimental data. The motivation of this section is to see if each of these variables impact group dynamics without controlling for other factors. That is, for example, do face-to-face groups do
better than their distributed counterparts regardless of group composition (leader-directed versus democratic) and incentive structures (local versus global)? After presenting these main effects, the study will proceed by considering interaction effects.

5.3.1 Hypothesis about Negotiation Outcomes

A. Performance

Communication theory predicts that when decision makers have a higher number of alternative communication media, information loss is decreased, resulting in more effective communication which in turn leads to improved performance [Rao, Jarvenpaa, 1991]. Thus, the groups which have both face-to-face and electronic communication support should perform better (i.e. higher rewards, or rewards being closer to the efficient frontier) than the groups which only have electronic communication support.

McGrath and Hollingshead [1993] have proposed a matrix of task type and communication media match, and have conjectured that face-to-face media provides a good fit for negotiation, and distributed Computer Mediated Communication (CMC) channel is a poor fit for negotiation tasks. This conjecture has not been empirically tested in leader-directed groups with varied incentives when decision makers have access to a Level 2 GDSS. To test the effect of proximity on the performance, we pose the following two hypothesis:

H1a: Member reward is higher for Face-To-Face groups than for Distributed groups.

H1b: Leader reward is higher for Face-To-Face groups than for Distributed groups.
In democratic groups, members have to negotiate to find a good solution. A good solution for members is one where everyone is doing as well as possible. Every member has to agree on a final solution and no member has authority to override another's solution. In leader-directed groups, a leader may impose a solution that may make members worse off in order to improve his or her reward. Thus, member reward should be higher for democratic groups than for leader-directed groups. We propose that:

**H2a:** Member reward is lower for leader-directed groups than it is for democratic groups.

Leader reward is directly tied to gross organizational payoff. We expect that gross organizational payoff would be higher when a leader explicitly protects organizational stakes than when department managers attempt to maximize their departmental payoffs without explicit consideration for organizational payoff. Thus,

**H2b:** Gross organizational payoff\(^2\) is higher for leader-directed groups than it is for democratic groups.

To compare member rewards when incentive is local to when it is global, since the two incentives are different, we have to first normalize the rewards. We divide member reward by the optimal member rewards for local and global incentive cases to normalize them. Members with local incentive should select optimal efforts and with global incentive are motivated to select low effort levels, thus the normalized member rewards should be higher for local incentive than for global incentive. Each member has

\(^2\) democratic groups do not have a leader, and thus we compare gross organizational payoff instead of leader reward.
to make two types of decisions: the effort level to exert on each order, and which orders to select. When incentive is local, each member can find the rational effort level (i.e. marginal analysis) for each order. The task is reduced to finding a feasible set of orders while attempting to maximize his/her reward. When incentive is global, each member's reward depends on other members' costs. Members may engage in gaming behavior because their bonus is shared by others while their departmental costs (UDEC) are born by themselves alone. This gaming behavior is representative of the prisoner's dilemma. In a prisoner's dilemma game, members try to protect themselves by selecting low effort levels. If all members pick an effort level which is optimal for the group, then everyone is better off. If one member picks low effort levels while others pick optimal effort levels from the group's perspective, the member who selected low effort levels is better off at the expense of others. If all select low effort levels instead of the optimal, then all are worse off. The fact that there are no binding contracts to force members to select optimal effort levels induces members to select low effort levels. Each member is motivated to select low effort levels since he/she fears that others would do the same. Without binding contracts forcing members to select high effort levels, the members are tempted to select low effort levels fearing that others would do the same. A low effort level translates into lower reward for each order compared to the local incentive case. The lower reward for each order generates a lower accumulated reward resulting from the selected orders. Because the leader reward depends on the member costs, and member costs are higher with lower effort levels, leader reward is also expected to be lower. Thus, the following two hypothesis are proposed:
**H3a**: Normalized Member reward is higher when member incentive is local than when it is global.

**H3b**: Leader reward is higher when member incentive is local than when it is global.

**B. Satisfaction with the solution**

The literature on the effect of proximity has generally shown that face-to-face group members are more satisfied with the solution [Raman, Tan, Wei, 1993], [Rhee, 1993], Jessup, Tansik, 1991] than their distributed counterparts. The reason has been attributed to 'low communication efficiency', and 'de-individuation' characterized by distributed CMC communication. To test this, the following hypothesis is suggested:

**H4a**: Member satisfaction with the solution is higher for Face-To-Face groups than it is for Distributed groups.

A group leader may override member solutions if he or she is not satisfied with solutions proposed by members. The leader's effectiveness should not be hindered by the GDSS [Lim, Raman, Wei, 1990]. The leader can override member solutions regardless of the communication channel. Thus, it is expected that leader satisfaction with the solution will not be influenced by the communication channel.

**H4b**: Leader satisfaction with the solution is the same between Face-To-Face groups and Distributed groups.

In leader-directed groups, a leader has the authority to impose a solution on members. The imposed solution may not be satisfactory to some members. In democratic groups, members negotiate and finally accept a solution that is satisfactory to all. Members in democratic groups are generally more satisfied with their solution than
are members in groups with an autocratic leader. To test this conjecture, the following hypothesis is posed:

**H5:** Member satisfaction with the solution is higher for democratic groups than it is for leader-directed groups.

When incentive is local, members can accurately calculate their reward because all the information to calculate it is accurately available in the departmental database. When incentive is global, members need to receive updated cost information from other members to calculate their reward. The interaction between a member's reward and other member's costs may promote gaming behavior representative of prisoner's dilemma. This gaming behavior could lead to reporting distorted information. This awareness may degrade member perception about the quality of the final decision resulting in a lower satisfaction with the adopted solution. When members can deterministically evaluate their rewards (i.e. local incentive), they should be more satisfied with their solution than when the incentive mechanism can promote gaming behavior and uncertainty (i.e. global incentive). Incentive is varied to test this effect:

**H6a:** Member satisfaction with the solution is higher for groups with local incentive than it is for global incentive.

Leader reward depends on actual cost information incurred at the departments. When incentive is local, members should select optimal effort levels. Optimal effort levels reduce the actual departmental costs (ADC) below the projected costs (PC). If the members report these costs to the leader, then the leader reward will improve as ADC's drop. As ADC's drop, the leader reward improves beyond what he/she gets when he/she optimizes with projected costs (reservation reward). With global incentive, members are
motivated to select low effort levels. If a member select high effort levels, he/she will share the increased bonus with others while bearing the extra uncompensated departmental effort costs (UDEC) alone. Low effort levels mean that ADC's will not necessarily be below PC's. Thus, the leader will not observe an increase in his/her reservation reward when incentive is global. This argument suggests that the leader may be more satisfied with the solution when incentive is local than when it is global. On the other hand, when member incentive is global, the leader could perceive his/her reward to be aligned with that of the members. Since the members can lower their effort levels to increase their perceived rewards when incentive is global, they may use this technique to counter the negative effect of leader's authority to override member solutions. Members, thus, may agree with the leader quicker in the global incentive case and the leader may perceive that members agree with his/her solution because of aligned incentives rather than thinking that members trick him/her by selecting low effort levels. The perception of aligned incentives may make the leader more satisfied with the solution when incentive is global. The incentive alignment argument is expected to dominate and the leader would be more satisfied with the solution when he/she feels less resistance from members to adopt a solution, suggesting that:

**H6b: Leader satisfaction with the solution is higher for global than for local incentive.**
5.3.2 Hypothesis about Negotiation Process

A. Frustration with the process

It has been conjectured that CMC mode provides a poor fit for negotiation tasks [McGrath, Hollingshead, 1993]. Frustration with the process should be higher when decision makers have to operate under CMC mode compared to face-to-face mode to solve a negotiation task, suggesting:

H7a: Member frustration with the process is higher for Distributed groups than it is for Face-To-Face groups.

There are two opposing factors at work as far as leaders are concerned. The restrictiveness of the communication media for the LDIST groups can be frustrating for the leader when he/she is attempting to obtain information, however, when it comes time to make a decision, it will be easier for the leader in the LDIST group to make an unpopular decision as he/she does not have to immediately face his/her group members. Because the groups have history and the leader has to work with the members on other projects later, we expect the leader to work with the members to find a solution than to unilaterally override their solution. Thus, it is not expected that the distributed communication, which may make it easier for the leader to override member solutions, to affect the leader's level of frustration as much as the restrictiveness imposed on him by the CMC channel. This suggests that:

H7b: Leader frustration with the process is lower for Face-To-Face groups than for Distributed groups.

This section presented a set of hypothesis on the main effects: proximity, leader, and incentive. In the following sections, some research variables will be kept constant
while the effect of other research variables are studied. For example, Section 5.4 presents effects of leader and incentive when proximity is Face-to-Face. For notational convenience, we use the following abbreviations to form the set of hypothesis in the following sections:

\[ \text{LFTF: leader-directed Face-to-Face groups} \]
\[ \text{NFTF: Non-Leader (Democratic) Face-to-Face groups} \]
\[ \text{LDIST: leader-directed Distributed groups} \]
\[ \text{NDIST: Non-Leader (Democratic) Distributed groups} \]

5.4 Face-to-Face GDSS Groups: Effect of Leader and Incentive

In this section, proximity is kept constant (i.e. face-to-face) while the other variables (group composition and incentive) are varied to form a series of testable hypotheses.

A. Performance

When incentive is local, members can easily find the optimal effort levels. Simply, each rational member will select effort levels at a point where marginal gain in bonus justifies marginal cost of extra effort to maximize his/her reward. When incentive is global, members are faced with a prisoner's dilemma problem. As explained in the discussion provided for hypothesis H6a, the gaming behavior induced by global incentive motivates members to select low effort levels. The lower effort levels translate into higher ADC's and lower reward per order. Thus, the profit per order is generally lower when incentive is global compared to the case that incentive is local. Lower profit per
order will result in lower accumulated profit from selected orders. Since leader reward is
directly proportional to the gross organizational profit, a higher leader reward is expected
when incentive is local than when it is global, and the following hypothesis is proposed:

**H8: Leader reward for LFTF groups is higher when member incentive is
local than when it is global.**

The rich face-to-face channel provides a good communication media for the
leader to convince members to cooperate by selecting the optimal effort levels from the
group's perspective instead of the lowest effort levels possible. The leader is motivated to
do this because his/her reward increases as members exert higher efforts resulting in
lower ADC. The leader, thus, should positively impact members to select the optimal
effort levels. To test the effect of leader on member rewards in FTF groups, the
following hypothesis for leader-directed FTF (LFTF) and democratic FTF (NFTF) groups
is proposed:

**H9: Member reward is higher for LFTF groups than it is for NFTF groups
when incentive is global.**

Leader will not accept member solutions if his/her reward is better served by
another set of orders. Because local member incentive is not aligned with leader
incentive, leader is a hindrance to each member as he/she wants to maximize his/her
reward. Although different orders have differential impacts for each member and
members may still sacrifice some orders in an attempt to agree with others, they will try
to find a solution where every member is relatively well off. We expect that on the
average members have to sacrifice more when there is a leader and this should degrade
their reward. To test the effect of leader on member rewards in FTF groups when incentive is Local, the following hypothesis is proposed:

**H10:** Member reward is lower for LFTF groups than it is for NFTF groups when incentive is local.

### 5.5 Distributed GDSS Groups: Effect of Leader and Incentive

In this section, the effect of leader and incentives will be explored, while keeping the proximity constant (i.e. distributed). Proximity affects decision making behavior. De-individuation, for example, defined as the process whereby submergence in a group produces loss of identity, weakening social norms and constraints [Festinger, Pepitone, NewComb, 1952], [Zimbardo, 1969] is promoted in distributed groups. De-individuation may foster the view of negotiation as a win-lose situation [Rhee, 1993] and cause the negotiators to behave more selfishly and competitively and care less about the others' positions. When members act more selfishly, they are less likely to report their true ADC's to the leader. When a leader acts more selfishly, he or she will override a solution more often than when he or she behaves more cooperatively.

**A. Performance**

The first hypothesis of this section is the same as H8 but instead of considering LFTF groups, here we consider LDIST groups. Thus, the same reasoning as provided for hypothesis H8 applies here as well. The incremental addition to that reasoning is that the effect of leader when proximity is distributed is different than when proximity is face-to-
face; the leader in LDIST groups will not be able to prevent members from falling in the prisoner's dilemma as effectively as he/she will in LFTF groups. Thus, members in LDIST groups with global incentive are more likely to select lower effort levels than they do in LFTF groups, leading to even lower leader rewards when incentive is global than when it is local. Thus, it is proposed that:

**H11: Leader reward for LDIST groups is higher when member incentive is local than when it is global.**

When member incentive is global, members may engage in gaming behavior to select their effort levels. The leader can make a good decision only if he or she has accurate cost information. Leaders will not be able to gauge member costs accurately when proximity is distributed due to the limited richness of this communication channel. Members in democratic groups should also exchange cost information when incentive is global in order to compute their rewards accurately. Thus, with global incentive, members in democratic groups have the same problem of having to exchange information between themselves as they do in leader-directed groups. Since member and leader incentives are aligned when member incentive is global, the leader is not expected to impact member rewards. For both democratic and leader-directed groups, members engage in gaming behavior, select low effort levels, and make decisions based on inaccurate information. The leader of leader-directed groups also is likely to make decisions based on inaccurate information. Thus, we expect the leader will not have a significant effect on member rewards and propose that member rewards would not be
different between distributed democratic (NDIST) groups and distributed leader-directed (LDIST) groups. The following hypothesis is posed:

**H12: Member reward for NDIST groups is the same as that for LDIST groups when incentive is global.**

With local incentive, members will select optimal effort levels. The only real decision faced by the members is, thus, what set of orders to select? The utility maximizing leader, in an attempt to maximize his/her reward, may override member solutions. The leader, thus, tends to negatively affect member rewards. The members in leader-directed groups should achieve lower rewards than those in democratic groups. The following hypothesis is posed:

**H13: Member reward for LDIST groups is lower than that for NDIST groups when incentive is local.**

### B. Satisfaction with the solution

Reward of each decision maker depends on the cost of others when incentive is global. Members, will thus, need to exchange more information between themselves compared to when incentive is local. This, however, should not affect member satisfaction with the solution because the templates provided by the structured message exchange capability should make this task easy. The fact that member solutions can be overridden by the leader and the non-alignment of incentives between the leader and members when incentive is local, however, makes us believe that member satisfaction with the solution would be higher when member incentive is global (aligned member and leader incentives) than when it is local. Thus, following hypothesis is posed:
H14a: Member satisfaction with the solution for LDIST groups with global incentive is higher than that with local incentive.

