RECEIVED
FEB 16 1996
OSTI

**THE DIFFERENCE BETWEEN TEAMWORK AND COMPLIANCE:
THE APPLICATION OF GAME THEORY TO
REAL-WORLD RESEARCH TEAMS**

by

James R. Frank
Energy Systems Division
Argonne National Laboratory
9700 South Cass Avenue
Argonne, Illinois 60439

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

April 1994

The submitted manuscript has been authored by a contractor of the U. S. Government under contract No. W-31-109-ENG-38. Accordingly, the U. S. Government retains a nonexclusive, royalty-free license to publish or reproduce the published form of this contribution, or allow others to do so, for U. S. Government purposes.

MASTER

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED 85

DISCLAIMER

Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.

**THE DIFFERENCE BETWEEN TEAMWORK AND COMPLIANCE:
THE APPLICATION OF GAME THEORY TO
REAL-WORLD RESEARCH TEAMS***

ABSTRACT

This study explores the relationships between cooperation, teamwork, and game theory in actual multidisciplinary research teams. Two types of cooperation have been differentiated as "compliance" (cooperation, which is enforced by short-term interest) and "teamwork" (in which team members give up short-term gains for longer-term gains). "Compliance" is best explained by the Principal Agent Theory and is best applied to routine activities. "Teamwork" is best explained by a modification of Axelrod's Theory of Cooperation and is best applied to problem-solving, non-routine activities. These exploratory findings have important implications for organizational structure considerations and management policies.

*This work was not funded through Argonne National Laboratory.

THE DIFFERENCE BETWEEN TEAMWORK AND COMPLIANCE: THE APPLICATION OF GAME THEORY TO REAL-WORLD RESEARCH TEAMS

INTRODUCTION

There is considerable consensus that the promotion of cooperation in interdisciplinary research is important, but there is little consensus on how to promote it. For example, Montjoy and O'Toole (1984) suggest that the solution is to make sure that organizations desire it and apply sufficient resources and pressure to make things happen. Their suggestion is that somehow organizations can enforce cooperative activities in research. They question whether individuals play an important role in developing cooperative teams. They admit, however, that there "...is as yet, no general agreement on a predictive theory of implementation or even on what variables are most important to consider." Other investigators (Quirk, 1986; Magerison, 1978; Smith, 1971; Tjosvold, 1984; Battelle, 1975; Kingdon, 1984; Kornhauser, 1965) suggest that "leaders" play an important role in the emergence of cooperation. Others suggest that cooperation can occur in the absence of leaders (Axelrod, 1984). Dawes (1980: 190) states, for example, that "...payoff utilities lead the players to defect, while the other utilities — e.g., those connected with altruism, norms, and conscience — lead the players to cooperate."

While much of the discussion about team cooperation centers around scientists, the problem of cooperation is a well known one in the political science and economics literature. In this context, it is known as the Problem of Collective Action (Mueller, 1982; Hardin, 1982; Olson, 1965; Abrams, 1980). The Problem of Collective Action was first extended to political science theory by Olson in *The Logic of Collective Action*. Olson (1965) argues that sanctions or private incentives are necessary to overcome the "free-rider" problem. Essentially, the problem of cooperation among scientists is also a free-rider problem.

The problem of cooperation among scientists is a universal one that applies to both industrial and academic institutions. In industry, it can occur at the level of rival groups vying for internal resources and prestige within a company (Kidder, 1981). In universities, institutional policies and organization structure often encourage independent investigation and discourage cooperative endeavors, even when the probability of success can be enhanced by cooperation. This problem has been described by A.S. Michaels (1989), who examined problems of interdisciplinary cooperation between scientists in universities:

The basic concept of cross-disciplinary collaboration is incompatible with the culture of intellectual inquiry in the university. Faculty in science and engineering are selected primarily on the basis of their demonstrated or projected ability to perform independent research that will earn the respect of their peers. Advancement in the university hierarchy is determined largely by individual research accomplishment and visibility (through publication) in their professional peer community. The situation becomes even more problematical when the proposed collaboration involves faculty of different departments in the same school, different departments in different schools within the same institution, or (God forbid) faculty members of different institutions. Thus, while the clarion call is out for interdisciplinary collaboration . . . the prevailing wisdom among university faculties and administrations is "solo is security" (Michaels, 1989: 18-19).

Michaels also describes the common faculty response to funding tied to "interdisciplinary" research as:

(bringing) his or her cup to the common pump, a cup that, if and when it is filled, will be carried back merely to water his or her private family enterprise. Such a "collaboration," I submit, is nothing more than a bunch of kids playing alone

together.... . What is obvious to me, however, is that while there may be a consensus on what *needs* to be done, there is depressingly little consensus on *how* it can be accomplished (Michaels, 1989: 18-19).

The purpose of this study has been to explore the question of how managers can encourage research scientists to cooperate together in teams. An initial examination of the literature on cooperation is not encouraging. Much of the literature is empirical or descriptive and deals with the characteristics of organizations and leaders but not what they actually *do* to improve teamwork and cooperation. Most of the how-to literature deals with people-management skills and methods to motivate groups or individuals or with analyses of corporate cultures that seemed to encourage innovation. Most of these, however, are based on participative management theories that describe the characteristics of good managers or organizations but not what managers should do when they find themselves in the position of developing teams to achieve specific goals.

The game theoretic literature, on the other hand, focuses primarily on idealized games, such as the Prisoner's Dilemma. Most of the literature, except for Axelrod's Theory of Cooperation, focuses on noncooperative, single-play games, which were shown *not* to yield Pareto-optimal outcomes under a variety of complex rules (Miller, 1992). Axelrod's Theory of Cooperation suggests that cooperative equilibria can occur under some conditions, but it fails to address some of the aspects of cooperation, such as the role of leaders, found in other cooperation literature. Despite shortcomings, however, game theories were among the only theories which appear to provide testable predictions.

COMPETING THEORIES OF COOPERATION

To answer the question of how interdisciplinary cooperation can be accomplished, two theories appear relevant because they make opposing predictions that should be testable. These are the Principal Agent theory and the Theory of Cooperation.

Principal Agent Theory

In the Principal Agent theory, the focus is on the utilization of compensation rules with which one player, the Principal, seeks to motivate another player (or other players), the Agent(s), to choose activities in a way advantageous to the Principal (MacDonald, 1984; Moe, 1984; Shavell, 1979). In team production, it is assumed that interdependence between players leads to results that would be unobtainable if each player contributed separate outputs. Therefore, the problem addressed by the Principal Agent models is that the individual output of each player is difficult to observe, so the individual contributions to the organization (or team effort) are difficult to monitor (Moe, 1984; Alchian and Demsetz, 1972). In the absence of mechanisms for monitoring each individual's behavior, the team's surplus must be divided through some rule that does not depend upon knowing each person's productive impact — such as "equal sharing." As a result, "shirking" or "free-riding" by individual members of the team is a problem, as it is for most "collective action" problems (Olson, 1965). A potential "solution" to this problem is the appointment of an outsider or team member to be a full-time monitor who has marketable title to the team's rewards and acts as the central contracting agent with all its members (Alchian and Demsetz, 1972). This Principal can make decisions related to allocating the team's surplus in a Pareto optimal manner.