Once the members with local incentive update their costs from projected costs to optimal costs and send that as a structured message to the leader, the leader gets a reward higher than his or her reservation reward (optimal reward based on projected costs). That is, the leader observes an improvement in his or her reward as a result of updated costs. This should make him/her more satisfied with the solution compared to when member incentive is global. With global incentive members are tempted to select low effort levels. If they are truthful about their costs, the costs associated with low effort levels will not be as low as when incentive is local (higher effort levels). If they are not truthful, they may report high costs for some orders that they do not like and low costs for orders they like affecting leader's perceived reward in different directions not necessarily resulting in a reward higher than leader's reservation reward. An opposite argument is that the leader may perceive that his/her reward is more aligned with that of the members when member incentive is global. This may lead him/her to believe that a solution that is good for him/her is "good for all". Since the latter argument requires less cognitive effort on the part of the leader, we expect it to provide a more fitting explanation of leader behavior resulting in higher leader satisfaction when incentives are perceived to be aligned (global incentive). Thus, it is proposed that:

H14b: Leader satisfaction with the solution for LDIST groups is higher when member incentive is global than when it is local.
5.6 Proximity

Prior Research in the literature has not studied the effect of proximity on decision quality of leader directed groups in a Level 2 GDSS setting performing a complex "mixed-motive" task. Only few studies have considered the effect of proximity for a simple transfer pricing problem in groups without a leader [Rhee, 1993], [Rhee et. al., 1995], [Arunachalam, 1991]. Incentive was not used as a research variable in any of these studies, the problems were relatively simple, and the GDSS was a Level 1 GDSS.

Some studies have considered the effect of GDSS, not proximity, on the leader [Lim, Raman, Wei, 1990] or "best member" [Gallupe, 1990]. It has been found in [Lim, Raman, Wei, 1990] that the dominant member in GDSS groups have less influence than in non-GDSS groups solving a simple allocation task. Lim et al.'s experimental study with student subjects at the National University of Singapore compared face-to-face groups with and without a GDSS and has found that GDSS promoted democracy. Another study [Gallupe, 1990] examined the effect of GDSS on the" best member", and it was found that GDSS groups did not do as well as the best member, but many non-GDSS groups did as well or better than their best member. The effect of proximity on groups performing a complex mixed-motive task in a Level 2 GDSS setting is experimentally investigated in this section. Other simultaneous research variables are the two types of group composition, and the two different incentive structures.
5.6.1 Proximity: Leader-directed groups with local incentive

In this section we study the effect of proximity on groups with a leader where member incentive is local. In an attempt to study the effect of GDSS proximity on the leader-directed group decision-making process and outcomes of functional managers within a firm, the following question is posed: In leader-directed groups performing a mixed-motive task, does geographic proximity significantly affect the decision process and outcomes within a Level 2 GDSS supported setting?

Within the current incentive structure (local incentive), the members will attempt to maximize their departmental profit while the leader tries to maximize organizational profit. Although, the leader has the authority to override member solutions, his/her ability to make "good" decisions would be limited by the information provided by the other members. Additionally, as the group members need to function effectively as a group after this experiment the leader may not be willing to make decisions that are extremely detrimental to any group member. However, this effect may be somewhat mitigated in the CMC environment, where factors such as de-individuation may become important.

De-individuation may foster the view of negotiation as a win-lose situation [Rhee, 1993] and cause the negotiators to behave more selfishly and competitively and care less about the others' positions. When members act more selfishly, they are less likely to report their true ADC's to the leader. When the leader acts more selfishly, he or she will override a solution more often than when he or she behaves more cooperatively. In a non-cooperative environment promoted by the distribution of agents, member rewards are
expected to be lower and the deviation from the efficient frontier to be higher compared to their face-to-face counterparts.

**Hypothesis about Negotiation Outcomes**

**A. Performance**

Communication theory predicts that when decision makers have a higher number of alternative communication media, information loss is decreased, thus, resulting in higher effectiveness of communication which in turn leads to improved performance [Rao, Jarvenpaa, 1991]. Thus, the groups which have both face-to-face and electronic communication support should perform better (higher rewards, as well rewards being closer to the efficient frontier) than the groups which only have electronic communication support.

McGrath and Hollingshead [1993], argue that tasks such as negotiation require a rich communication media, hence media such as CMC that do not provide the communication media richness of the face-to-face approach would be a poor fit for negotiation tasks. Rhee et al. [1994], found that although the CMC groups tend to perform poorly compared to face-to-face groups for Mixed-motive tasks, the effect of the media can be mitigated to a certain extent by providing tools that support the negotiation activity. In this research, given the complexity of the task, the tools are more of necessity for both groups than in the prior study. However, in this study the group members are attempting to convince the leader to accept a solution which maximizes their payoff while the leader also maximizes his/her benefits. Given the communication media richness of
the face-to-face approach we hypothesize that the face-to-face group will be able to more effectively convince the leader to accept a solution in their favor. Another factor that will contribute to this effect is that in the CMC approach due to de-individuation it may be easier to impose a solution whose impact is detrimental to the group members. Thus, member rewards should be higher in LFTF groups than in LDIST groups. The following hypothesis is posed:

**H15a:** Member rewards for the LFTF groups is higher than the LDIST groups when incentive is local.

As a result of hypothesis H15a, it is natural to expect that member rewards would be closer to the efficient frontier in LFTF groups than in the CMC or LDIST groups:

**H15b:** Member reward is closer to the efficient frontier in LFTF groups than in LDIST groups when incentive is local.

Several factors affect the leader's ability to select a solution. Based on the projected cost the leader already has a lower bound on his/her payoff. The issue, therefore, becomes how high a payoff beyond the lower bound can he/she obtain. In arriving at a solution there are three factors that come into play. First, the quality of the information that he/she obtains from the managers, i.e. the ADC's obtained will determine his/her ability to make an informed decision. Given the media richness of the face-to-face approach combined with the use of the tools one expects that the leader will be able to accurately obtain information about costs and thus make decisions that will result in payoffs in the face-to-face mode to be higher than in the CMC mode. The second factor that comes into play is that leaders cannot completely ignore the group
members payoff as they have to work with them in the future and hence, their final solution may take into consideration the payoffs that the members will obtain. This could imply that the leaders, as long as they are above their lower bound, i.e. projected cost optimal solution, may be willing to choose a solution that would make the members better off at little or no expense to him/her. Finally, in the case of CMC de-individuation plays two roles. As a result of de-individuation the leader based on the available information may be willing to make decisions that are favorable to him/her at the expense of the members since he/she does not have to face the members to communicate the unpopular decision (i.e. overriding member solutions). On the other hand as a result of de-individuation the members may not be completely honest when reporting their costs to the leader, this again causes the leader to make decisions that may not be the best for everyone involved. Given these factors the following hypothesis regarding the leader is proposed:

**H16a:** Leader reward for LFTF groups is higher than that for LDIST groups when incentive is local.

**H16b:** The leader reward's distance from the efficient frontier for the LFTF is lower than that for the LDIST groups when incentive is local.

One of the issues that arises is that the members are able to compute their payoff accurately given any combination of orders, the leaders perceived reward on the other hand is dependent on the members revealing their actual costs. The members have an incentive to lie and inflate the costs of orders that are not to their liking by the same token they may provide costs lower than actual to induce the leader to accept an order that
otherwise the leader may not agree on (in the experiment, to keep the analysis simple the members were confined to actual cost plus or minus a fixed amount). As a result of de-individuation and the fact that they don’t have to face the leader when doing so, the tendency to lie would be higher in the distributed case than in the face to face case, hence the following hypothesis is proposed:

**H17:** The members in the LFTF group tend to reveal their costs more truthfully than the members in the LDIST groups when incentive is local.

Leader perceived reward is equal to his or her actual reward if the members communicate accurate cost information to the leader. Face-to-face media is a rich communication channel and thus information exchange is facilitated. As a result, leaders may have a better estimate of member costs in LFTF groups than in LDIST groups. This would imply that in the final solution adopted, the leader’s perceived reward would be closer to his or her actual reward. To test this claim, the following hypothesis is suggested:

**H18:** The difference between the leader’s actual reward and perceived reward is higher in LDIST groups than it is in LFTF groups when incentive is local.

We expect that in the LFTF groups, the leader will sacrifice some of his or her reward to assure that members receive approximately equal rewards. The de-individuation promoted in distributed groups should make the leader less concerned about achieving a solution where member rewards are approximately equal. In other words, the variance between member rewards should be smaller in LFTF groups than in LDIST groups. The following hypothesis is proposed:
H19: In the final solution adopted, the variance between member rewards is smaller in LFTF groups than it is in LDIST groups when incentive is local.

B. Satisfaction with The Solution

Prior research on satisfaction with the solution has generally revealed that satisfaction is higher in face-to-face groups than in distributed groups [Raman, Tan, Wei, 1993], [Jessup, Tansik, 1991], [Rhee et. al., 1995]. Of these studies only one, [Rhee et. al., 1995], has considered a mixed-motive task. No study has considered a complex mixed-motive task with leaders. Based on previous research, it is expected that satisfaction with the solution will be higher for face-to-face groups than for distributed groups, suggesting that:

H20a: Member satisfaction with solution is higher in LFTF than in LDIST groups when incentive is local.

H20b: Leader satisfaction with solution is higher in LFTF than in LDIST groups when incentive is local.

Hypothesis about Negotiation Process

In this section, negotiation process variables considered include: level of frustration with the process, time to end the negotiation process, and number of structured messages exchanged.
A. Frustration with the process

Prior research has generally reported lower frustration associated with face-to-face groups than with distributed groups [Rhee et. al., 1995]. Electronic communication channel is an artificially restrictive communication channel, and members are likely to feel more frustrated due to having to operate under this unnaturally restrictive communication channel. Because people are habitually more comfortable with face-to-face channel than with the restrictive electronic communication channel, our results are expected to support prior research findings. Also, since more restrictions normally increase frustration, groups that have both face-to-face and electronic communication channels are expected to be less frustrated than groups that only have an electronic communication channel. Another reason for justifying our hypothesis may be explained by the impact of de-individuation promoted in distributed groups. De-individuation may foster the view of negotiation as a win-lose situation which could lead to higher frustration. All of these reasons lead us to believe that frustration is lower in LFTF groups than in LDIST groups. This suggests that:

**H21a: Member frustration is lower in LFTF groups than in LDIST groups when incentive is local.**

The same reasoning as provided for hypothesis H7b applies for the next hypothesis, and we will not duplicate it here. To test that hypothesis for the more specific case of when incentive is Local, the following hypothesis is posed:

**H21b: Leader frustration is higher for LDIST groups than for LFTF groups when incentive is local.**
B. Efficiency: Negotiation Time

Prior research has shown that it generally takes longer for distributed groups to reach a solution than for face-to-face groups [Rhee, 1993], [Rhee et. al., 1995]. For our study, the groups may be utilizing GDSS modeling and computation capabilities while they communicate information verbally in face-to-face condition, whereas, they have to exit the computation capabilities in order to communicate in distributed groups. This may cause more inefficient communication in distributed groups that lead to longer time duration to reach a decision in LDIST groups than in LFTF groups. However, in our case since the leader can impose solutions on the group, it is possible that in the LDIST case, once the leader is satisfied with a solution that he/she imposes it on the group and terminates further negotiation. This may be tempered by the fact that in the LDIST case the leader is not able to obtain satisfactory information as easily, requiring additional time in obtaining information. On the other hand the LFTF groups may spend time in trying to come up with an equitable solution that satisfies all parties, or engage in more non-task related interactions. These various factors will all lengthen the time for both LFTF and LDIST groups, and it is expected that the two groups will take the same time to end the negotiation process, suggesting that:

H22: Negotiation time is the same for LDIST and LFTF groups when incentive is local.

C. Number of messages exchanged

The most efficient way to exchange task relevant information is through predefined templates. Because of this efficiency, it is expected that both LFTF and
LDIST groups will use structured information exchange capability for transmitting task specific blocks of information instead of sending messages through the CMC or the verbal method. Thus, there should not be any difference between the number of structured messages between the two experimental conditions. The following hypothesis is proposed:

**H23:** Number of structured messages exchanged electronically will be equal between LFTF groups and LDIST groups when incentive is local.

5.6.2 Proximity: Leader-directed groups with Global incentive

With global member incentive, members need to communicate their cost information to the leader before the leader can find the best set of orders. In addition, each member needs to know the actual cost of other members to find his or her reward accurately. Due to the high interaction requirements in global incentive and the fact that LFTF groups have a richer communication medium, leaders in LFTF groups should be able to gauge member costs more accurately and also more successfully convince members that the rational effort levels is not the lowest effort. With more accurate information, the leader will be able to make better decisions. Also with a more effective ability to convince members to exert higher effort levels, the leader reward would be higher for LFTF groups than for LDIST groups. Thus, leader reward is hypothesized to be higher for LFTF groups than for LDIST groups, and it is proposed that:

**H24:** Leader reward for LFTF groups is higher than that for LDIST groups when incentive is global.
B. Satisfaction with the solution

As explained before, member satisfaction with the solution is expected to be higher for face-to-face groups than for distributed groups. To test this for leader-directed groups with global incentive, the following hypothesis is proposed:

H25a: Member satisfaction with the solution is higher for LFTF groups than for LDIST groups when incentive is global.

The leader may find it easier to convince members to exert higher effort levels in face-to-face groups than in distributed groups. Higher effort levels increase leader payoff beyond the reservation payoff (optimal based on projected costs) and this should improve leader's satisfaction with the solution. Therefore, it is proposed that:

H25b: Leader satisfaction with the solution is higher for LFTF groups than for LDIST groups when incentive is global.

5.6.3 Proximity: Democratic groups

In democratic groups, members have to negotiate to select a set of orders that is acceptable by everyone. Distribution of members promotes de-individuation. In our problem selfish behavior, resulting from de-individuation, may encourage members to misrepresent their true ADC's to other parties. In a noncooperative environment promoted by the distribution of agents, members may find it easier to misreport their costs than in a face-to-face environment. Each member is tempted to select low effort levels to prevent others from taking free rides from him or her. Thus, member rewards are expected to be lower compared to their face-to-face counterparts who would be able to negotiate more effectively and reveal their costs more truthfully. To study the effect of
proximity on member rewards for democratic groups, the following hypothesis is proposed:

**H26:** Member reward for NFTF groups is higher than that for NDIST groups when incentive is global.

### 5.7 Proximity and Leader

Section 5.7.1 presents a set of hypothesis by varying proximity when incentive is local. Section 5.7.2 investigates the effect of proximity and leader when incentive is global.

#### 5.7.1 Proximity and Leader: Local incentive

With local incentive, members will select effort levels based on marginal analysis since all the information needed for this analysis is available at the department. Face-to-face channel should positively impact members to negotiate more effectively, however, the leader negatively impacts member rewards since a solution which may be desirable by the members may not be acceptable by the leader. These two factors impact member rewards in different directions. However, since the groups have group history, the leader will try his or her best to accommodate member concerns. Thus, the effect of leader is expected to be less significant than the effect of proximity on member rewards. Thus, the following hypothesis is posed:

**H27:** Member reward for LFTF groups is higher than that for NDIST groups when incentive is local.
De-individuation in distributed groups may prompt the leader to unilaterally override member solutions. However, members in democratic groups have to negotiate to arrive at a solution, and the face-to-face communication is conjectured to be a more appropriate media for negotiated tasks. Members can deterministically find their rewards when incentive is local. Once the members determine their optimal effort levels, they know exactly what their rewards are for a set of orders. They are apt to strive to find the integrative solution, where all members are doing relatively well. This should lead to higher average member rewards in democratic face-to-face (NFTF) groups than in distributed leader-directed (LDIST) groups because both the leader and the distributed channel provide a hindrance for members to achieve high rewards. The following hypothesis is proposed:

H28: Member reward for NFTF groups is higher than that for LDIST groups when incentive is local.

5.7.2 Proximity and Leader: Global incentive

We expect that leader and the distributed communication channel to negatively affect member rewards when incentive is global. Global incentive will promote gaming behavior in members to select low effort levels. Distributed CMC channel will make it easier for the leader to care less about member suggestions. Both of these effects will negatively affect member rewards. Thus,

H29: Member reward for NFTF groups is higher than that for LDIST groups when incentive is global.
The global incentive motivates members to engage in gaming behavior (prisoner's dilemma) to select low effort levels. The face-to-face channel can help members negotiate more effectively to select effort levels based on economic justifications (marginal analysis). The leader in LFTF groups also positively impacts members to achieve higher effort levels than the lowest since as member effort levels increase, leader is better off. Effort levels based on economic justifications should make members better off than lowest effort levels induced by the prisoner's dilemma strategy. The leader in LFTF groups can create the trust in members necessary to prevent them from falling in the prisoner's dilemma. Thus, both face-to-face channel and the leader positively impact member rewards when incentive is global. It is, thus, propose that:

**H30:** Member reward for LFTF groups is higher than that for NDIST groups when incentive is global.

5.8 Incentive: Distributed Leader-directed groups

**Hypothesis on Negotiation Outcomes**

**A. Performance**

It was hypothesized in H11 that leader reward is higher when member incentive is local than when it is global. Leader reward is directly proportional to organizational profit, and H11 implies that organizational profit is higher when member incentive is local than when it is global. The argument used to explain this has been that with global incentive members exert lower effort levels than they do with local incentive. This claim is tested by posing the following hypothesis:
H31: Member effort level for LDIST groups is lower for global than for local incentive.

As a result of hypothesis H42 and the effect of prisoner's dilemma, we believe that with global incentive members do not select the rational effort levels from the group's perspective, but with local incentive they do select the rational effort levels (marginal analysis). Thus, it is proposed that:

H32: The deviation of member efforts from the optimal effort for LDIST groups with local incentive is lower than those with global incentive.

**Hypothesis on negotiation processes**

**A. GDSS Feature Usage**

Todd and Benbasat [1991] have experimentally shown that decision makers adopt their strategies to the GDSS features to minimize cognitive effort (maximize utility). The frequency of using "what if" and "optimization" capability during the negotiation process is used to form a set of testable hypothesis in this section.

The "what-if" capability allows members to evaluate two types of changes made to a solution. One is to study the impact of selecting a different set of orders on rewards, and the second is to study the impact of changes to effort levels. The problem of finding the effort levels when incentive is local was shown to be trivial (see chapter three). The members basically solved the first sub-problem to find the optimal effort levels. Thus, when member incentive is local, members will only use the "what-if" capability to evaluate the impact of different sets of orders, and not that of effort levels. When incentive is global, finding the optimal effort levels is not as trivial since it requires more
coordination between members. With global incentive, as each member changes his or her costs and reports it to others, the reward of others change as well. Because of this distributed effect of other members' costs on one's reward when incentive is global, members are expected to experiment with effort levels more frequently (each time other people report new costs) than they would in groups with local incentive. The higher frequency of evaluating the impact of different effort levels, to gain assurance that low effort levels is the best they can do\(^3\), leads to a higher use of "what-if" capability when incentive is global than when it is local. The following hypothesis is proposed:

**H33:** Members use the "what-if" capability more frequently in LDIST\(^4\) groups with global incentive than they do in groups with local incentive.

When member rewards depend on one's own cost as well as other member's costs (i.e. global incentive), participants have to optimize each time one member changes his or her costs, suggesting that:

**H34:** Members use the "optimization" capability more frequently in LDIST groups with global incentive than they do in groups with local incentive.

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\(^3\) Low effort levels leading to highest rewards when incentive is global may seem unintuitive to members, and thus they use "what-if" tool extensively to gain confidence that indeed low effort is the best they can do.

\(^4\) It is expected that the frequency of the use of GDSS modeling features (i.e. optimization) is dependent on the task and incentive differences (local versus global) rather than communication channel differences. Therefore, the frequency of GDSS modeling feature use is not investigated for the FTF condition separately. It is expected that the results for DIST channel will also hold for the FTF condition.
5.9 Incentive and Proximity: Leader-directed groups

With local incentive, members select optimal effort levels because that is the best they can do. With global incentive, however, the members are faced with a prisoner's dilemma problem leading them to select low effort levels. Lowest effort levels translate into higher ADC and thus lower leader reward per order. Selecting a set of orders when reward per order is lower results in lower accumulated leader reward. The distributed channel in LDIST groups make it harder for the leader to convince members to select effort levels based on the rational analysis from the group's perspective. Thus, leader reward should be higher for LFTF groups with local incentive than for LDIST groups with global incentive, suggesting:

H35: leader reward for LFTF groups with local incentive is higher than that for LDIST groups with global incentive.

5.10 Effort Level: Who works harder for the company?

Organizational performance is determined by how hard the members work towards the objectives of the organization. Incentive structures, a group leader, and proximity can be evaluated from the perspective of their effect on member efforts. In this final section, the effect of these variables on member efforts are evaluated.

Members with global incentive, with the fruits of their effort being shared with other members and their costs of extra effort being born by themselves alone, have a

---

5 Working harder for the company is identified by the effort levels that members select to fill orders.
higher motivation to engage in gaming behavior to select low effort levels than do members with local incentive. Groups with local incentive can easily find that their best effort levels are at the point where marginal cost of extra effort is justified by the marginal increase in their bonus, and will not engage in gaming behavior for selecting effort levels. The gaming behavior is expected to prompt group members with global incentive structure to exert less effort than groups with local incentive, suggesting the following hypothesis:

**H36**: The groups with local incentive will exert more effort than the groups with global incentive.

The effect of leader and proximity on effort levels is considered next. Global incentive structure is apt to induce gaming behavior, and the communication channel is likely to affect the richness of communication. The leader should be able to better motivate managers to work harder for the good of the organization in face-to-face groups compared to distributed groups. In democratic groups, face-to-face members can more easily convince one another that no one behave as predicted by prisoner's dilemma to select lowest efforts. This should cause face-to-face groups to exert more effort than the distributed groups. This suggests:

**H37**: Members in Face-To-Face groups will exert more effort than their Distributed counterparts when incentive is global.

The differences in H37 are expected to be magnified for leader-directed groups because the leader will have a more negotiation power to convince members to exert more effort by using face-to-face communication, compared to being constrained by the distributed channel. To study the effect of communication channel on the leader's
effectiveness to convince members to exert high effort levels, the following hypothesis is proposed:

**H38:** Members in LFTF groups will exert more effort than will members in LDIST groups when incentive is global.

Leader should motivate members to exert higher effort levels, because the higher the member effort is, the higher will the leader reward become. Members are likely to exert more effort in leader-directed groups than in democratic groups. Thus, it is proposed that:

**H39:** Members in leader-directed groups will exert more effort than their democratic counterparts when incentive is global.
6.1 Introduction

This chapter presents the results of our experiments along with the statistical analysis for the set of hypotheses proposed in chapter 5. Chapter 7 will provide the interpretation, evaluation, and implications of our findings.

6.2 Statistical Methods

Data analyses were carried out following assumptions in which the research variables can be main effects, or can combine to create interaction effects. Data analysis for this type of theoretical model calls for multiple regression when combination of main effects and interaction effects are posited [Boal, Bryson, 1987].

In addition to a multiple regression, a Duncan multiple range test was used to isolate differences in the means of the dependent variables. After the significance of each factor in the model had been determined using multiple regression, the research variables were explored one at a time in a two factor ANOVA. Each ANOVA included one of the
research variables as an explanatory factor, to examine the main effect and the interaction.

The GLM analysis on SAS, performed on all data obtained from the experiment, reveals that reward is significantly dependent on the proximity, and incentive. It was only weakly dependent on group composition (i.e. leader-directed versus democratic). To test each hypothesis posed in chapter 5, the study performs a t-test to compare the mean rewards of each treatment condition.

6.3 Main Effects: Proximity, Incentive, Leader

In this section all experimental results are combined and only one of the research variables is varied at a time resulting in two treatment conditions each time. Generalizing across treatment conditions by varying only one of the main research variables, one may be able to make general statements about the effect of each variable. The reader should be cautious about generalizing beyond the scope of this experimental setting. It seems that proximity and incentive are more influential on rewards than is the leader.

6.3.1 Results on Negotiation Outcomes

A. Performance

Table 6.1 presents the data gathered from the experiment to compare rewards for face-to-face and distributed groups for the members and the leader.
Table 6.1: Effects of geographic proximity on member rewards

<table>
<thead>
<tr>
<th>Proximity</th>
<th>Average</th>
<th>Std. Dev.</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Member</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FTF</td>
<td>102.35</td>
<td>20.51</td>
<td>63</td>
</tr>
<tr>
<td>DIST</td>
<td>87.62</td>
<td>23.84</td>
<td>87</td>
</tr>
<tr>
<td><strong>Leader</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FTF</td>
<td>95.36</td>
<td>20.08</td>
<td>21</td>
</tr>
<tr>
<td>DIST</td>
<td>84.58</td>
<td>24.38</td>
<td>29</td>
</tr>
</tbody>
</table>

Duncan range test detects a difference between the means of member rewards for face-to-face and distributed groups. The p-value reported by SAS output from the GLM results is .0001. A T-test to compare the means reveals that member rewards for FTF groups are higher than those for DIST groups (p<.0005\(^1\)), thus, hypothesis H1a is not rejected.

Leader reward is higher for face-to-face groups than for distributed groups, but the statistical evidence to reject hypothesis H1b is not as strong in the case of leader (.05<p<.1) as it was for the member. At an alpha level of lower than .05, hypothesis H1b is rejected. This means that the impact of proximity is different on member and leader. The leader with the authority to override member solutions is not significantly impacted by proximity, but members negotiate better when proximity is FTF.

Table 6.2 depicts information on member rewards for democratic and leader-directed groups. It also presents information on organizational payoff for the two treatments.

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\(^1\)The statistical table used did not include values lower than .0005.
Table 6.2: Effect of leader on member rewards and organizational payoff

<table>
<thead>
<tr>
<th>Composition</th>
<th>Average</th>
<th>Std. Dev.</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Member</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Democratic</td>
<td>95.86</td>
<td>21.82</td>
<td>72</td>
</tr>
<tr>
<td>Leader-directed</td>
<td>91.21</td>
<td>26.76</td>
<td>72</td>
</tr>
<tr>
<td><strong>Organization</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Democratic</td>
<td>924.38</td>
<td>237.98</td>
<td>24</td>
</tr>
<tr>
<td>Leader-directed</td>
<td>1051.67</td>
<td>265.85</td>
<td>24</td>
</tr>
</tbody>
</table>

Duncan range test does not detect a difference between the means for member rewards between democratic groups and leader-directed groups. Hypothesis H2a is rejected (p>.05). Because groups have history, the leader works with members to find a solution that is good for the members instead of overriding their solution without concern for member rewards. Gross organizational payoff is higher in leader-directed groups than it is in democratic groups, and hypothesis H2b is not rejected (.025<p<.05). P-value is closer to .05 than .025 and thus the statistical evidence for not rejecting H2b is not very strong. However, it seems that a leader positively impacts gross organizational payoff.

Table 6.3 presents the experimental averages for comparing leader reward when member incentive is local to that when member incentive is global.
Table 6.3: Effect of incentive on normalized member reward and leader reward

<table>
<thead>
<tr>
<th>Incentive</th>
<th>Average</th>
<th>Std. Dev.</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Member</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Local</td>
<td>59.00</td>
<td>16.50</td>
<td>71</td>
</tr>
<tr>
<td>Global</td>
<td>41.33</td>
<td>7.80</td>
<td>75</td>
</tr>
<tr>
<td><strong>Leader</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Local</td>
<td>110.70</td>
<td>19.23</td>
<td>12</td>
</tr>
<tr>
<td>Global</td>
<td>78.60</td>
<td>16.11</td>
<td>12</td>
</tr>
</tbody>
</table>

Normalized member reward\(^2\) is higher when member incentive is local than when it is global, and hypothesis H3a is not rejected \(p<.0005\). Duncan range test detects a difference between the means of leader rewards for groups with local and global member incentives. The p-value reported by SAS output from the GLM procedure is .0001.

Leader reward is higher when member incentive is local than when it is global, and thus, hypothesis H3b is not rejected.