Theory of Cooperation

The other theory relevant to interdisciplinary cooperation is the Theory of Cooperation described by Axelrod (1981, 1984). This theory is quite different from the Principal Agent theory because, rather than being induced, cooperation can evolve if players believe the future is important enough. Axelrod has shown that in sequences of encounters between two players, cooperative (nice) strategies (where a player cooperates if the other player cooperates) will evolve into cooperation under two conditions: (1) the probability (w) for the players to meet again is sufficiently high, and (2) the nice strategy is provokable (punishing defection by mutual defection) but forgiving (returning to cooperation when the opponent does).

Essentially, the Theory of Cooperation is based on an extension of the example of the problem described previously in the *Logic of Collective Action* by Olson (1965) in which "free-riders" can reduce the benefits gained by a community. The variation of the "free-rider" situation upon which the Theory of Cooperation is based is called a Prisoner's Dilemma (Hardin, 1971). In the game theory terminology used by Axelrod (1984), the Prisoner's Dilemma is described by the matrix and equations shown in Table 1. In the terms used in Table 1, the Prisoner's Dilemma is defined as $T > R > P > S$ and $R > (S + T)/2$.

Table 1. Prisoner's Dilemma^a

	Cooperate	Defect
Cooperate	R,R	S,T
Defect	T,S	P,P

^a Where R = reward for mutual cooperation; T = temptation to defect; S = sucker's payoff; P = punishment for mutual defection.

In this game, two individuals can either cooperate or defect. No matter what the other one does, defection yields a higher payoff than cooperation. Therefore, in a game with a known number of moves it pays to defect, because mutual defection will occur on the first move of any series of plays in which the number of interactions is of known length (Axelrod, 1981; Luce and Raiffa, 1957). The dilemma occurs because mutual defection (which is individually rational) leads to a lower payoff over the long-term than mutual cooperation. However, if an iterated Prisoner's Dilemma takes place in which the relative importance of the future, w , is high for both players, then a cooperative equilibrium can occur.

According to Axelrod (1981), the discount parameter (w) can be given either of two interpretations:

The standard economic interpretation is that later consumption is not valued as much as earlier consumption. An alternative interpretation is that future moves may not actually occur, since the interaction between a pair of players has only a certain probability of continuing for another move. In either interpretation, or a combination of the two, w is strictly between zero and one. The smaller w is, the less important later moves are relative to earlier ones.

For the purposes of this study, an important theorem in the Theory of Cooperation is that Tit for Tat, a strategy in which a player cooperates when the other player cooperates and defects when the other player defects, is collectively stable if and only if w is at least as great as the larger of $(T - R)/(T - P)$ and $(T - R)/(R - S)$. Furthermore, any nice strategy, which may call for the first move to be a cooperative one, may be collectively stable only when w is sufficiently large. The proof of these theories is described in detail in Axelrod (1984: 206-211).

The implication of this theorem is that if w is high enough, players are more likely to cooperate. This argument is supported by Taylor (1976), who showed that for cooperation to be part of an equilibrium in an N -person Prisoner's Dilemma when some players always defect, it is necessary that either "the shadow of the future" (i.e., w) or the number of cooperators must be large so that there is a high frequency of cooperative interactions.

There is another important new implication of this theorem related to the impact of payoff on levels of cooperation that has not been previously examined. According to Axelrod (1981, 1984), when the strategy Tit for Tat is practiced, a collectively stable equilibrium is established if and only if the discount parameter (w) is *greater than or equal to* $(T - P/R - S)$ and $(T - R/R - S)$. This condition means that if all four payoffs are multiplied by a factor n , the level of w that results in a collectively stable cooperative equilibrium should be unaffected. That is, the *magnitude* of the payoffs, and therefore the total payoff, should have *no* effect on the level of cooperation, because $(nT - nP/nR - nS) = (T - P/R - S)$. This result predicts that while the relative payoffs are important, the total amount of payoff is not important with respect to the emergence of cooperation. This is particularly true when w is either much greater (a cooperative equilibrium is established) or much less (a noncooperative equilibrium is established) than $(T - P/R - S)$ and $(T - R/R - S)$. This prediction directly contradicts the assumption in the Principal Agent theory that increases in utility will also increase cooperation in a team and that the goal of each team member is to maximize his or her own utility at the expense of others. The prediction that total payoff will not affect cooperation is also somewhat counterintuitive.

Superficially, one can argue that the Theory of Cooperation is only a subset of the Principal Agent theory if the net benefits over time are quantified in an iterated game. This issue was examined in an earlier study not reported here (Frank, 1991). It was found in a laboratory study that high payoffs (when frequency of interaction was high) actually decreased the level of cooperation while a high frequency of interactions (and low payoffs) increased the level of

cooperation. This result supported the applicability of the Theory of Cooperation to teamwork, but it also appeared that there was a significant interaction between payoff and frequency of interaction that could not be explored in the experimental design being used. There are other indications, however, that the two theories are significantly different. These differences include the observations that Principal Agent theoretical approaches are principally useful in single-period, competitive games, whereas the Theory of Cooperation is applicable to iterative, cooperative games. Most Principal Agent strategies are complex, requiring maximizing behaviors and considerable monitoring, while Theory of Cooperation strategies are extremely simple, requiring high expectations of future benefits and observations of response to interactions rather than exhaustive calculations of outcomes and efforts of particular players. More specifically, however, it is the effect of payoff on cooperation that differentiates the two theories.

METHODS

An exploratory field study was conducted with 24 actual cases of multidisciplinary research teams. The purpose was to test the hypotheses that increases in total payoff lead to increases in cooperation (Principal Agent Theory) and that increases in the frequency or importance of future interactions lead to increased cooperation. The definition of cooperation in this field study used several measures, and even several meanings. For example, researchers may be outwardly cooperative with a manager and yet tacitly noncooperative with each other. The methodological approach of this field study was to develop a questionnaire that could be quantitatively answered by managers very familiar with the projects being monitored. The questionnaire included questions related to measures of variables important in the Principal Agent and Theory of Cooperation theories. These important variables included cooperation, payoffs, importance of future interactions, and frequency of interactions. Measures of these variables were then grouped by means of factor analysis. Path analysis (a form of regression analysis) was then used to test the validity of models based on the Theory of Cooperation and Principal Agent theory.