B. Satisfaction with the solution

Table 6.4 depicts information on member and leader satisfaction with the solution for face-to-face and distributed groups.

\(^2\) Normalized member reward is calculated as follows: divide the reward achieved by each member by his/her optimal reward and multiply this ratio by hundred.
Table 6.4: Effect of geographic proximity on satisfaction with the solution

<table>
<thead>
<tr>
<th>Proximity</th>
<th>Average</th>
<th>Std. Dev.</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Member</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FTF</td>
<td>5.03</td>
<td>1.56</td>
<td>63</td>
</tr>
<tr>
<td>DIST</td>
<td>4.89</td>
<td>1.80</td>
<td>87</td>
</tr>
<tr>
<td><strong>Leader</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FTF</td>
<td>4.83</td>
<td>1.28</td>
<td>12</td>
</tr>
<tr>
<td>DIST</td>
<td>5.42</td>
<td>1.26</td>
<td>12</td>
</tr>
</tbody>
</table>

Although member satisfaction with the solution is higher for face-to-face groups than it is for distributed groups, the difference is not statistically significant (p>.1), and thus hypothesis H4a is rejected. Leader satisfaction with the solution is not statistically different between the two groups, and thus H4b is not rejected. Thus, proximity does not seem to significantly affect member and leader satisfaction with the solution when it is considered as the main effect. This finding contradicts previous findings that claim "In general, FTF group members are more satisfied than their distributed counterparts". Such general statements do not seem to be valid when the researcher does not control for other factors such as different incentives and group compositions.

Table 6.5 depicts the experimental results to compare member satisfaction with the solution between democratic and leader-directed groups.

\[\text{Based on a Linkert scale from 1 to 7 (1=lowest, 7=highest).}\]
Table 6.5: Effects of leader on member satisfaction with the solution

<table>
<thead>
<tr>
<th>Composition</th>
<th>Average</th>
<th>Std. dev.</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>Democratic</td>
<td>4.91</td>
<td>1.70</td>
<td>78</td>
</tr>
<tr>
<td>Leader-directed</td>
<td>4.96</td>
<td>1.71</td>
<td>72</td>
</tr>
</tbody>
</table>

Member satisfaction with the solution is not significantly different between democratic and leader-directed groups, and thus, hypothesis H5 is rejected ($p>.1$). This result may be explained by the fact that democratic groups have to trade-off some of their reward so that an acceptable solution to all members can be achieved.

Table 6.6 depicts information on member satisfaction with the solution for groups with local and global member incentives.

Table 6.6: Effect of incentive on satisfaction with the solution

<table>
<thead>
<tr>
<th>Incentive</th>
<th>Average</th>
<th>Std. Dev.</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>Member</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Local</td>
<td>4.72</td>
<td>1.69</td>
<td>72</td>
</tr>
<tr>
<td>Global</td>
<td>5.13</td>
<td>1.70</td>
<td>78</td>
</tr>
<tr>
<td>Leader</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Local</td>
<td>5.08</td>
<td>1.11</td>
<td>12</td>
</tr>
<tr>
<td>Global</td>
<td>5.17</td>
<td>1.46</td>
<td>12</td>
</tr>
</tbody>
</table>

Member satisfaction with the solution is higher for groups with global member incentive than it is for those with local incentive. Hypothesis H6a is weakly supported ($0.05<p<0.1$), but for an alpha level of 0.05, H6a is rejected. This means that member satisfaction with the solution is not significantly higher for groups with global incentive than it is for those with local incentive. For the leader, there is also not a significant difference between
leader's satisfaction with the solution for groups with global member incentive and those with local incentive. Thus, hypothesis H6b is also rejected. Because these two hypothesis do not control for the interaction effects of incentive and other variables, namely proximity and group composition, the results are contrary to what was hypothesized in H6a and H6b.

6.3.2 Results on Negotiation Process

A. Frustration with the process

Table 6.7 depicts information on member and leader frustration with the negotiation process for face-to-face and distributed groups.

<table>
<thead>
<tr>
<th>Proximity</th>
<th>Average</th>
<th>Std. Dev.</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Member</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FTF</td>
<td>4.68</td>
<td>1.74</td>
<td>63</td>
</tr>
<tr>
<td>DIST</td>
<td>4.51</td>
<td>2.11</td>
<td>87</td>
</tr>
<tr>
<td><strong>Leader</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FTF</td>
<td>4.42</td>
<td>1.89</td>
<td>12</td>
</tr>
<tr>
<td>DIST</td>
<td>5.00</td>
<td>1.35</td>
<td>12</td>
</tr>
</tbody>
</table>

Member frustration with the process is not significantly different between face-to-face and distributed groups, thus H7a is rejected (p>.1). Although leader frustration with the process is higher for distributed groups than it is for face-to-face groups, the difference is not statistically significant (p>.1) and thus H7b is rejected. Proximity seems to interact
with other variables (incentive and group composition). It is not true that member and leader are more frustrated with the process in FTF groups than in DIST groups. More specific hypothesis, where incentive and group composition are held constant, on the effect of proximity on member and leader frustration with the process will be provided later in this chapter.

6.4 Face-to-face GDSS Groups: Effect of Leader and Incentive

A. Performance

Table 6.8 depicts the averages and standard deviations of leader rewards for groups with local and global member incentives.

<table>
<thead>
<tr>
<th>Incentive</th>
<th>Average</th>
<th>Std. Dev.</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>Global</td>
<td>76.95</td>
<td>14.03</td>
<td>6</td>
</tr>
<tr>
<td>Local</td>
<td>116.93</td>
<td>10.96</td>
<td>6</td>
</tr>
</tbody>
</table>

Leader reward is higher for groups with local incentive than for those with global incentive, and thus hypothesis H8 is not rejected (p<.0001).

To test hypothesis H9 and H10, consider the average rewards for leader-directed face-to-face (LFTF) groups and that for democratic face-to-face (NFTF) groups. This information is provided in Table 6.9.
Table 6.9: Effect of leader on member rewards for face-to-face groups

<table>
<thead>
<tr>
<th>Composition</th>
<th>Average</th>
<th>Std. Dev.</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Global</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Democratic</td>
<td>112.47</td>
<td>16.24</td>
<td>18</td>
</tr>
<tr>
<td>Leader-directed</td>
<td>105.79</td>
<td>22.02</td>
<td>18</td>
</tr>
<tr>
<td><strong>Local</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Democratic</td>
<td>94.89</td>
<td>16.88</td>
<td>9</td>
</tr>
<tr>
<td>Leader-directed</td>
<td>86.95</td>
<td>26.73</td>
<td>18</td>
</tr>
</tbody>
</table>

Hypothesis H9 is rejected (p>.1). Member reward is not significantly reduced due to the existence of a group leader in face-to-face groups when incentive is global. It was proposed that the leader would be able to convince members to exert optimal effort levels resulting in higher rewards for both member and leader. However, since members are faced with a prisoner's dilemma problem and the GDSS "what-if" capability convinces them that low effort levels lead to higher rewards, the members will not select optimal effort levels that make everyone better off.

Members with local incentive do better when they operate as a democratic group than when there is a leader in charge. However, the effect of leader on member rewards is not statistically significant (p>.1), suggesting the rejection of hypothesis H10. The leader, in an attempt to protect organizational stakes selects orders that are best for the organization but because there is group history, does not make decisions that are very bad for the members. Because a leader in groups with history has a secondary objective of helping members, member rewards are not significantly degraded as a result of the
existence of a leader. In addition, because of asymmetry of the information and to protect themselves against a leader who may override their solutions, the members may not report their costs to the leader truthfully.

6.5 Distributed GDSS Groups: Effect of Leader and Incentive

A. Performance

Table 6.10 depicts information on leader reward for distributed leader-directed (LDIST) groups as incentive is varied.

<table>
<thead>
<tr>
<th>Proximity</th>
<th>Average</th>
<th>Std. Dev.</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>Global</td>
<td>67.42</td>
<td>9.34</td>
<td>6</td>
</tr>
<tr>
<td>Local</td>
<td>104.48</td>
<td>25.51</td>
<td>6</td>
</tr>
</tbody>
</table>

Leader reward for LDIST groups is higher when member incentive is local than when it is global. Hypothesis H1 is not rejected.

The experimental results for the effect of leader on member rewards in distributed groups is depicted in Table 6.11.

<table>
<thead>
<tr>
<th>Composition</th>
<th>Average</th>
<th>Std. Dev.</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>Democratic</td>
<td>99.50</td>
<td>21.61</td>
<td>24</td>
</tr>
<tr>
<td>Leader-directed</td>
<td>101.12</td>
<td>15.51</td>
<td>18</td>
</tr>
<tr>
<td>Democratic</td>
<td>81.89</td>
<td>15.71</td>
<td>27</td>
</tr>
<tr>
<td>Leader-directed</td>
<td>66.89</td>
<td>27.55</td>
<td>18</td>
</tr>
</tbody>
</table>
Member reward is not significantly different between democratic and leader-directed distributed groups when incentive is global. Hypothesis H12 is not rejected. When member incentive is local, member reward is higher for democratic groups than for leader-directed groups. Hypothesis H13 is not rejected (.025<p<.05). It was found in hypothesis H9 and H10 that leader did not significantly impact member rewards when proximity was face-to-face. So, one could conclude that proximity does affect the effectiveness of negotiators. In particular, face-to-face channel provides a more appropriate media for members to negotiate with the leader than does distributed channel.

B. Satisfaction with the solution

Table 6.12 depicts the results on member and leader satisfaction with the solution for LDIST groups with global and local incentives.

<table>
<thead>
<tr>
<th>Treatment Cond.</th>
<th>Average</th>
<th>Std. dev.</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>Local</td>
<td>4.20</td>
<td>1.79</td>
<td>18</td>
</tr>
<tr>
<td>Global</td>
<td>5.56</td>
<td>1.83</td>
<td>18</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Treatment Cond.</th>
<th>Average</th>
<th>Std. Dev.</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>Local</td>
<td>4.83</td>
<td>1.34</td>
<td>6</td>
</tr>
<tr>
<td>Global</td>
<td>6.00</td>
<td>0.82</td>
<td>6</td>
</tr>
</tbody>
</table>

Member satisfaction with the solution is higher for LDIST groups with global incentive than it is for local incentive, and thus hypothesis H14a is not rejected (.01<p<.025).
Leader satisfaction with the solution is also higher when member incentive is global than when it is local, and hypothesis H14b is also not rejected (.01<p<.025).

6.6.1 Proximity: leader-directed groups with local incentive

A. Performance

This section reports the results obtained from our experiment and performs a t-test for each hypothesis.

Table 6.13 depicts the effect of geographic proximity on member rewards and the deviations from the efficient frontier. The efficient frontier provides the set of solutions that can not be dominated by another set of solutions. The leader and member rewards achieved by each group is depicted as a point in Figure 6.1. The distances from each experimental point to the efficient frontier is measured and the mean distance for leader and members are presented in Tables 6.13 and 6.14.

Table 6.13: Member reward and deviation from efficient frontier

<table>
<thead>
<tr>
<th>Treatment Cond.</th>
<th>Reward</th>
<th>Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Average</td>
<td>Std. dev.</td>
</tr>
<tr>
<td>FTF</td>
<td>94.76</td>
<td>17.80</td>
</tr>
<tr>
<td>DIST</td>
<td>66.89</td>
<td>26.77</td>
</tr>
<tr>
<td></td>
<td>Average</td>
<td>Std. Dev.</td>
</tr>
<tr>
<td>FTF</td>
<td>29.24</td>
<td>23.75</td>
</tr>
<tr>
<td>DIST</td>
<td>100.35</td>
<td>51.87</td>
</tr>
</tbody>
</table>
From the results, one may conclude that member reward is higher in LFTF groups than in LDIST groups ($p < .0005$), and thus H15a is not rejected. Figure 6.1 plots the experimental points against the efficient frontier. The deviations from the efficient frontier for the members are calculated and depicted at the bottom of Table 6.13 for LDIST and LFTF groups. The deviation of member rewards from the efficient frontier is higher in LDIST groups relative to LFTF groups ($0.05 < p < 0.001$). Hypothesis H15b is not rejected.
The same information as in Table 6.13 is depicted in Table 6.14, but this time for the leader.

Table 6.14: Leader reward and deviation from efficient frontier

<table>
<thead>
<tr>
<th>Treatment Cond.</th>
<th>Reward</th>
<th>Average</th>
<th>Std. dev.</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>LFTF</td>
<td></td>
<td>116.93</td>
<td>12.01</td>
<td>6</td>
</tr>
<tr>
<td>LDIST</td>
<td></td>
<td>104.48</td>
<td>25.51</td>
<td>6</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Deviation</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>LFTF</td>
<td></td>
<td>28.20</td>
<td>23.49</td>
<td>6</td>
</tr>
<tr>
<td>LDIST</td>
<td></td>
<td>61.08</td>
<td>21.08</td>
<td>6</td>
</tr>
</tbody>
</table>

Leader reward is higher for LFTF groups than for LDIST groups, however, this difference is not statistically significant (p>.1). Thus, H16a is rejected. Leader reward is not significantly affected by communication channel. Thus, it seems that the leader is effectively protecting his/her interests at the expense of the members. However, if one removes the point which seems to be an outlier (a very high leader reward in distributed case) and redo the calculations, then hypothesis H16a is not rejected (.005<p<.01).

As shown in Figure 6.1, the deviation of leader reward from the efficient frontier is higher in LDIST groups than in LFTF groups. On average the deviation from the efficient frontier for the LDIST groups was 61.08, while for the LFTF group it was 28.2, thus, H16b is not rejected (.01<p<.025). However, it should be noted that it is the members payoff that suffers substantially more than the leaders in the distributed groups.
If the point which seems to be an outlier for distributed groups is removed, then the statistical evidence to support hypothesis H16b is stronger (p<.005).

Table 6.15 depicts the average number of times that members report their optimal costs to the leader for LDIST and LFTF groups. For each member, the cost he/she reported to the leader is subtracted from the ADC associated with the optimal effort levels for each order, and if the difference is zero, then the member has truthfully transmitted his/her cost to the leader. A non-zero difference indicates that a member has not transmitted true ADC of filling an order to the leader. Figures 6.2 and 6.3 graphically depict this information for LFTF and LDIST cases.