SUBJECTS

The subjects of this exploratory field study were working scientists involved in interdisciplinary research projects. Some of them were university professors, engineers in industrial research firms, or scientists in government laboratories. These cases consisted of individual projects with budgets between \$50,000 and \$500,000+ per Principal Investigator. Projects were involved in the production or conversion of biomass to methane, microbial corrosion, or environmental technology development. Each case study focuses on a particular set of interactions between Principal Investigators (PIs) from the same project over extended periods of time (two to six years). In these cases, PI's were from different institutions or departments. All of these problems required multidisciplinary cooperation by scientists and engineers from different institutions or departments.

The projects used in this study were developed and managed by myself and/or a comanager over the past 10 years. We have intimate knowledge of the project details, decisions, and individuals involved. In most cases, final decisions regarding program direction, funding, and personnel were made by myself, my comanager, or by colleagues in organizations with whom we collaborated.

I would like to emphasize that this exploratory field study is on "cooperation" and not research effectiveness. In fact, some of the least "cooperative" researchers were the most effective. Despite lack of cooperation, some principal investigators (PI's) have persisted in the program because of factors such as unique capabilities or expertise, continued successes despite lack of collaborations with others, and even "politics" with cofunders in which compromises were made to accommodate organizational needs of funding agencies. In other cases, individuals who have been the least "cooperative" in some respects have been extremely supportive in others. For example, PI's may be extremely cooperative with the project manager but noncooperative with other PI's.

There may also be reasons for lack of cooperation which can be extremely difficult to overcome in some instances by any external mediators. These can include mutually exclusive competition for the same resources, personal animosities, lack of professional respect for another PI, or more than sufficient funding from other sources. Therefore, we were not being judgmental regarding performance in these evaluations. In most cases, PI's were selected and retained in the projects because they were among the best available. The question addressed in this study is what actions were associated with higher or lower levels of cooperation.

DESIGN

A questionnaire was developed that explored different measures of several dependent and independent variables. The 27 questions attempted to measure key variables that influence cooperation, according to the Principal Agent theory and the Theory of Cooperation. These variables included cooperation, payoff, importance of future interactions, and frequency of interactions between the PI's and/or the manager. The questionnaire was designed to be answered by project managers familiar with the programs and investigators. It was decided not to question PI's in this study. I have found that PI's usually assert they are being cooperative even when their actions result in actual defection from the program through the pursuit of unrelated or poorly related goals. Usually other PI's or factors outside their control are cited as reason for their defections, and they often give examples where they did cooperate. In contrast, project managers are familiar with the overall objectives and the purposes of specific actions, they know how the activities of the various investigators compare, and they receive information from a multitude of sources.

In this field study, two project managers who were intimately familiar with the individuals and the decision making process (myself and a colleague) independently filled out the questionnaire. This procedure both is a major strength and weakness of this exploratory study. The

strength is that, as managers for these projects, we were in a unique position to objectively judge the performance of the investigators in the pursuit of the *program* goals as well as their interactions with each other. This is because, as managers, we received information from many sources, including other investigators, confidential peer reviews and expert panels, the subjects of this study, other managers and colleagues, and could observe, over a number of years, the results of the work and personal relationships that resulted. In addition, as managers of the projects, we were intimately aware of all of the implicit and explicit decisions regarding politics, funding, and program goals. This involvement allows the manager to have unparalleled insight into the performance of the investigators and their interactions. Unfortunately, this personal involvement is also a major drawback because subjective evaluations could result and because individual investigators often attempt to affect decisions involving themselves or others by developing personal relationships with the manager or by selectively using information and relationships to pursue personal goals. While I tried to design the questionnaire to be objective and easily answerable, it is possible that bias could have been introduced. In order to test that possibility, I asked a colleague who was not familiar with the purposes of this study, but who was intimately familiar with the projects and investigators being evaluated, to independently answer the questionnaire for the same cases. Thus, two managers evaluated the cases used. While only two evaluators were used, there were no other individuals who could have answered the questionnaire, including the subjects of the study. My colleague was able to evaluate 18 of the 24 cases. The other six cases occurred prior to his involvement. Based on these 18 cases, there was a 56% agreement between the two managers (e.g., answers to the questions were identical in the 18 cases which both investigated). Furthermore, 97.5% of the scores differed by one interval or less (on a three-point, four-point, or seven-point scale, depending on the particular questions). For example, the differences appeared to be due to value judgments regarding whether a researcher seldom (= 1) or sometimes (= 2) used program funds effectively, rather than to a disagreement about the trends. Separate factor analyses of the responses of each manager resulted in the same organization of measures into factors (five independent variables and two dependent variables). In order to resolve

the minor discrepancies between the two managers, the results were averaged in all analyses, which actually appeared to improve the data quality. Clearly, studies conducted in the future using this approach would benefit from eliciting responses from a wider variety of sources, but for exploratory purposes, I believe these results are valid and reproducible. One reason for using this methodology was that it was considered more important to obtain more cases that could be evaluated against each other by fewer managers than to have more managers evaluating fewer cases. In this way, a sufficient sample size could be examined for statistically significant trends.

THE QUESTIONNAIRE

Case studies were examined in the context of the following variables: cooperation between research groups, cooperation with the project manager and research group, payoff to the investigator, the importance of the next interaction, the frequency of interaction with the project manager, and frequency of interaction with other PI's on the program.

Cooperation between research groups:

- C1) Co-author papers.
- C2) Support other project leaders and team members with project manager.
- C3) Transfer findings and materials to other project teams in a timely and helpful manner.
- C4) Collaborate with other project leaders on joint projects requiring other funding sources.
- C5) Seek out other research teams when needed rather than using resources to build capabilities in-house.

Cooperation with the project manager and research group:

- CM1) Fully inform manager of capabilities and activities useful to the program.
- CM2) Expedite contract and keep manager fully informed.

- CM3) Design and carry out a research program that is in the best interests of the project manager's goals even if they are different from one's own goals and objectives.
- CM4) Respond to requests for travel, presentations, and reports in order to support the project manager's efforts to keep the program productive and well supported externally and by his organization.
- CM5) Use program funds cost-effectively to benefit program even at expense of own laboratory.

These measures were ranked on a three-point scale in which 1 = seldom, 2 = sometimes, and 3 = usually.

Payoff to the Investigator:

To determine the relative degree of payoff, four aspects of payoff were examined: the dollar amount the PI receives; the "expected" payoff, or the amount he expected to receive; "slack," or the amount of funds he receives which can be used more or less at his discretion; and the timing the payoffs are received. This last parameter (timing) was determined by examining the three other types of payoffs at both initial levels and midpoint levels (midpoint refers to the project in the prime of the program before decline takes place). Note that a program is made up of many projects and that individual projects can decline even as a program continues to flourish. The goal here was to consider the fate of the project independent of the entire program.

- P1) Initial funding level is [] expected by PI.
- P2) Funding at mid-project is [] expected by PI.
- P3) Initial funding level is [] the job requires for basic tasks (slack).
- P4) Mid-point funding level is [] the job requires for basic tasks (slack).

P5) Initial funding range of project is [].

P6) Mid-point funding range of project is [].

These measures were ranked on a three-point scale in which 1 = lower than expected, 2 = about the same as expected, 3 = greater than expected. For P5 and P6, a seven-point scale of actual funding ranges was used.

The importance of the next interaction (w):

W1) PI is at [] stage of professional career.

W2) Manager is at [] stage of professional career.

W3) Overall program is likely to be [] in length.

W4) Project is likely to be [] in length.

W5) Funding from this source is [] critical to the PI.

W6) Performance in this project is [] important in developing opportunities in other projects.

These measures were ranked on a three-point scale: for W1 and W2, 1 = early (0 to 10 years), 2 = middle (10 to 25 years), and 3 = late (25+ years); for W3 and W4, 1 = short term (0 to 2 years), 2 = mid-term (3 to 5 years), and 3 = long-term (5+ years); and for W5 and W6, 1 = not critical, 2 = somewhat critical, and 3 = very critical.

Frequency of interaction with the project manager:

FI1) How often does the manager talk to the PI on the phone on this project?

FI2) How often does the manager meet face to face with the PI on this project?

FI3) How often does the manager request presentations on this program by the PI?

Frequency of interaction with other PI's on the program:

PI1) How often does the PI talk to other PI's on the phone?

PI2) How often does the PI meet with other PI's?

These measures were ranked on a four-point scale: 1 = 1 to 4 times/year, 2 = 5 to 12 times/year, 3 = 13 to 50 times/year, and 4 = 50+ times/year.

FIELD STUDY FINDINGS

Factor Analyses of Measures of Cooperation

To examine the factor structure underlying the questionnaire items, factor analyses were performed. Factor analysis is a statistical technique used to identify a relatively small number of factors that can be used to represent relationships among sets of many interrelated variables (Norusis, 1988). Factor analysis can be used to construct indices (even out of ordinal data), since it produces nonparametric correlation matrices that can be used for other types of analysis (e.g., multiple regression) that are normally used for interval or continuous variables (Nie, Bent, and Hull, 1970). In this study, measures of the dependent variable, cooperation, were examined using principal component analysis.

The results of the Principal Component analysis for the measures of cooperation are shown in Table 2. Results of the Principal Component analysis appeared to be excellent, based on several diagnostic tests. For example, the Kaiser-Meyer-Olkin measure of sampling adequacy, which is an index for comparing the magnitudes of the partial correlation coefficients, was equal to 0.802 which is considered "meritorious" based on Kaiser (1974). Another measure of sampling adequacy (MSA) is shown on the diagonals of the Anti-Image Correlation Matrix. The MSA's for

C1, C2, C3, C4, C5, CM1, CM2, CM3, CM4, and CM5 are .626, .726, .875, .819, .875, .726, .878, .827, .663, and .840, respectively. These and other measures indicated that there is adequate data to develop a good factor structure. The percent of variance explained by the two factors was 74.4%. An examination of the communalities, the proportion of variance explained by the common factors, indicates that these two factors accounted for 60% or greater of the variance of the measures.

Table 2 Factor Matrix After Varimax Rotation (Cooperation)

Measure of Cooperation	Factor 1 (Ct)	Factor 2 (Cm)
C5	.885	.163
CM5	.882	.189
C4	.823	.161
CM3	.807	.513
C2	.780	.123
C3	.694	.660
CM2	.342	.848
CM4	.073	.782
C1	.095	.766
CM1	.533	.568

The factor analysis results reduced the ten measures of cooperation to two factors. (Factor 1 (called Ct) corresponded to measures C2, C3, C4, C5, CM3, and CM5. An obvious interpretation of this factor is that it describes team building behavior such as supporting other PI's with the project manager (C2), transfer findings and materials in a timely manner to collaborators (C3), collaborate with other PI's to obtain other funding (C4), build teams with outside groups for the benefit of the overall program rather than build capabilities in-house (C5), carry out the program goals even if detrimental to own short-term interests (CM3), and use program funds

cost-effectively even if at expense of own laboratory (CM5). In other words, it corresponds to "altruistic" behavior in which subjects carried out activities which were not necessarily in their short-term interest and which were needed for successful team functioning.

Factor 2 (Cm) corresponded to measures C 1, CM1, CM2, and CM4. An interpretation of this factor is that it corresponds to compliance to the requests of the program manager, such as keeping the program manager fully informed of important findings, contacts, and other occurrences (CM1), helping the manager expedite contractual matters (CM2), and responding in a timely manner to direct requests of the manager (CM4). It appears that coauthoring papers (C1) is in this category as well. An interpretation would be that paper authorship is a result of individual short-term interest rather than result of team building.

The results of the factor analysis suggest that the "cooperation" described in the literature may be a composite of compliance (cooperation resulting from coercion) and teamwork (cooperation resulting from giving up short-term gains for longer-term gains). A major question to be explored is whether these types of "cooperation" are influenced differently by the same independent variables, and whether a Principal Agent or Theory of Cooperation model best describes these effects.

Factor Analyses of the Measures for the Independent Variables

A principal component analysis of all of the independent variables was performed in order to determine whether the measures for payoff, importance of the future, and frequency of interactions grouped in a logical manner. The results are shown in Table 3. In this analysis, the measure W1 (the stage of career of the PI) was dropped because the MSA was low (.265). Removing W1 from the analyses improved the Kaiser-Meyer-Olkin measure of sampling adequacy from 0.639 which is considered "mediocre" to 0.728 which is "middling" based on Kaiser (1974).

It should be noted that five factors were specified because the Eigenvalue for the fifth factor was close to 1.00 (0.926). The five factors accounted for 87% of the variance.