**Table 6.15: Number of times untruthful information transmitted to leader**

<table>
<thead>
<tr>
<th>Treatment Cond.</th>
<th>Average</th>
<th>Std. Dev.</th>
<th>n^4</th>
</tr>
</thead>
<tbody>
<tr>
<td>LFTF</td>
<td>17.00</td>
<td>15.32</td>
<td>360</td>
</tr>
<tr>
<td>LDIST</td>
<td>28.83</td>
<td>20.74</td>
<td>360</td>
</tr>
</tbody>
</table>

Members in LFTF do seem to reveal their departmental cost information (ADC) to the leader more truthfully than they do in the LDIST groups, and hypothesis H17 is not rejected (p<.0005). As a result of de-individuation and the fact that the members do not have to face the leader when they lie about their costs, members in distributed groups were engaged in more untruthful reporting than their face-to-face counterparts.

---

4 Three members in each of the six groups each reporting costs for 20 orders.
Figure 6.2: Deviation between member reported cost to leader and optimal cost for each order: LFTF groups
Figure 6.3: Deviation between member reported cost to leader and optimal cost for each order: LDIST groups
The experimental results that compare actual and perceived leader reward and variability of member rewards is depicted in Table 6.16.

**Table 6.16: Difference of actual and perceived leader reward and spread of member rewards**

<table>
<thead>
<tr>
<th>Treatment Cond.</th>
<th>Average</th>
<th>Std. Dev.</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>LFTF</td>
<td>8.67</td>
<td>8.12</td>
<td>6</td>
</tr>
<tr>
<td>LDIST</td>
<td>22.5</td>
<td>19.14</td>
<td>6</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Spread</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>LFTF</td>
<td>12.56</td>
<td>11.57</td>
<td>6</td>
</tr>
<tr>
<td>LDIST</td>
<td>13.50</td>
<td>13.10</td>
<td>6</td>
</tr>
</tbody>
</table>

Figures 6.4 and 6.5 provide plots of leader perceived and actual reward for LFTF and LDIST groups. The statistical evidence to support hypothesis H18 is not significant (.05<p<.1), and thus H18 is rejected. However, as shown in Figures 6.3 and 6.4, the leaders in the distributed case have very little actual cost data, and their choices very often are made with the projected cost estimates rather than the actual cost, hence the perceived payoff of the leaders in the majority of the cases is below their optimal projected cost choice. It also seems that in order to accommodate the members, the leaders are willing to take a smaller payoff even in the distributed groups.
Figure 6.4: Actual versus perceived leader reward for LDIST groups

Figure 6.5: Actual versus perceived leader reward for LFTF groups
Hypothesis H19 is rejected (p-value >.1). The average spread (variance) of member rewards is not smaller in LFTF groups than in LDIST groups. This means that leaders in both LFTF and LDIST groups are equally concerned with adopting a set of orders where the member rewards are approximately equal. Proximity does not seem to be an important variable affecting equality of member rewards, and this may be due to the fact that groups have group history and furthermore need to maintain their relationships for future projects.

B. Satisfaction with the solution

The effect of proximity on satisfaction with the solution is studied next. The results of the post experimental questionnaire on member satisfaction with the solution is depicted in Table 6.17.

<table>
<thead>
<tr>
<th>Table 6.17: Member and leader perceptions</th>
</tr>
</thead>
<tbody>
<tr>
<td>AVG.</td>
</tr>
<tr>
<td>------</td>
</tr>
<tr>
<td><strong>FTF n=18</strong></td>
</tr>
<tr>
<td><strong>DIST n=18</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Leader</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>FTF n=6</strong></td>
</tr>
<tr>
<td><strong>DIST n=6</strong></td>
</tr>
</tbody>
</table>

Satisfaction Frustration

T-tests reveal that the differences in member satisfaction with the solution is higher for LFTF groups than it is for LDIST groups. The data, however, does not provide
statistical evidence that the leader satisfaction with the solution is higher for LFTF groups than for LDIST groups. Hypothesis H20a is not rejected (.025 < p < .05), but hypothesis H20b is rejected (p>.1). The empirical evidence to accept hypothesis H20a is consistent with prior findings in the literature and is not surprising. Hypothesis H20b, however, presents the interesting result that proximity does not affect leader's satisfaction with the solution. The leader with the authority to override member solutions is not constrained by the limited richness of the distributed communication channel to exercise his/her authority. Leader may adopt a solution that is most satisfactory to him/her among all the solutions that are available regardless of the communication channel.

**Hypothesis about negotiation process**

**A. Frustration with the process**

Table 6.17 reveals that member frustration with the process is lower for LFTF groups than for LDIST groups, and thus H21a is not rejected (p<.0005). For the leader, the level of frustration is higher for LDIST groups than for LFTF groups. Thus, hypothesis H21b is not rejected (.01<p<.025).

**B. Efficiency: Negotiation Time**

Table 6.18 reports the average time taken to end the negotiation process as well as the number of structured electronic information exchanges during the negotiation process.
Table 6.18: Time (m), number of structured messages

<table>
<thead>
<tr>
<th></th>
<th>AVG.</th>
<th>STD.</th>
<th>AVG.</th>
<th>STD.</th>
</tr>
</thead>
<tbody>
<tr>
<td>LFTF n=6</td>
<td>100.67</td>
<td>32.74</td>
<td>14.67</td>
<td>3.35</td>
</tr>
<tr>
<td>LDIST n=6</td>
<td>114.67</td>
<td>24.50</td>
<td>15</td>
<td>2.16</td>
</tr>
</tbody>
</table>

Negotiation time is the same for LFTF and LDIST groups, and hypothesis H22 is not rejected. Although the restrictive communication media might increase the communication time and thus the decision time, it seems that the LFTF groups were willing to spend more time negotiating to come up with an equitable solution.

C. Number of messages exchanged

Number of structured messages exchanged electronically (predefined task specific templates) was the same between the LDIST and the LFTF groups and H23 is not rejected. Although the number of structured messages exchanged were the same for LFTF and LDIST groups, rewards were higher when proximity was FTF. It seems that the leader, after a certain number of exchanges, decides to converge the process when he/she believes that there is no more information to be obtained. With the FTF media, the secondary verbal channel seems to allow for the exchange of cues to positively affect the relevance of the contents of structured messages leading to better decisions.
6.5.2 Proximity: leader-directed groups with global incentive

A. Performance

Table 6.19 depicts information on leader reward for LFTF and LDIST groups when member incentive is global.

<table>
<thead>
<tr>
<th>Proximity</th>
<th>Average</th>
<th>Std. Dev.</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>LFTF</td>
<td>89.78</td>
<td>15.37</td>
<td>6</td>
</tr>
<tr>
<td>LDIST</td>
<td>67.42</td>
<td>9.34</td>
<td>6</td>
</tr>
</tbody>
</table>

Hypothesis H24 is not rejected (.005 < p < .01). Leader reward is higher for LFTF groups than for LDIST groups. The leader is better able to gauge member costs accurately resulting in better decisions. Also because FTF channel is more appropriate for negotiation tasks [McGrath, Hollingshead, 1993], the leader may be more effective in negotiating with members to exert higher effort levels than the low effort levels they are motivated to select as they are faced with a prisoner's dilemma problem due to the global incentive.

B. Satisfaction with the solution

The experimental results on satisfaction with the solution is depicted in Table 6.20.
Member satisfaction with the solution for LFTF groups is higher than that for LDIST groups. However, this difference is not statistically significant (.05<p<.1), and thus, hypothesis H25a is rejected. Leader satisfaction with the solution is higher for LDIST groups. Hypothesis H25b is rejected. The leader seems to be more satisfied with the solution in LDIST groups because he/she does not have to face members to make an unpopular decision (to override member solutions), making it easier to select the best solution for him/her. The de-individuation caused by the distributed channel explains why it may be easier for the leader to maximize his/her objective without as much concern about member objectives as he/she probably has when proximity is face-to-face.

6.6.3 Proximity: democratic groups

Table 6.21 depicts information on member reward for democratic face-to-face (NFTF) and democratic distributed (NDIST) groups.
Table 6.21: Effect of proximity on member rewards for democratic groups

<table>
<thead>
<tr>
<th>Proximity</th>
<th>Average</th>
<th>Std. Dev.</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>NFTF</td>
<td>112.47</td>
<td>16.24</td>
<td>18</td>
</tr>
<tr>
<td>NDIST</td>
<td>99.50</td>
<td>21.61</td>
<td>24</td>
</tr>
</tbody>
</table>

Member reward for NFTF groups is higher than that for NDIST groups, and thus, hypothesis H26 is not rejected (.01<p<.025).

6.7.1 Proximity and leader: local incentive

The experimental results on the interaction effects of proximity and leader for local incentive is depicted in Table 6.22.

Table 6.22: Effect of leader and proximity on member reward

<table>
<thead>
<tr>
<th>Treatment Cond.</th>
<th>Member</th>
<th>Average</th>
<th>Std. Dev.</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>LFTF</td>
<td>86.95</td>
<td>26.73</td>
<td>21</td>
<td></td>
</tr>
<tr>
<td>NDIST</td>
<td>81.89</td>
<td>15.71</td>
<td>27</td>
<td></td>
</tr>
<tr>
<td>NFTF</td>
<td>94.89</td>
<td>16.88</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>LDIST</td>
<td>66.89</td>
<td>27.55</td>
<td>18</td>
<td></td>
</tr>
</tbody>
</table>

Member reward for LFTF groups is higher than for their NDIST counterparts; however, this difference is not statistically significant (p>.1) and thus, hypothesis H27 is rejected. Member reward for NFTF groups is higher than for their LDIST counterparts, thus hypothesis H28 is not rejected (.001<p<.005). These results indicate that the existence of
a leader and the distribution of communication channel both cause a reduction in member rewards.

6.7.2 Proximity and leader: global incentive

The experimental results on the interaction effects of leader and proximity is depicted in Table 6.23.

<table>
<thead>
<tr>
<th>Treatment Cond.</th>
<th>Average</th>
<th>Std. Dev.</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>NFTF</td>
<td>112.47</td>
<td>16.24</td>
<td>18</td>
</tr>
<tr>
<td>LDIST</td>
<td>101.12</td>
<td>15.51</td>
<td>18</td>
</tr>
<tr>
<td>LFTF</td>
<td>105.79</td>
<td>22.02</td>
<td>18</td>
</tr>
<tr>
<td>NDIST</td>
<td>99.50</td>
<td>21.61</td>
<td>24</td>
</tr>
</tbody>
</table>

Member reward for NFTF groups is higher than it is for their LDIST counterparts with global member incentive. Hypothesis H29 is not rejected (.01<p<.025). Member reward for LFTF groups is higher than it is for their NDIST counterparts, however, this difference is not statistically significant (p>.1). Thus hypothesis H30 is rejected.

6.8 Incentive: Distributed leader-directed groups

Results on negotiation outcomes

A. Performance

Table 6.24 displays the averages of effort levels for order 1 and order 2. Every solution contained at least two orders and thus comparing the mean effort for the first two
orders of every solution reveals information regarding the mean effort levels of groups
with global and local incentives.

Table 6.24: Effort levels expended when incentive is global and when it is local

<table>
<thead>
<tr>
<th></th>
<th>Avg. (1st)</th>
<th>Std. (1st)</th>
<th>Avg. (2nd)</th>
<th>Std. (2nd)</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>Local</td>
<td>1.06</td>
<td>.23</td>
<td>1.28</td>
<td>.56</td>
<td>18</td>
</tr>
<tr>
<td>Global</td>
<td>2.00</td>
<td>.75</td>
<td>2.94</td>
<td>1.22</td>
<td>18</td>
</tr>
</tbody>
</table>

There is evidence to support the conjecture that member effort is lower when incentive is
Global than when incentive is local. Thus, hypothesis H31 is not rejected (p < .0005).

Further analysis of the data reveals that effort levels are much lower than optimal
levels in groups with global incentive than in groups with local incentive. Define the
following measure to evaluate the deviation of the exerted effort from the optimal.

Define,

\[ U^*_i \cdot \begin{cases} 
1 & \text{if optimal effort < exerted effort} \\
0 & \text{O.W.} 
\end{cases} \]

\[ W_i \cdot \begin{cases} 
1 & \text{if optimal effort > exerted effort} \\
0 & \text{O.W.} 
\end{cases} \]

Then,

\[ \hat{d} = \frac{\sum_{i=1}^{n} U^*_i}{n} \], \quad \hat{d} = \frac{\sum_{i=1}^{n} W_i}{n} \]

Applying the above measure to the data obtained from the experiment, the information
depicted in Table 6.25 is obtained:
Table 6.25: Deviations of member effort levels from optimal effort levels

<table>
<thead>
<tr>
<th>Incentive</th>
<th>$d^*$</th>
<th>$d'$</th>
<th>$n$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Local</td>
<td>0.03</td>
<td>0.406</td>
<td>160</td>
</tr>
<tr>
<td>Global</td>
<td>0.072</td>
<td>0.664</td>
<td>125</td>
</tr>
</tbody>
</table>

Since the sample size is large, $d_{GLOBAL} - d_{LOCAL}$ has approximately a standard normal distribution:

\[
Z = \frac{\bar{X} - \bar{Y}}{\sqrt{\frac{d'_{LOCAL} (1-d'_{LOCAL})}{n_{LOCAL}} + \frac{d'_{GLOBAL} (1-d'_{GLOBAL})}{n_{GLOBAL}}} \cdot \frac{.664 - .406}{\sqrt{\frac{.406(.594)}{160} + \frac{.664(.336)}{125}}} = 4.497
\]

There is strong statistical evidence to support the conjecture that groups with global incentive exert effort levels way below the optimal effort levels relative to groups with local incentive. Thus, hypothesis H32 is not rejected (p-value < .0005).

Results on Negotiation Process

A. GDSS feature use

The decision makers seem to adapt their strategies to GDSS features to maximize their utility. The "what if" capability motivates members to exert lower effort levels when incentive is global. Utilizing the GDSS "what if" capability on different effort levels, members will quickly find that low effort levels are their dominant choice if they ignore the action of other members when incentives are global. Thus, each time a member updates his or her costs and the message "New Costs Reported" appears on another member's screen, the agent receiving the message is likely to use "what if"
capability to check effort levels again. Table 6.26 depicts information on the frequency of "what-if" capability for groups with global and local incentives.