Table 3 Rotated Factor Analysis of Measures of Independent Variables

Measures of Independent Variables	Factor 1 (FREQ)	Factor 2 (PAY1)	Factor 3 (FUT1)	Factor 4 (PAY2)	Factor 5 (FUT2)
FI1	.897	.052	.080	.228	.186
PI1	.879	-.020	.208	.170	.110
PI2	.836	.306	.240	.043	.053
FI2	.826	.057	-.064	.290	.257
FI3	.577	.399	.076	.521	.210
P3	-.003	.946	.206	.074	-.124
P1	.085	.884	.204	.131	-.158
P5	.476	.726	.139	.377	-.168
W3	.005	.149	.916	.168	-.070
W4	.231	.204	.857	.262	.131
W2	-.336	-.446	-.703	.217	.176
P2	.340	.079	.150	.850	-.045
P6	.527	.447	.113	.622	-.211
P4	.176	.559	.337	.583	.133
W5	.272	-.106	.198	.130	.866
W6	.178	-.240	-.317	-.197	.765

In combination, the two principal component analyses resulted in the identification of seven factors, including the two dependent variables and five independent variables, which appear to describe the twenty-seven measures listed in the Questionnaire. These seven factors are summarized Table 4 in terms of which items are related to particular factors and how these factors are interpreted.

Table 4 Summary of Factors Derived from Principal Component Analyses

Factor	Items to Which Related	Interpretation
Ct	C2, C3, C4, C5, CM3, CM5	Cooperation that leads to team building
Cm	C1, CM1, CM2, CM4	Compliance with the manager's requests
PAY1	P1, P3, P5	Initial payoffs as related to actual funding, slack, and funding relative to expectations.
PAY2	P2, P4, P6	Later payoffs as related to actual funding, slack, and funding relative to expectations.
FUT1	W2, W3, W4	Length of the interactions (e.g., length of the program/project).
FUT2	W5, W6 Note: W1 was dropped in factor analysis	Importance of current activities to future career.
FREQ	FI1, FI2, FI3, PI1, PI2	Frequency of interactions.

Regression (Path) Analyses

Regression analyses were used to determine which models best described how the independent variables are related to the dependent variables. A type of regression analysis called path analysis was used to describe the Principal Agent theory and Theory of Cooperation. The limited quality of data used in this exploratory field study makes the use of this approach somewhat

risky if the goal is to quantify the direct and indirect effects of the independent variables on the dependent variables as pointed out by Hays (1973). This approach is, however, useful for comparative tests of the Principal Agent and Theory of Cooperation models as possible explanations for compliance and teamwork. That is, the causal models describing these theories can be readily constructed using the variables extracted from this field study, and they can be compared using this analytical approach as long as interpretations are not too stringent (i.e., given the quality of the available data).

CONSTRUCTING THE MODELS

Principal Agent Model

In the Principal Agent theory, it would be expected that compliance or teamwork would be directly affected by the degree of monitoring (e.g., frequency of interaction) and the payoff (e.g., reward or punishment for effort or outcome). If later payoffs are high (PAY2), it would be expected that cooperation would increase, if monitoring is also at a high level. In contrast, if the initial payoff (PAY1) is high, in the absence of monitoring for outcome or effort (since the payoff is made prior to initiation of the effort), the level of cooperation might be expected to be low. This might be equivalent to providing funds to a researcher as a grant in which the award is made on the basis of the reputation of the researcher and in which few or no demands are made regarding the outputs. This would be in contrast to a contract, in which the outputs would be specifically described. Another relationship that would be expected in this model would be that the later payoff (PAY2) might be positively correlated with initial payoffs (PAY1) and the length of the program or project (FUT1). That is, high initial payoffs (PAY1) could lead to high subsequent payoffs (PAY2) (since contract dollars seldom decline relative to initial startup costs until the project is being phased out or redirected). It would also be expected that projects of greater length (FUT1) would often have higher later payoffs (PAY2). Reasons for this include the probability that an

applications-oriented multidisciplinary project will require hardware development and hence have higher costs associated with the latter phases of the project. Another probable relationship is that the frequency of interaction (FREQ) would be related to initial (PAY1) and later (PAY2) payoffs since the more funding a project involves the more likely the manager is to pay attention and try to maximize the surplus. In this field study, the manager did not receive a residual of the profits, but any money saved could be used by the manager for other purposes and for his own benefit (e.g., expanding existing projects, starting new projects, or creating slack and hence flexibility in the program). This model is diagrammed in Figure 1 for both dependent variables (Ct and Cm).

Theory of Cooperation Model

In contrast to the Principal Agent theory, the Theory of Cooperation predicts that the importance of the future (w) is the direct cause of cooperation. This is a difficult parameter to measure directly, but the variable FUT2 is a close approximation because it contains measures of how critical the current interactions are relative to future opportunities. It is possible that the length of the project/program (FUT1) could have an indirect positive effect because increasing the expectation that interactions will continue might increase the perception that the future is important. It is also possible, however, that expectations of long interactions could decrease the importance of the future by providing the investigator with the assumption that funding is assured. In the Theory of Cooperation, it is not necessarily the length of the interaction that is important. Rather, cooperation depends on maintaining uncertainty about how long that interaction will last. Therefore, projects of long duration could either increase or decrease the amount of cooperation, depending on the degree of uncertainty about future funding. For the sake of the model formulation, however, it will be assumed that the length of the project (FUT1) has an indirect effect on cooperation by affecting the importance of future interactions (FUT2). A more distinct difference between the Principal Agent and the Theory of Cooperation models is that in the latter, the frequency of interactions (FREQ) has an indirect effect on the level of cooperation. In the

Figure 1. Principal Agent Models.

Theory of Cooperation model, FREQ is positively related to the importance of the future (FUT2), while in the Principal Agent model, FREQ is equated with the degree of monitoring. Therefore, while the posited impact of FREQ is the same for both theories, the reason for the effects and the direct and indirect effects are distinctly different. The Theory of Cooperation model is shown in Figure 2.

RESULTS

The purpose of this analysis was to determine which of the two causal models described in the previous section was consistent with the data.

Principal Agent Model

The Principal Agent model, described in Figure 1, postulates a causal ordering such that the dependent variable is directly affected by the initial payoff (PAY1), the later payoffs (PAY2), and the frequency of interactions (which is interpreted in this model as the level of monitoring or FREQ). The first step in the analysis was to determine whether these postulated direct effects were significant. The second step was to determine whether the presumed effect of later payoffs (PAY2) on level of monitoring (FREQ) was significant. The third step was to determine whether the presumed effects of program length (FUT1) and initial payoff (PAY1) on later payoffs (PAY2) were also significant. The final step was to test the restriction, implied by the model, that program length (FUT1) does not have a direct effect on the dependent variables (Cm or Ct). This cannot be accomplished by regressing FUT1 on the dependent variable, because the F test normally used to determine whether a regression is significant can be affected by multicollinearity, and because it has a built-in bias against direct effects from remote causes and in favor of their indirect effects (Kim and Kohout, 1975: 393). As a result, it is possible to conclude erroneously that there is both a nonzero indirect effect and a null direct path. Instead, a large-sample chi-square test is used,

Figure 2. Theory of Cooperation Models.

which tests the hypothesis that FUT1 has no direct effects on the dependent variable (e.g., compliance, Cm). In other words, a significant chi square ($p < .05$) means that the "restricted" model should be rejected because a direct effect cannot be ruled out. Finally, the restrictions implied by the model, namely, that PAY1 and FUT1 do not have direct effects on FREQ, were tested using the same type of large-sample chi-square test. In the following section, these steps will be described in more detail as we test the potential applicability of the Principal Agent model to the dependent variable, compliance (Cm), as described in Figure 1.

Compliance (Cm)

To determine whether the Principal Agent model shown in Figure 1 for compliance (Cm) is consistent with the data obtained in the field study, the dependent variable, compliance (Cm), was regressed onto the independent variables pertaining to initial payoff (PAY1), later payoffs (PAY2), and frequency of monitoring (FREQ). The results indicate that these independent variables do significantly affect the dependent variable as described by the regression equation $Cm = 0.633 \text{ FREQ} - 0.393 \text{ PAY1} + 0.456 \text{ PAY2}$ (where the values shown are the standardized regression coefficients). In addition, the adjusted coefficient of determination, $\text{adj. } R^2$, was 0.690, which indicates that almost 70% of the variation in compliance (Cm) can be explained by the linear regression on the three independent variables. The next step was to examine the regression of the level of monitoring (FREQ) onto later payoffs (PAY2). It was found that PAY2 accounted for about 36% of the variation in FREQ, as described by the equation $\text{FREQ} = 0.622 \text{ PAY2}$. Again, a restricted model is assumed, such that the upstream independent variables PAY1 and FUT1 are postulated to have only an indirect effect on FREQ. This assumption can be tested using the large-sample chi-square test as suggested by Kim and Kohout (1970: 394) and Pedhauzer (1982: 618), as shown in Equation (1). That is, the large-sample chi-square coefficient is:

$$L = N \log_e \left[\frac{(1 - R^2) / d_{ri}}{(1 - R_{fi}^{2ri}) / d_{fi}} \right] \quad \text{Equation 1}$$

where R_{fi} is the multiple correlation between a dependent variable i and all the predictors with higher causal order in the general model, R_{ri} is the multiple correlation between the same dependent variable and the restricted set of predictors with direct paths leading to the dependent variable, d_{ri} and d_{fi} are degrees of freedom (df) associated with the residual sum of squares of each regression equation, and N is the sample size (Kim and Kohout, 1970: 394). In other words, in this example, R^2_{fi} would be the coefficient of determination for FREQ regressed onto PAY2, PAY1, and FREQ, while R^2_{ri} is the coefficient of determination for FREQ regressed only onto PAY2. In this case, $N = 24$ because there are 24 cases in the field study. The test for the restricted model and the calculations in Equation (1) are shown in Table 5. The results indicate that the alternative model (that there are significant direct effects of PAY1 and FUT1 on FREQ) can be rejected because $p > 0.10$. This can therefore be taken as support for the restricted model (that only PAY2 has a direct effect on FREQ).

Table 5. Test of Restricted Principal Agent Model (Effects of Pay 1, Pay 2, and FUT1 on FREQ)^a

Dependent Variable	Independent Variable(s)	N	Adj. R^2	D_f	$1 - R^2/d_f$
FREQ	PAY2	24	.359	22	.0290
	PAY2 PAY1 FUT1	24	.304	20	.0348

^a In this example, $L = 24(\ln 0.0290/0.0348) = -4.29$, where the degrees of freedom (df) = 2, $p > .10$. Therefore, the restricted model assumptions (that PAY1 and FUT1 have only indirect effects on FREQ) are not rejected.

The next step was to test the model assumption that PAY2 is directly affected by PAY1 and FUT1. The adjusted coefficient of determination is equal to 0.471, suggesting that the two independent variables account for about 47% of the variance in PAY2. The regression equation is $PAY2 = 0.367 FUT1 + 0.532 PAY1$. The final step in this analysis was to test the assumption that FUT1 does not have a direct effect on the dependent variable, compliance (Cm). This step was carried out by using a large-sample chi-square test similar to the one previously described. In this case, Cm is regressed onto PAY1, PAY2, and FREQ (from which R^2_{ri} is derived) and onto PAY1, PAY2, FREQ, and FUT1 (from which R^2_{fi} is derived). The results, listed in Table 6, show that $L = -2.36$ for $df = 1$ and $p > .05$. Therefore, the restricted model (e.g., that FUT1 has only indirect effects on Cm) is not rejected.

Table 6. Test of Restricted Principal Agent Model (Effects of FUT1 on Cm)^a

Dependent Variable	Independent Variable(s)	N	Adj. R^2	Df	1 - R^2/df
Cm	PAY1 PAY2 FREQ	24	0.690	20	0.0155
Cm	PAY1 PAY2 FREQ FUT1	24	0.675	19	0.0171

^a In this example, $L = 24(\ln 0.0155/0.0171) = -2.36$, where $df = 1$, $p > .10$. Therefore, the restricted model assumption that FUT1 has only indirect effects on Cm is not rejected.

It is therefore concluded that the Principal Agent model postulated in Figure 3 is an acceptable model for describing the effects of the independent variables on compliance (Cm). However, these results do *not* mean that this is necessarily the "true" model (Pedhauzer, 1982: 618). This model is summarized in Figure 3.

Figure 3. Principal Agent Model (compliance, Cm).

Teamwork (Ct)

To determine whether the Principal Agent model shown in Figure 1 for teamwork (Ct) is consistent with the data obtained in the field study, the independent variables pertaining to initial payoff (PAY1), later payoffs (PAY2), and frequency of monitoring (FREQ) were regressed on the dependent variable, teamwork (Ct). The results indicate that the regression analysis does *not* support the Principal Agent model as an acceptable explanation for the effects of the independent variables on the dependent variable, teamwork (Ct). The results indicate that later payoffs (PAY2) do not have a significant effect on changes in teamwork (Ct). Since the Principal Agent theory, as well as the model proposed as a description of that theory, postulates that the dependent variable is affected by changes in later payoff (PAY2), the Principal Agent model is rejected as a model for explaining teamwork (Cm). Note that all of the other relationships are the same since the effects are independent of the dependent cooperation variable. In addition, a test of the restricted model is shown in Table 7 which shows that the restricted model is not rejected. However, since PAY2 is shown not to cause significant changes in teamwork (Ct), the model is rejected as an acceptable explanation. The results are summarized in Figure 4.

Figure 4. Principal Agent Model (teamwork, Ct).