<table>
<thead>
<tr>
<th>Incentive</th>
<th>Mean Value</th>
<th>Std. Dev.</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>Local</td>
<td>10.11</td>
<td>7.61</td>
<td>18</td>
</tr>
<tr>
<td>Global</td>
<td>21.28</td>
<td>13.16</td>
<td>18</td>
</tr>
</tbody>
</table>

Members in LDIST groups with global incentive use the "what-if" capability more frequently than members with local incentive. Thus, hypothesis H33 is not rejected (p < .005).

Table 6.27 contains the results to test hypothesis H34.

<table>
<thead>
<tr>
<th>Incentive</th>
<th>Mean Value</th>
<th>Std. Dev.</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>Local</td>
<td>4.44</td>
<td>4.49</td>
<td>18</td>
</tr>
<tr>
<td>Global</td>
<td>9.28</td>
<td>7.98</td>
<td>18</td>
</tr>
</tbody>
</table>

LDIST groups with global incentive used "optimization" more frequently than their counterparts with local incentive. Hypothesis H34 is not rejected (p < .025). With local incentive, members found the optimal effort levels for each order and then they optimized. With global incentive, each time one member sends new cost information to others, the receivers needed to optimize again.
6.9 Incentive and Proximity: leader-directed groups

Table 6.28 contains the results to test hypothesis H35.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Mean</th>
<th>Std. Dev.</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>LFTF: local</td>
<td>116.93</td>
<td>12.01</td>
<td>6</td>
</tr>
<tr>
<td>LDIST: global</td>
<td>67.43</td>
<td>9.34</td>
<td>6</td>
</tr>
</tbody>
</table>

The results indicate that leader reward is higher for LFTF groups with local member incentive than for LDIST groups with global incentive. This difference is statistically significant (p<.0005), and hypothesis H35 is not rejected.

6.10 Effort Level: Who works harder for the company?

To test the effect of each variable on member effort levels to test hypotheses H36 to H39, the experimental data depicted in Table 6.29 is used.
Table 6.29: Effect of variables on member effort levels

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Mean</th>
<th>Std. Dev.</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>Local</td>
<td>7.75</td>
<td>2.37</td>
<td>115</td>
</tr>
<tr>
<td>Global</td>
<td>3.97</td>
<td>1.28</td>
<td>186</td>
</tr>
<tr>
<td>face-to-face: global</td>
<td>4.40</td>
<td>1.40</td>
<td>94</td>
</tr>
<tr>
<td>distributed: global</td>
<td>3.50</td>
<td>.90</td>
<td>101</td>
</tr>
<tr>
<td>LFTF: global</td>
<td>5.00</td>
<td>1.37</td>
<td>53</td>
</tr>
<tr>
<td>LDIST: global</td>
<td>3.54</td>
<td>.85</td>
<td>44</td>
</tr>
<tr>
<td>Democratic: global</td>
<td>3.60</td>
<td>1.00</td>
<td>85</td>
</tr>
<tr>
<td>Leader-directed: global</td>
<td>4.30</td>
<td>1.30</td>
<td>96</td>
</tr>
</tbody>
</table>

Members with local incentive exert substantially higher effort than do members with global incentive. Hypothesis H36 is not rejected (p<.0005). Members in face-to-face groups exert more effort than do their distributed counterparts when incentive is global, and hypothesis H37 is not rejected (p<.0005). For leader-directed groups with global member incentive, face-to-face members exert more effort than do their distributed counterparts, and hypothesis H38 is not rejected (p<.0005). Members in leader-directed groups with global incentive exert more effort than do their democratic counterparts, and thus, one should not reject hypothesis H39 (p<.0005).

5 The same kind of information reported on this row and the following rows could be presented for local incentive as well; however, optimal effort level on each order for local incentive case is trivially determined by marginal analysis and is not dependent on communication channel or group composition differences. Analysis of member effort levels when incentive was local supported the claim that almost all members used marginal analysis to find their optimal effort levels.
Thus, when the incentive promotes gaming behavior, the leader as well as the proximity play a significant role in affecting the gaming behavior. In this case, both the leader and face-to-face communication channel positively impact member behavior to exert more effort on filling orders.

6.10 Summary

This section summarizes the results obtained from our experiment, by tabulating each hypothesis and whether it was rejected or not in Table 6.30. The comparison of reward, satisfaction with the solution, and frustration with the process between the groups studied are provided in Table 6.31. Table 6.32 provides information on the set of hypotheses presented in chapter 5 that compared member effort between different groups. Other results such as deviation from the efficient frontier, time taken to end the negotiation process, number of messages exchanged, and the frequency of GDSS feature used have not been summarized here.
Table 6.30: Hypothesis and the decision to reject or not (support)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>H1a</td>
<td>YES</td>
<td>H14b</td>
<td>YES</td>
<td>H29</td>
<td>YES</td>
</tr>
<tr>
<td>H1b</td>
<td>NO</td>
<td>H15a</td>
<td>YES</td>
<td>H30</td>
<td>NO</td>
</tr>
<tr>
<td>H2a</td>
<td>NO</td>
<td>H15b</td>
<td>YES</td>
<td>H31</td>
<td>YES</td>
</tr>
<tr>
<td>H2b</td>
<td>YES</td>
<td>H16a</td>
<td>YES</td>
<td>H32</td>
<td>YES</td>
</tr>
<tr>
<td>H3a</td>
<td>YES</td>
<td>H16b</td>
<td>YES*</td>
<td>H33</td>
<td>YES</td>
</tr>
<tr>
<td>H3b</td>
<td>YES</td>
<td>H17</td>
<td>YES</td>
<td>H34</td>
<td>YES</td>
</tr>
<tr>
<td>H4a</td>
<td>NO</td>
<td>H18</td>
<td>NO</td>
<td>H35</td>
<td>YES</td>
</tr>
<tr>
<td>H4b</td>
<td>YES</td>
<td>H19</td>
<td>NO</td>
<td>H36</td>
<td>YES</td>
</tr>
<tr>
<td>H5</td>
<td>NO</td>
<td>H20a</td>
<td>YES</td>
<td>H37</td>
<td>YES</td>
</tr>
<tr>
<td>H6a</td>
<td>NO</td>
<td>H20b</td>
<td>NO</td>
<td>H38</td>
<td>YES</td>
</tr>
<tr>
<td>H6b</td>
<td>NO</td>
<td>H21a</td>
<td>YES</td>
<td>H39</td>
<td>YES</td>
</tr>
<tr>
<td>H7a</td>
<td>NO</td>
<td>H21b</td>
<td>YES</td>
<td></td>
<td></td>
</tr>
<tr>
<td>H7b</td>
<td>NO</td>
<td>H22</td>
<td>NO</td>
<td></td>
<td></td>
</tr>
<tr>
<td>H8</td>
<td>YES</td>
<td>H23</td>
<td>YES</td>
<td></td>
<td></td>
</tr>
<tr>
<td>H9</td>
<td>NO</td>
<td>H24</td>
<td>YES</td>
<td></td>
<td></td>
</tr>
<tr>
<td>H10</td>
<td>NO</td>
<td>H25a</td>
<td>NO</td>
<td></td>
<td></td>
</tr>
<tr>
<td>H11</td>
<td>YES</td>
<td>H25b</td>
<td>NO</td>
<td></td>
<td></td>
</tr>
<tr>
<td>H12</td>
<td>YES</td>
<td>H26</td>
<td>YES</td>
<td></td>
<td></td>
</tr>
<tr>
<td>H13</td>
<td>YES</td>
<td>H27</td>
<td>NO</td>
<td></td>
<td></td>
</tr>
<tr>
<td>H14a</td>
<td>YES</td>
<td>H28</td>
<td>YES</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* This hypothesis is not rejected after removing the outlier, otherwise it is rejected.
Table 6.31: Summary of results on reward, satisfaction and frustration

<table>
<thead>
<tr>
<th>Group</th>
<th>Member reward</th>
<th>Leader reward</th>
<th>Member satisf.</th>
<th>Leader satisf.</th>
<th>Member frust.</th>
<th>Leader frust.</th>
<th>Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>FTF</td>
<td>&gt;</td>
<td>=</td>
<td>=</td>
<td>=</td>
<td>=</td>
<td>=</td>
<td>DIST</td>
</tr>
<tr>
<td>Autocratic</td>
<td>=</td>
<td>&gt;(^7)</td>
<td>=</td>
<td>&gt;(^8)</td>
<td>=</td>
<td>=</td>
<td>Democratic</td>
</tr>
<tr>
<td>Local</td>
<td>&gt;(^9)</td>
<td>&gt;</td>
<td>=</td>
<td>=</td>
<td>=</td>
<td>=</td>
<td>Global</td>
</tr>
</tbody>
</table>

| LFTF: Loc.  | >             | >             | >              | <              | <             | <             | LFTF: Glo.  |
| LFTF: Glo.  | =             | =             | >              | >\(^7\)        | =             | =             | NFTF: Glo.  |
| LFTF: Loc.  | =             | =             | =              | =             | =             | =             | NFTF: Loc.  |
| LDIST: Loc. | >             | <             | <              | >              | >\(^7\)       | =             | LDIST: Glo. |
| LDIST: Glo. | =             | =             | =              | =             | =             | =             | NDIST: Glo. |
| LDIST: Loc. | <             | =             | =              | =             | =             | =             | NDIST: Loc. |
| LFTF: Loc.  | >             | >             | >              | =              | <             | <             | LDIST: Loc. |
| LFTF: Glo.  | >             | >             | =              | <             | >\(^8\)       | =             | LDIST: Glo. |
| NFTF: Glo.  | >             | <             | <              | >\(^7\)        | =             | =             | NDIST: Glo. |
| LFTF: Loc.  | =             | >             | <\(^7\)        | <\(^8\)        | <             | <             | NDIST: Loc. |
| LDIST: Loc. | <             | =             | >              | >\(^7\)        | =             | =             | NFTF: Loc.  |
| LDIST: Glo. | <             | =             | =              | =             | =             | =             | NFTF: Glo.  |
| LFTF: Glo.  | =             | <             | >\(^7\)        | =             | =             | =             | NDIST: Glo. |

\(^7\) Organizational payoff is used instead of leader reward when a group is democratic.

\(^8\) The relationships presented in the shaded region of Table 6.32 do not have an explicit hypothesis in chapter 5.

\(^9\) Normalized member reward is calculated by dividing each member reward by the optimal the member could have achieved.
<table>
<thead>
<tr>
<th>Group</th>
<th>Effort</th>
<th>Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Local</td>
<td>&gt;</td>
<td>Global</td>
</tr>
<tr>
<td>FTF: Glo.</td>
<td>&gt;</td>
<td>DIST: Glob.</td>
</tr>
<tr>
<td>LFTF: Glo.</td>
<td>&gt;</td>
<td>LDIST: Glob.</td>
</tr>
<tr>
<td>LDIST: Loc.</td>
<td>&gt;</td>
<td>LDIST: Glo.</td>
</tr>
</tbody>
</table>
CHAPTER VII

SUMMARY, LIMITATIONS, AND FUTURE DIRECTIONS

7.1 Introduction

This chapter summarizes the research findings of this dissertation and discusses its limitations and areas for future research.

7.2 Summary

This dissertation develops a mixed-motive task (StriveCo Manufacturing Case) and a Level Two GDSS (StriveLink) and studies the impact of three factors: proximity of decision makers, incentive structures (local versus global), and group composition (leader-directed versus democratic) on decision-making. The outcome variables include absolute performance, as measured by the rewards achieved, performance with respect to the efficient frontier, and the decision maker's satisfaction with the final solution. The process variables include frustration with the process, time taken to end the negotiation
process, number of structured messages exchanged electronically, and the truthfulness of the information exchanged between members and the leader (see figure 7.1).

Figure 7.1: Relationship between variables
The three factors studied in this research are found to have the following effects on the negotiation process and outcome measures.

**Proximity effects**

Proximity is found to have a significant impact on member performance; face-to-face members performed better than their distributed counterparts. Proximity, however, did not significantly affect leader performance; the leader, with the authority to override member solutions, performed as well in DIST condition as in the FTF condition. This finding suggests that unlike member performance, leader effectiveness is not significantly hampered by the communication channel. At first glance, these results may seem to support that organizations that consider GDSS technology need not worry about the degradation of organizational performance as a result of distributed proximity when a leader is in charge. Such inference is misleading as both the leader and the members in LFTF groups were closer to the efficient frontier than were their counterparts in LDIST groups. After solutions were compared with the efficient frontier, it was found that given what the members have accepted, the leader does better when proximity is face-to-face; and given what the leader has accepted, the members do better when proximity is face-to-face.

Distributed proximity made it easier for the leader to make the unpopular decision of overriding member decisions, but since the leaders in face-to-face groups could gauge member costs more effectively, the solutions were not better when proximity was distributed and leader faced less social pressure to override member solutions. The face-
to-face channel provided a more cooperative environment conducive to higher trust than did the distributed channel. Therefore, the members performed better when proximity was face-to-face, as the richness of the media made it easier for members to negotiate with the leader more effectively.

Proximity does not seem to affect member or leader satisfaction with the solution when one does not control for different incentive schemes and group compositions. This surprising result makes us question the commonly accepted proposition that "FTF groups are more satisfied with their solution than their DIST counterparts". Such a claim needs to be qualified by specifying other factors such as task type, incentive, and group composition. Each feature that can be operationalized within a DIST setting may impact different tasks differently. For example, it has been shown that for idea generation tasks an anonymity feature that can be easily operationalized plays a significant role on member satisfaction with the solution by reducing the dominating effect of a single powerful member. Because such factors as group composition and incentive affect satisfaction with the solution, management should evaluate such factors in the design of organizational structures.

It should be noted that although satisfaction with the solution did not differ significantly between FTF and DIST groups, member decisions were better in FTF groups than in DIST groups as evidenced by higher reward. Most GDSS designers use the improvement of actual performance as a selling point for their technology (e.g. Lotus Notes). However, if the technology helps improve the performance without linking this improvement to decision-maker perception of performance (i.e. satisfaction with the
solution), decision makers may tend to lose interest in the technology. The lack of alignment of performance and perceived performance may create the feeling that the nature of their job has changed [Zuboff, 1988].

Member and leader frustration with the process is not significantly affected by proximity when incentive and group composition differences are not controlled for. Distributed channel is a more restrictive media and McGrath and Hollingshead [1993] have conjectured that it provides a poor fit for negotiation tasks. However, when the task requires structured information such as costs for orders and the GDSS provides structured information sharing capabilities, the restrictiveness of the distributed media will be diminished by the efficiency of the structured messages.

**Leader effects**

The effect of leader on member rewards is not found to be significant. This suggests that member rewards in democratic groups are not inherently better than in leader-directed groups. The organizational profit, however, is higher when a leader explicitly protects organizational stakes. Since a leader protects organizational stakes without degrading member stakes, companies may want to be cautious about replacing leader-directed groups with democratic groups.

A leader may help reduce communication chaos. Democratic group communication could perhaps be modeled as a "many-to-many" communication as every member communicates with all others. In leader-directed groups, when members transmit information to the leader, communication is "one-to-one", and when leader
broadcasts messages to members, communication is "one-to-many". The focused
communication induced as a result of the leader may make CMC more appropriate for
leader-directed groups than for democratic groups from a purely communication load
requirement viewpoint.

Why the effect of leader on member reward was not significant? Two plausible
explanations may be offered. First, because of the group history that exists within
groups, the leader does not ignore member concerns to unilaterally maximize his/her
reward. Second, because the leader does not have all the information to make decisions,
the leader can not make accurate decisions to maximize his/her reward at the expense of
lowering member reward. The information asymmetry may actually help members to
protect themselves against a leader who may have little concern for them. When leader
incentive is tied to organizational performance, profit is higher for leader-directed groups
than for democratic groups. Also, when the reward of members and leader are aligned
(global incentive), the leader needs to convince members to increase their effort and the
members can leverage their authority over their effort level to negotiate with the leader
not to unilaterally override their solutions. Hence, in groups with a history and in the
face of information asymmetry, a leader does not make members worse off, but positively
impacts organizational stakes.
**Incentive effects**

Comparing individual and group incentive schemes, the results of this study show that rewarding everyone from a single pot is not necessarily the best compensation scheme. In fact, both members and leader are worse off under this incentive scheme when compared to a scheme where member incentive is based on individual contributions. Although this result relies on the particular task and implementation of this study, it highlights the potential pitfalls in using group incentive that may lead to gaming and free riding that may degrade group performance from the perspective of both members and leader. If group incentive schemes are used, then there needs to be particular attention paid to "free riding" behavior. The decision making environment should either be conducive to trust, or prevent members from free riding behavior.

**Interaction effects**

Members in LDIST groups with local incentive performed worse than their counterparts in LFTF groups. The members do not seem to negotiate with the leader effectively when the communication channel is not rich. This leads to lower member rewards and higher member frustration levels in distributed groups. There seems to be more cooperation in the FTF groups as neither the leader nor the members are worse off. There seems to be less social pressure on the leader in the distributed groups, but the leader is often unable to protect the organizational objective any better in the distributed groups than in the FTF groups. One reason is the accuracy of the information that the
leader receives. The leader can gauge member costs more accurately in LFTF groups than in LDIST groups.

The effect of leader and incentive on member and leader rewards are compared between FTF and DIST channels to see if these traditional variables have the same impacts under the two different channels. In both LDIST and LFTF groups, leader reward is higher when incentive is local than when it is global. This difference, however, is more severe for LDIST groups than for LFTF groups. One reason is that the leader in LFTF groups is more effective in convincing members to increase their effort levels than he/she was in LDIST groups when incentive was global and members had the tendency to select low effort levels. This again suggests that FTF channel is a more effective channel to support a negotiation process. This again implies that FTF channel is a more appropriate channel for negotiation.

For FTF groups with global member incentive, member reward is not significantly different for leader-directed and democratic groups. This result also holds for DIST groups, but the magnitude of the difference is not the same between FTF and DIST groups. With local incentive, however, the results between FTF and DIST conditions differ not just in magnitude but also in direction. For FTF condition, member reward is not significantly different for leader-directed and democratic groups. For DIST groups, members in democratic groups do significantly better (higher rewards) than those in leader-directed groups. Thus, proximity and group composition have interaction effects. Members with local incentive may, therefore, prefer democratic groups when they are distributed, but when they are face-to-face, they may not prefer one over the
other. Members can not negotiate effectively with the leader in distributed groups to stop
him/her from overriding their solutions. However, with FTF channel the members seem
to negotiate effectively with the leader so that the leader takes member concerns into
account. The leader seems to find it harder to override member solutions when proximity
is FTF because of the increased social pressure of making an unpopular decision.

For leader-directed groups with local incentive, the leader satisfaction with the
solution is not much different between LFTF and LDIST conditions. This implies that
once the leader's threshold for satisfaction with the solution is reached, the leader simply
overrides member solutions as a strategy, stopping any severe drops in his/her
satisfaction. The leader's frustration is higher when operating under a DIST
communication channel. Due to the artificiality of the unnatural communication channel
in the distributed groups, leader frustration with the process is higher in distributed
groups even in the face of the threshold argument.

In comparing the effect of communication channel on efficiency, it is found that
the LFTF group solutions came closer to the efficient frontier than the LDIST group
solutions for both the members and the leader. So the LFTF groups, on average,
achieved significantly better solutions than their distributed counterparts. This supports
Hollingshead and McGrath's hypothesis that computer mediated communication is a poor
fit for negotiation tasks for leader-directed groups with local incentive. Managers should
be cautious about replacing face-to-face meetings with distributed meetings when they
are faced with a negotiated task.
The LDIST groups with local incentive, in general, found the optimal effort levels. They divided the problem into the two separate subproblems of finding optimal effort levels and selecting optimal set of orders. The members in LDIST groups with global incentive expended lower effort levels than their counterparts with local incentive. Almost all members with local incentive exerted optimal effort levels, whereas, most members with global incentive expended much lower than optimal levels of effort. This implies that the incentive system plays a significant role on member solutions and rational behavior, and managers should design incentive systems to encourage members to make decisions that serve organizational objectives.

The members with global incentive used the what-if capability to evaluate the effect of changes in their effort levels on their rewards more frequently than their counterparts with local incentive. With global incentive, members found that lower effort levels lead to higher rewards for them when the effort levels of other members remained constant. So they used low effort levels when incentive was global. The what-if capability of the GDSS made it cognitively easier for members to decrease their effort levels as a strategy to maximize their rewards. This supports Todd and Benbasat's hypothesis that decision makers adapt their strategies to the type of decision support aids they are using in order to reduce cognitive effort [Todd, Benbasat, 1991]. We generalize Todd and Benbasat's finding, based on Utility Theory, and claim that decision makers adapt their strategies to the type of decision support aids used to maximize utility.

Because of group history, it seems that the leader cooperates with the members to find good solutions for all. The face-to-face channel promotes this behavior. The trust
that promotes an environment conducive of cooperative behavior must be a result of the facial cues under FTF channel that are blocked under DIST channel. Group members in FTF condition seem to effectively negotiate with the leader to take their objective into account instead of having the leader unilaterally override their solutions, making members worse off. The richness of the FTF channel coupled with group history create an environment conducive of trust and cooperation and this may explain why the leader does not have a significant impact on member rewards when proximity is face-to-face.

The use of structured messages was examined between LFTF and LDIST groups with local incentive and it was found that both groups used the structured messages with the same frequency. The structured messages provided the means of transmitting task relevant information more efficiently than through any other means. This implies appropriate structured messages could help overcome some of the restrictions of the DIST channel. This is an important finding for the designers of distributed GDSS systems. It illustrates the need for understanding the information requirements of tasks and designing appropriate templates to facilitate such information exchanges.

Member decisions on how much effort to expend is significantly affected by leader, proximity, and incentive. Local incentive substantially diminished the gaming behavior on how much effort to expend as it provided decision makers with an easy decision rule (marginal analysis). Global incentive promoted free riding that lead to low member effort levels. The leader encouraged members to exert high effort levels because his/her incentive was increased as members increased effort. The leader was more successful in convincing members to increase their effort when proximity was FTF.
Thus, LFTF group members with local incentive exerted the most effort leading to highest organizational profit. The lowest organizational profit was achieved by NDIST groups with global incentive.

7.3 Contribution

Prior research on the effectiveness of GDSS on group problem solving whether it be in the context of creative, choice, preference or negotiated tasks has considered democratic groups. Although equal within the group, typically group members once outside of the group have differential power, status, and decision-making authority. This has given rise to features in GDSS, such as anonymous input of ideas. However, in organizations groups are typically created with the leader in charge of directing the activities of the group as well as bearing responsibility for the decisions proposed by the group. It, therefore, is important to study the effect of support systems on leader-directed groups. Also group members often have different stakes in the outcomes with each member trying to maximize his/her stake. The leader's role within such groups is to protect the interests of the organization and his/her stake is typically tied to the organization's stake in the decision.

Several factors distinguish the current study from past work in this area. First, although the task chosen for the study is complex, there is an objective measure that can be used to determine the quality of the negotiation outcomes. Second, there is information asymmetry between the group members; group members do not have accurate knowledge about how their decisions affect the payoffs of other members or the
leader. Third, all groups have access to the negotiation tools to aid them in their negotiation. The GDSS is an integral part of the problem solving arsenal as the complexity of the task required GDSS use. Fourth, we simulated an environment where the decision makers have high stakes riding on the solutions. Fifth, the group members know each other and have to continue working together on other projects in the future. Finally, the incentive structures that are used in this study allow one to compare the behavior of group members vis-a-vis the group leader.

The study analyzed negotiation processes and outcomes. The outcomes were analyzed within the context of the efficient frontier as well as the individual rewards for the leader and the members. The results of the study, presented in chapter 6, indicate that proximity and incentive have a more significant impact on performance than does a leader. The interaction effects were also presented.

The negotiation process was analyzed on several dimensions. The use of the negotiation tool\(^1\) in different groups was analyzed. Results indicate that all groups used the tools frequently, and this is not surprising as the complexity of the task was such that they cannot determine the quality of a solution unless they used the tool. All groups used the structured messages frequently for exchanging task relevant (costs) information. This suggests that if support systems provide predefined templates for specific task related exchanges, then users will use them effectively instead of relying on unstructured and less efficient methods.

\(^1\)Negotiation tools refer to GDSS features to support the negotiation task such as optimization capability, what-if capability, and structured message exchange capability.
The study also showed that organizational designers need to re-evaluate their organizational variables as they introduce GDSS into their organizations to facilitate distributed decision-making. They also have to evaluate GDSS features as each feature may promote a certain behavior in decision-makers. For example, the "what-if" capability of StriveLink GDSS promoted members to behave in a manner as to select low effort levels when incentive was global resulting in detrimental impacts on the organizational interests. This feature made it easy for members to consider only the isolated effect of his/her effort level on his/her solution.

As companies promote groups as a structural unit within organizations, management is being asked to identify and evaluate organizational structures and processes that can hinder or enhance group functioning. This research attempted to identify and evaluate three specific organizational structure and process variables to test if they hinder or enhance group functioning when groups are equipped with a GDSS. One variable was the form of group decision making hierarchy (autocratic/democratic captured by groups having a leader and those without a leader); another was the reward structure (bonus tied to departmental performance versus organizational performance); and the third was the geographic proximity of group members using the GDSS. If the GDSS is more effective in collective-synthesis and with incentive tied to organizational performance, then a GDSS can be an effective tool to facilitate and promote quality teams, concurrent engineering, and functional integration. If the GDSS is not effective in supporting self-managed groups, then it could hinder quality teams, concurrent engineering, and functional integration. Such finding are relevant to both organizations
who wish to invest in GDSS technology and those who try to implement and promote quality, concurrent engineering, and functional integration to solve group problems. This research also addresses the important practical concerns raised by Malone and Crowston [1994] that computer systems should help people work together more effectively, and provide tools for supporting a more satisfying and more flexible organization of collective human activity [Malone, 1994]. Empirical research like this study can identify what works well and what does not in a distributed computer-supported decision-making environment.

7.4 Research limitations

The study was not without its limitations. The use of advanced undergraduate students as subjects may cause external validity concerns. One should be cautious about generalizing the findings of this research beyond the scope of this restrictive setting. Controlled experiments, like the one in this study, provide high internal validity. Field studies with actual decision makers would have created severe internal validity problems as it is hard to find decision makers with similar backgrounds, education, and computer expertise coming from companies with comparable industries, size, nature of business, internal power structures, and organizational culture. These factors, which are hard to control within organizational contexts, have been shown to affect decision making processes and outcomes. The lack of control would have made it impossible to achieve reasonable internal validity. It would then be hard or impossible to understand the real causes of any differences in results. Achieving high internal validity at the expense of the
possibility of sacrificing external validity may be justified for this first study on the effect of proximity, incentive, and leader on the processes and outcomes of groups engaged in a mixed-motive task within a Level 2 GDSS setting. The use of student subjects as surrogates for actual decision makers is justified [McGrath, 1984] when members are familiar with the task and have significant stakes in the outcomes. Students who had fifteen percent of their grade depend on their decision outcomes had significant stakes in the outcomes. They were inherently familiar with the task as it was introduced in conjunction with related topics in class.

7.5 Future directions and extensions

Interdivisional, interfirm, and interfunctional decision making, from a coordination standpoint, seem to have much in common. Further research should attempt to study interfirm and interdivisional coordination, as well as coordination between all units within and outside the organization. Such studies would be generalizations and extensions of chain management, joint ventures, and alliances for mutual gain.

Future research should focus on the study of the effect of other factors, such as different reward mechanisms (partly group and partly individual), other group compositions (i.e. based on decision-maker personality profiles), and different levels of GDSS, on negotiation process and outcomes. All of these factors are important organizational variables, controllable by organizational designers, that need to be studied as distributed groups are becoming a reality with the proliferation of computer networks.
into organizations. The implications of video-conferencing on organizational work and how it affects traditional variables provide a fertile ground for future research.

Face-to-face and electronic communication channels differ in degree of media richness, and many studies have compared one to the other. It may be possible to find that for certain tasks, face-to-face and electronic interactions complement one another to produce higher quality decisions. TelePort Corporation has developed TeleDining to "trick" the distributed luncheon meeting participants that they are meeting face-to-face [Dispatch, 1995]. Although this technology may not replace the initial face-to-face hand-shake meeting, it is conjectured to suffice for most follow-up meetings. This conjecture requires further testing. Further research is also required to study whether the two channels complement one another, and if so, for what types of tasks.