Table 7. Test of Restricted Principal Agent Model (Effects of PAY 1, PAY 2, and FREQ on Ct)^a

Dependent Variable	Independent Variable(s)	N	Adj. R ²	Df	1 - R ² /df
Ct	PAY1	24	0.451	20	0.0275
	PAY2				
	FREQ				
Ct	PAY1	24	0.451	19	0.0289
	PAY2				
	FREQ				
	FUT1				

^a In this example, $L = 24(\ln 0.0275/0.0289) = -1.19$, where $df = 1$, $p > .20$. Therefore, the restricted model assumption that FUT1 has only indirect effects on Ct is not rejected.

Theory of Cooperation Model

A similar procedure was undertaken to test the applicability of the Theory of Cooperation models shown in Figure 2 to the dependent variables related to compliance (Cm) and teamwork (Ct). This model is also a restricted model, since two of the three independent variables are postulated to have only an indirect effect on the dependent variable. In the Theory of Cooperation model, the only variable assumed to have a direct effect on the dependent variables (Cm or Ct) is the importance of the current project to future opportunities (FUT2). The variable FUT1, the expected length of the interaction, could also potentially have an effect on the importance of the future, but may not because there may be at least two different opposing effects of this variable. One potential effect is that if an investigator expects a long-term project, he could have heightened expectations that the future is important. Alternatively, his expectations that the future is assured

could mean that the value of the current work is less important, and therefore the importance of the future is decreased. Since the effects of FUT1 on the importance of the future (FUT2) were likely to be ambiguous, FUT1 was not included in the model. To test the possibility that one of the possible opposing effects of FUT1 was more important than the other, a regression analysis was performed for the effects of frequency of interactions (FREQ), initial payoffs (PAY1), and the expected length of interaction (FUT1) on the importance of the current interaction on the future (FUT2). The results indicated that FUT1 does not significantly affect FUT2 (based on the t-test; $p > 0.785$). Therefore, the Theory of Cooperation model shown in Figure 2 does not include FUT1 as an independent variable, but the effects of FUT1 may need to be studied in the future under conditions where they can be segregated.

Compliance (Cm)

To determine whether the Theory of Cooperation model diagrammed in Figure 2 is a reasonable description of how the independent variables, including initial payoff (PAY1), frequency of interactions (FREQ), and importance of future interactions (FUT2), affect compliance (Cm), the appropriate regressions were compared. The first step was to regress the dependent variable, compliance (Cm) onto the independent variable FUT2. The adjusted coefficient of determination, $\text{adj. } R^2$, was 0.078 (compared to 0.690 in the Principal Agent model). This low value suggests that FUT2 accounts for less than 8% of the variance of Cm. Another indication that this model is a poor description of the effects of the independent variables on the dependent variable is that the effect of FUT2 on Cm was insignificant ($p < .0997$, where $p < .05$ is the cutoff).

Another step in testing the model was to test the restrictions assumed in the model that neither PAY1 nor FREQ have direct effects on Cm. These assumptions were examined by using the large-sample chi-square test described in earlier sections. In this test, Cm was regressed onto

FUT2 and separately onto FUT2, PAY1, and FREQ, to determine whether the restricted model shown in Figure 2 is valid. The results, shown in Table 8 indicate that the chi-square value is 17.16, with $df = 2$ and $p < .01$. Using a $p < .05$ cutoff, the restricted model representing the Theory of Cooperation model is rejected when compliance (Cm) is the dependent variable. That is, the significant chi-square value suggests that FREQ and/or PAY1 may have direct effects. These results are summarized in Figure 5.

Table 8. Test of Restricted Theory of Cooperation Model (Effects of PAY 1 and FREQ on Cm)^a

Dependent Variable	Independent Variable(s)	N	Adj. R ²	Df	1 - R ² /df
Cm	FUT2	24	0.078	22	0.0419
Cm	PAY1 FREQ FUT2	24	0.590	20	0.0205

^a In this example, $L = 24(\ln 0.0419/0.0205) = 17.16$, where $df = 2$, $p < .01$. Therefore, the restricted model assumptions that PAY1 and FREQ have only indirect effects on Cm are rejected.

Teamwork (Ct)

Using the same approach as that described in the previous section, the Theory of Cooperation model was tested for its applicability to the dependent variable teamwork (Ct). In this case, when Ct was regressed on FUT2, it was highly significant ($p < .0045$). The adjusted coefficient of determination, adj. R², was 0.281, indicating that about 28% of the variance observed in Ct could be explained by changes in FUT2. The regression equation describing the direct effect of FUT2 on Ct was derived as $Ct = 0.559 \text{ FUT2}$.

Figure 5. Theory of Cooperation Model (compliance, Cm).

The next step required to test the Theory of Cooperation model was to determine whether the restricted model (i.e., that PAY1 and FREQ do not necessarily have direct effects on Ct) was valid. This was accomplished by using the large-sample chi-square test in which Ct was regressed onto FUT2 and separately onto FUT2, PAY1, and FREQ. As shown in Table 9, $L = 5.50$, where $df = 2$, and $p > .05$. Therefore, it is concluded that the restricted model is not rejected.

Table 9. Test of Restricted Theory of Cooperation Model (Direct Effects of FUT2 on Ct)^a

Dependent Variable	Independent Variable(s)	N	Adj. R ²	Df	1 - R ² /df
Ct	FUT2	24	0.281	22	0.0327
Ct	FUT2 PAY1 FREQ	24	0.480	20	0.0260

^a In this example, $L = 24(\ln 0.0327/0.0260) = 5.50$, where $df = 2$, $p > .05$. Therefore, the restricted model assumptions that FREQ and PAY1 have only indirect effects on Ct are not rejected.

Finally, FUT2 was regressed onto PAY1 and FREQ. The adjusted coefficient of determination, adj. R², was 0.250 and the regression equation was $FUT2 = 0.500 FREQ - 0.473 PAY1$. It can therefore be concluded that the Theory of Cooperation model is an adequate model when teamwork (Ct) is the dependent variable. The results are summarized in Figure 6.

Conclusions of Field Study

The results of the exploratory field study described here are summarized in Table 10.

Figure 6. Theory of Cooperation Model (teamwork, Ct).

Table 10. Summary of Field Study Results

Model	Dependent Variable	Adj. R ²	Restricted Model	Independent Variables	Model Status
Principal Agent	Compliance (Cm)	0.690	Not Rejected	All Signif.	Accept
	Teamwork (Ct)	0.464	Not Rejected	Later payoffs not signif.	Reject
Theory of Cooperation	Compliance (Cm)	0.083	Rejected	Not signif.	Reject
	Teamwork (Ct)	0.281	Not Rejected	All signif.	Accept

^a Significant if $p < .05$.

DISCUSSION

This exploratory study has developed several new findings that merit additional investigation:

- *Compliance* and *teamwork* are two distinctly different types of cooperation.
- Both types of cooperation can occur in the same projects but not necessarily. For example, team members may be compliant to a manager but not cooperative as a team. Likewise, they may work well as a team but not be very compliant to direction by a manager.
- *Compliance* is best explained with a model based on the *Principal Agent Theory* and is directly influenced by payoff and level of monitoring.