Another extension would be to conduct a longitudinal field study. It would be interesting to study firms which use GDSS technology for distributed decision-making over a long period of time to understand the effect of decisions on measurable outcomes and processes such as gross profit, return on investments, improvements in decision time, and user satisfaction with solutions. To make any statistically significant generalizations, however, one needs to have a large sample with relatively homogeneous characteristics so that they can be compared without too many confounding effects. Finding a large sample of organizations with these characteristics is hard as this technology is new. One way to alleviate this difficulty is to conduct detailed case studies on few companies. The problem, however, would be that detailed case studies would provide insights only about the companies under study and not much beyond those companies.
The exchange of local knowledge between decision making entities within a group is required for group problem solving. In organizational settings, where groups are responsible for projects with long durations, it is possible that a decision maker is temporarily not available to provide information to other members. Members should be able to access the knowledge base of other members and query it for specific partial answers to their problem, provided that appropriate access rights have been granted. The implications of information exchange between a human decision maker and the computer knowledge base node of other members should be studied before human-computer interaction can synergistically work. A framework for such a networked knowledge base system is provided in [Jacob, Pirkul, 1990], and [Jacob, Pirkul, 1992]. Further research is required to implement systems proposed in these studies and empirically test structural and contextual variables on the working of such systems.

Structured communication is an integral part of problem solving and users utilize this form of communication regardless of the communication channel. Designers of GDSS technology should provide task specific structured information exchange capabilities for their users. Further research is required to create a taxonomy for specific structured messages required for different classes of tasks. Providing appropriate structured templates may reduce the need for FTF communication.

It was found here CMC has some shortcomings: low communication efficiency, and de-individuation. These factors coupled with global incentive structure promoted gaming behavior as members wanted to select effort levels. Most members with local incentive, however, selected optimal effort levels. This suggest the following: "It may be
possible to design incentive structures to overcome the shortcomings associated with CMC. It is found in this study that local incentive produced better results than global incentive. Other types of incentives (i.e. combinations) provide avenues for further research. Of particular interest and practical value would be the identification of incentive mechanisms that induce members to make decisions that achieve organizational objectives.
Appendix A

Optimization and Parser Programs
Optimization Program

The following is an example of the LINDO code that the GDSS automatically creates. This will automatically be saved in a file and the next LINDO statement "take <filename>" will run the commands to generate a LINDO output file.

\[
\text{MAX } + 20X_1 + 28X_2 + 8X_3 + 28X_4 + 20X_5 + 20X_6 - 18X_7 + 26X_8 - 12X_9 + 32X_{10} + 8X_{11} + 8X_{12} + 18X_{13} + 14X_{14} + 24X_{15} + 60X_{16} + 12X_{17} + 12X_{18} + 6X_{19} - 18X_{20}
\]

\[
\text{SUBJECT TO}
\]

1) \[
200x_1 + 50x_2 + 100x_3 + 400x_4 + 350x_5 + 400x_6 + 150x_7 + 200x_8 + 755x_9 + 300x_{10} + 600x_{11} + 55x_{12} + 100x_{13} + 300x_{14} + 500x_{15} + 450x_{16} + 210x_{17} + 200x_{18} + 150x_{19} + 250x_{20} < 1500
\]

2) \[
450x_1 + 2000x_2 + 0x_3 + 100x_4 + 1100x_5 + 55x_6 + 50x_7 + 1100x_8 + 300x_{10} + 800x_{11} + 400x_{12} + 400x_{13} + 50x_{14} + 400x_{15} + 1000x_{16} + 210x_{17} + 300x_{18} + 310x_{19} + 55x_{20} < 1950
\]

3) \[
200x_1 + 100x_2 + 50x_3 + 150x_4 + 550x_5 + 420x_6 + 250x_7 + 300x_8 + 455x_9 + 300x_{10} + 950x_{11} + 100x_{12} + 250x_{13} + 100x_{14} + 300x_{15} + 835x_{16} + 315x_{17} + 310x_{18} + 400x_{19} + 520x_{20} < 3400
\]

4) \[
400x_1 + 800x_2 + 400x_3 + 650x_4 + 950x_5 + 155x_6 + 80x_7 + 700x_8 + 0x_9 + 300x_{10} + 300x_{11} + 300x_{12} + 450x_{13} + 700x_{14} + 600x_{15} + 2250x_{16} + 255x_{17} + 350x_{18} + 450x_{19} + 110x_{20} < 2850
\]

END

INTEGER 0

GO

DIVERT

MK_OPTS.IN

INTEGER 20

GO

RVRT

QUIT
Pascal Parsing Program

The following Pascal code is an example of the program that parses the output generated by LINDO. The program looks at the last solution in LINDO output, parses the objective function value and the integer values assigned to each of the decision variables. Then this information is stored in another file which is accessed by the GDSS to be displayed to the user.

```pascal
PROGRAM CONVERT(INPUT, OUTPUT);
VAR
  STRING8: STRING[8];
  STRING3: STRING[3];
  string7: string[7];
  VAL_01, OFV: REAL;
  v: array [1..20] of real;
  X: array [1..20] of STRING[4];
  INF, OUTF: TEXT;
  i: integer;
BEGIN
  Assign(inf, 'MK_OPT.IN');
  Reset(inf);
  Assign(outf,'MK_OPT.OUT');
  Rewrite(outf);
  while not eof(inf) do
  begin
    Readln(inf, string8,string3);
    if string3='OBJ'
    then
      begin
        ofv:=0.0;
        for i:=1 to 20 do
          begin
            v[i]:=0;
            x[i]:='■';
          end;
        readln(inf,string8);
        readln(inf,string8,string3,ofv);
        readln(inf,string8,string3);
        readln(inf,string8,string3);
        for i:= 1 to 20 do
          begin
            readln(inf,string7,string3,val_01);
            if val_01<>0
              then begin
```
if string3='X1' then begin
x[1]='1 ';
v[1]:=val_01;
end
else if string3='X2' then begin
x[2]='2 ';
v[2]:=val_01;
end
else if string3='X3' then begin
x[3]='3 ';
v[3]:=val_01;
end
else if string3='X4' then begin
x[4]='4 ';
v[4]:=val_01;
end
else if string3='X5' then begin
x[5]='5 ';
v[5]:=val_01;
end
else if string3='X6' then begin
x[6]='6 ';
v[6]:=val_01;
end
else if string3='X7' then begin
x[7]='7 ';
v[7]:=val_01;
end
else if string3='X8' then begin
x[8]='8 ';
v[8]:=val_01;
end
else if string3='X9' then begin
x[9]='9 ';
v[9]:=val_01;
end
else if string3='X10' then begin
x[10]='10 ';
v[10]:=val_01;
end
else if string3='X11' then begin
v[11]:=val_01;
end
else if string3='X12' then begin
  x[12]:=12 ;
  v[12]:=val_01;
end
else if string3='X13' then begin
  x[13]:=13 ;
  v[13]:=val_01;
end
else if string3='X14' then begin
  x[14]:=14 ;
  v[14]:=val_01;
end
else if string3='X15' then begin
  x[15]:=15 ;
  v[15]:=val_01;
end
else if string3='X16' then begin
  x[16]:=16 ;
  v[16]:=val_01;
end
else if string3='X17' then begin
  x[17]:=17 ;
  v[17]:=val_01;
end
else if string3='X18' then begin
  x[18]:=18 ;
  v[18]:=val_01;
end
else if string3='X19' then begin
  x[19]:=19 ;
  v[19]:=val_01;
end
else if string3='X20' then begin
  x[20]:=20 ;
  v[20]:=val_01;
end
end;
end;
end;
write(outf,ofv:10:2,' ');
for i:=1 to 20 do
if v[i]<>0
  then write(outf,x[i]);
  writeln(outf,'');
close(inf);
close(outf);
end.
The Theoretical Efficient Frontier

The following program is an example of a two-objective program for finding the efficient frontier. The weights ($W_M$ and $W_L$) are the respective weights assigned to the member and leader objectives. We solved this program multiple times by varying the weights to find the breakpoints in the efficient frontier.

\[
\text{MAX } W_M (20X1 + 28X2 + 8X3 + 28X4 + 20X5 + 20X6 - 18X7 + 26X8 - 12X9 + 32X10 + \\
8X11 + 8X12 + 18X13 + 14X14 + 24X15 + 60X16 + 12X17 + 12X18 + 6X19 - 18X20 + \\
24X1 - 2X2 + 10X3 + 14X4 + 20X5 + 12X6 - 16X7 - 6X8 + 50X9 - 6X10 + \\
15X11 + 8X12 + 12X13 + 16X14 + 12X15 + 70X16 + 24X17 + 12X18 + 26X19 - 12X20 \\
10X1 + 8X2 + 14X3 + 14X4 - 30X5 + 18X6 + 27X7 - 30X8 - 16X9 - 24X10 + \\
10X11 + 12X12 + 6X13 + 12X14 + 12X15 + 40X16 + 12X17 + 24X18 - 10X19 + 36X20) + \\
W_L (14X1 + 29X2 + 16X3 + 23X4 + 31X5 + 15X6 + 20X7 + 18X8 + 20X9 + 16X10 + \\
42X11 + 18X12 + 11X13 + 25X14 + 18X15 + 56X16 + 20X17 + 20X18 + 29X19 + 23X20)
\]

\[
\text{SUBJECT TO } \\
1) 200x1 + 50x2 + 100x3 + 400x4 + 350x5 + 400x6 + 150x7 + 200x8 + 755x9 + 300x10 + \\
600x11 + 55x12 + 100x13 + 300x14 + 500x15 + 450x16 + 210x17 + 200x18 + 150X19 + 250x20 < 1500 \\
2) 450x1 + 2000x2 + 0x3 + 100x4 + 1100x5 + 55x6 + 50x7 + 1100x8 + 300x10 + \\
800x11 + 400x12 + 400x13 + 50x14 + 400x15 + 1000x16 + 210x17 + 300x18 + 310x19 + 55x20 < 1950 \\
3) 200x1 + 100x2 + 50x3 + 150x4 + 550x5 + 520x6 + 250x7 + 300x8 + 455x9 + 300x10 + \\
950x11 + 100x12 + 250x13 + 100x14 + 300x15 + 835x16 + 315x17 + 310x18 + 400x19 + 520x20 < 3400 \\
4) 400x1 + 800x2 + 400x3 + 650x4 + 950x5 + 155x6 + 80x7 + 700x8 + 4x9 + 300x10 + \\
300x11 + 300x12 + 450x13 + 700x14 + 600x15 + 2250x16 + 255x17 + 350x18 + 450x19 + 110x20 < 2850 \\
\text{END}
\]
Integrative Solution

To find the integrative solution, we added constraints 5 to 12 and changed the objective function. Constraints 5 to 8 assure that every solution is higher than sixty percent of their respective optimal solution. Constraints 9 to 12 finds the deviations of not achieving this percentage, and it is minimized in the objective function.

MAX \( 0.58480Y_4 + 0.79365y_1 + 0.657899y_2 + 0.67114y_3 \)

SUBJECT TO

1) \( 200x_1 + 50x_2 + 100x_3 + 400x_4 + 350x_5 + 400x_6 + 150x_7 + 200x_8 + 755x_9 + 300x_{10} + 600x_{11} + 55x_{12} + 100x_{13} + 300x_{14} + 500x_{15} + 450x_{16} + 210x_{17} + 200x_{18} + 150x_{19} + 250x_{20} < 1500 \)
2) \( 450x_1 + 2000x_2 + 0x_3 + 100x_4 + 1100x_5 + 55x_6 + 50x_7 + 1100x_8 + 300x_{10} + 800x_{11} + 400x_{12} + 400x_{13} + 50x_{14} + 400x_{15} + 1000x_{16} + 210x_{17} + 300x_{18} + 310x_{19} + 55x_{20} < 1950 \)
3) \( 200x_1 + 100x_2 + 50x_3 + 150x_4 + 550x_5 + 420x_6 + 250x_7 + 300x_8 + 455x_{15} + 315x_{17} + 310x_{18} + 400x_{19} + 520x_{20} < 3400 \)
4) \( 400x_1 + 800x_2 + 400x_3 + 650x_4 + 950x_5 + 155x_6 + 80x_7 + 700x_8 + 60x_9 + 300x_{10} + 300x_{11} + 300x_{12} + 450x_{13} + 700x_{14} + 600x_{15} + 2250x_{16} + 255x_{17} + 350x_{18} + 450x_{19} + 110x_{20} < 2850 \)
5) \( 0.58480y_4 > 60 \)
6) \( 0.79365y_1 > 60 \)
7) \( 0.657899y_2 > 60 \)
8) \( 0.67114y_3 > 60 \)
9) \( 20X_1 + 28X_2 + 8X_3 + 28X_4 + 20X_5 + 20X_6 - 18X_7 + 26X_8 - 12X_9 + 32X_{10} + 8X_{11} + 8X_{12} + 18X_{13} + 14X_{14} + 24X_{15} + 60X_{16} + 12X_{17} + 12X_{18} + 6X_{19} - 18X_{20} - Y_1 = 0 \)
10) \( 24X_1 - 2X_2 + 10X_3 + 14X_4 + 20X_5 + 12X_6 - 16X_7 - 6X_8 + 50X_9 - 6X_{10} + 15X_{11} + 8X_{12} + 12X_{13} + 16X_{14} + 12X_{15} + 70X_{16} + 24X_{17} + 12X_{18} + 26X_{19} - 12X_{20} - Y_2 = 0 \)
11) \( 10X_1 + 8X_2 + 14X_3 + 14X_4 - 30X_5 + 18X_6 + 27X_7 - 30X_8 - 16X_9 - 24X_{10} + 10X_{11} + 12X_{12} + 6X_{13} + 12X_{14} + 12X_{15} + 40X_{16} + 12X_{17} + 24X_{18} - 10X_{19} + 36X_{20} - Y_3 = 0 \)
12) \( 14X_1 + 29X_2 + 16X_3 + 23X_4 + 31X_5 + 15X_6 + 20X_7 + 18X_8 + 20X_9 + 16X_{10} + 42X_{11} + 18X_{12} + 11X_{13} + 25X_{14} + 18X_{15} + 56X_{16} + 20X_{17} + 20X_{18} + 29X_{19} + 23X_{20} - Y_4 = 0 \)

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