- *Teamwork* is best explained by the *Theory of Cooperation* and is directly influenced by the importance of future interactions (w) and indirectly influenced by variables that affect w .

The results of the exploratory study described in this paper provide possible explanations for some of the confusion in the previous work on cooperation. Previous researchers reported on the difficulty of developing theories about how to implement cooperation and even about identifying the key variables that must be considered in a theory of implementation. The reasons for this difficulty lie in the definitions of cooperation and the preoccupation of different schools of thought with either compliance (e.g., organization theory, classical economics) or teamwork (e.g., psychology, education, political science). As a result, organization theory suffered from an inability to explain why "entrepreneurs" are needed to develop innovation and creativity, while the psychology literature hypothesized the need for extrarational impulses among individuals in organizations relating to moral, normative, and altruistic concerns that are difficult to quantify and predict. Miller's (1972) book on *Managerial Dilemmas* is an excellent description of these dichotomies, discusses the limitations of principal agent theory, and then suggests that "those organizations whose managers can inspire members to transcend short-term self-interest will always have a competitive advantage."

An alternative explanation to this hypothesis, based on the findings in this exploratory study, is that the two types of cooperation (e.g., compliance and teamwork) can simultaneously co-exist in an organization and that strategies to increase each of them may not necessarily be compatible. For example, if the objective is to build a bridge, the mechanics of building the bridge are well known, there are no major unsolved problems, and the main requirement is to get the numerous contractors to do their pieces of the work in a timely manner with adequate quality control. In this example, close monitoring and adequate rewards and penalties to ensure compliance with the blueprints and scheduling are critical. In this case, the Principal Agent-Style

Manager might be most appropriate. In another example, if innovative and creative solutions to a problem are required (e.g., development of a new product), forming a multidisciplinary team may be necessary. Close scrutiny (e.g., monitoring) and constant management direction are likely to be detrimental to maintaining the team's integrity. After all, if the answer was well known and capable of being solved through detailed management direction, why form the team in the first place? In this case, the Theory of Cooperation-Style Manager might be most applicable. In general, an organization may need both types of managers co-existing in different parts of its organization. For example, functions like administration (e.g., accounting, procurement, contracts, support functions, assembly-line productions, etc.) may do best with a Principle-Agent-Style Management while other functions like company management, project management, policy development and implementation, marketing, trouble shooting, or R&D require a Team Work-Style Management.

There are numerous potential implications to organizational theory. The main issue is how to design and run organizations which incorporate both elements simultaneously. Future studies on organizations should examine how organizational practices affect the parameters examined in this exploratory study in terms of both compliance and teamwork. For example, how can a manager create the perception that the future is important if he is not empowered to make critical decisions about funding and programs? How can an organization make interdepartmental cooperation a goal throughout the organizational structure? What are the tradeoffs and benefits? What is the proper mix of compliance and teamwork? If one understands the basic components of cooperation (e.g., compliance or teamwork) then one should be in a much better position to design organizational structures that fulfill these objectives and correct management problems where they occur. In order to improve our understanding, it is clearly important to test theoretical predictive models in "real-world" situations and then modify the models as needed. The principles appear simple; their application will be a major challenge.

REFERENCES

Abrams, R.

1980 Foundations of political analysis. New York, Columbia University Press.

Alchian, A.A. and Demsetz, H.

1972 Production, information costs and economic organization. *American Economic Review* 62: 777-795.

Axelrod, R.

1981 The emergence of cooperation among egoists. *American Political Science Review* 75: 306-318.

1984 The evolution of cooperation. New York, Basic Books, Inc.

Battelle-Columbus Laboratories

1973 Interactions of science and technology in the innovative process: Some case studies. Final Report, National Science Foundation, Contract NSF-C 667, Columbus, Ohio.

Dawes, R.M., Orbell, J.M., Simmons, R.T., and Van de Kragt, A.J.C.

1986 Organizing groups for collective action. *American Political Science Review* 80: 1171-1185.

Frank, J.R.

1991 The application of cooperation theory to team management. Dissertation, University of Illinois, University Microfilms International, No. 9213101.

Friant, Ray J.

1991 Leadership training for long-term results. *Management Review* July: 50-53.

Hardin, R.

1982 *Collective action*. Baltimore, Johns Hopkins University Press for Resources of the Future.

Hays, W.L.

1973 *Statistics for the social sciences*, 2nd edition. New York, Holt, Rinehart and Winston, Inc.

Kidder, T.

1981 *The soul of a new machine*. New York, Avon Books.

Kingdon, J.W.

1984 *Agendas, alternatives, and public policies*. Boston, Little, Brown and Company.

Kornhauser, W.

1963 *Scientists in industry: Conflict and accommodation*. Berkeley, University of California Press.

Knott, J.H. and Miller, G.

1986 *Dilemmas in teams and firms: Experiments on simple hierarchies*. Presented at 1986 Annual Meeting of the American Political Science Association, Chicago.

Kreps, D.M.

1984 *Corporate culture and economic theory*. Stanford University, Typescript.

Magerison, C.

1978 Managing the R&D Group. Management Decision 16(1): 52-63.

Michaels, A.S.

1989 Dealing with academic parochialism in a changing technological environment. Chemical Engineering Progress, February: 16-20.

Miller, G.J.

1992 Managerial dilemmas: The political economy of hierarchy. Cambridge University Press.

Moe, T.M.

1984 The new economics of organizations. American Journal of Political Science 28: 739-777.

Montjoy, R.S. and O'Tool, L.J.

1984 Interorganizational policy implementation - a theoretical perspective Public Administrative Review, Volume 44(6):491-503.

Mueller, D.C.

1982 Public Choice. New York, Cambridge University Press.

Nie, N., Bent, D.H., and Hull, C.H.

1970 SPSS: Statistical Package for the Social Sciences. New York, McGraw-Hill Book Company.

Norusis, M.J.

1988 SPSS/PC + advanced statistics V2.0. Chicago, SPSS, Inc.

Olson, M.

1965 The logic of collective action. Cambridge, Massachusetts, Harvard University Press.

Shavell, S.

1979 Risk sharing and incentives in the principal and agent relationship. *Bell Journal of Economics* 10: 55-73.

Smith, C.G.

1971 Scientific performance and the composition of research teams. *Administrative Science Quarterly* 16(4): 486-495.

Taylor, M.

1976 Anarchy and cooperation. New York, Wiley Press.

Tjosvold, D.

1984 Cooperation theory and organizations. *Human Relations* 37(9): 743-767.