THE ROLE OF ACCOUNTING IN ACHIEVING COOPERATIVE EFFORTS WITHIN A FIRM

Dissertation

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To Mom and Dad and the rest of my Family

Without your support, this would not have been possible.
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CHAPTER I

INTRODUCTION

1.1 OVERVIEW

This dissertation examines the influence of accounting information on employees' cooperative efforts within a firm. Accounting procedures are examined using experimental economic methods to determine their roles in encouraging cooperation in team production. The better one player can infer the other player's behavior (the less noise), the more likely cooperation will result (Kreps [1990]). This dissertation uses experimental economic techniques and manipulation of accounting mechanisms to test this issue.

In an experiment, players are expected to choose their strategies as if they form beliefs about the other player's effort choice. A player cannot perfectly infer the opponent's choice through the observables in these experiments. This is one form of imperfect information or noise in the environment. However, observables, and a known probability structure, allow the players to revise their beliefs about the opponent's choice. Manipulation of observables through the cells in the experiment introduces a second level of noise in the environment and creates different opportunities for belief revisions in an
experimental setting. When interacting over time, a manager can respond to his\(^1\) perceptions of the other player's choice. It is the potential ability of asset measurement, pre-play communication, and correlation to allow more accurate revision of beliefs that makes cooperation more likely.

Asset measurement is defined as the ability of the accounting system to measure the individual inputs of each division manager into the joint production process. Pre-play communication is also introduced as a budgeting or forecasting technique and is expected to allow for coordination of strategies to better achieve cooperation. The pre-play communication is costless, non-binding, and payoff irrelevant when utilized in the experiment.\(^2\) Correlation between environments is introduced to determine whether the accounting mechanisms of asset measurement and pre-play communication are still beneficial in a friendlier environment. Higher correlation between divisions allows one manager's realization of input asset quality to provide information about the probable effort choice of the other manager based on the observable attribute of asset quality or joint output. Repeated interaction is used because it can reduce lost production due to non-cooperation (transaction costs) and, thereby, increase social welfare.

By using accounting to manipulate information, this dissertation considers how accounting helps to sustain the cooperative solution necessitated by interdependencies in the production process. Interdependencies in production are captured through a

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\(^1\) For ease of exposition, the term he is used to refer to managers and participants of either gender.

\(^2\) The term pre-play communication is also referred to as cheap talk in other literature.
synergistic joint production function and are enhanced with the introduction of
correlation between the environments of two managers. Repeated play and a stochastic
ending to the experiment are used, allowing managers to develop strategies besides that
of non-cooperation which is the theoretical equilibrium for an isolated encounter with
perfect information.

Results of the experiment show that coordination of activities increases over time
indicating the importance of repeated play. Effort levels are higher in later rounds of the
experiment when aggregated across all cells. When asset quality information (asset
measurement) is available to managers, high effort is selected more often. The result of
the cells with pre-play communication appear contrary to the predicted direction. Effort
choices are lower when pre-play communication is available. As a matter of fact, this
mechanism appears to increase noise in the environment. However, later rounds of these
cells show increased selection of high effort. This may be as a result of participants
learning to utilize pre-play communication thereby reducing noise in the environment.
Although results with correlation alone are not significantly different than when no
correlation is available, correlation, combined with asset measurement, results in more
frequent selection of high effort. These results provide evidence about the need for
accounting, even in correlated (friendly) environments, in order for managers to
coordinate activities.

1.2 Research Problem and Related Literature

Several studies have considered that the structural setting within a firm may be
thought of as a prisoner's dilemma in some characteristics. However, one significant
limitation of most empirical and theoretical work researching the prisoner's dilemma is
the assumption that each player has perfect information about his partner's action even
with repeated play (Axelrod [1980], Shubik [1970], Aumann [1981], Camerer and
Weigelt [1988], Andreoni and Miller [1993], Cooper, DeJong, Forsythe, and Ross
[1989], Murnighan and Roth [1983]). This allows flawless inferences with respect to the
other player's moves.

However, when the prisoner's dilemma setting is used to describe large and
complex firms, it must consider that division managers are often physically removed
from each other, and are consequently unable to observe each other's behavior directly.
Moreover, the payoffs they obtain may reflect exogenous shocks from the economy, the
behavior of customers, suppliers, the workforce, etc. that may not be perfectly known by
their colleagues. As a result of these disturbances that are external to the organization's
dyadic relationship, decision makers may occasionally draw incorrect inferences about
their peers' actions. Several studies have looked at the impact of uncertainty or 'noise' as
it affects the prisoner's dilemma relationship both theoretically (Kreps, Milgrom, Roberts.
and Wilson [1982], Fudenberg and Maskin [1986], Fudenberg, Levine, and Maskin
[1994]) and experimentally (Bendor et al. [1991], Lehrer [1992], Forges [1988], Kahn
and Murnighan [1993]). The primary aim of this dissertation is to investigate the role of
accounting in mitigating noise or imperfect information and evaluating the effect of
accounting information, within a firm, on the cooperative effort choices of its employees.

A key issue addressed by this dissertation is the repeated play of a prisoner's
dilemma. Strategic rivalry in a long-term relationship may differ from that of a one-shot
game. Repeated play allows players to respond to each other's actions, enabling each player to consider the reactions of his opponent in making a decision. The fear of retaliation may thus lead to outcomes that otherwise would not occur. The "Folk Theorem" for repeated games addresses this issue by stating that any outcome that Pareto dominates the minimax point is called individually rational. This issue has been looked at both theoretically and experimentally with a variety of manipulations.

Kreps, Milgrom, Roberts, and Wilson [1982] illustrate a possible theoretical explanation for cooperation in experiments that find participants cooperating in a finitely repeated prisoner's dilemma. They analyze a reputation effect and demonstrate how a reputation effect due to informational asymmetries can generate cooperative behavior in finitely repeated versions of the prisoner's dilemma. In order to solve this problem, they utilize a "small amount" of the "right kind" of incomplete information. The uncertainty they speak of is in the mind of (at least) one player about the other player. This uncertainty may be manifested in the possibility that the other player may not play rationally but instead might play a Tit-for-Tat strategy. Therefore, cooperation is possibly an effective strategy.

Works by Kreps and Wilson [1982] and Milgrom and Roberts [1982] utilize a similar train of thought in proposing reasons why a finite number of repetitions might allow cooperation. Their explanations suppose that players are uncertain about the payoffs or possible actions of their opponents. Such "incomplete information" in the prisoner's dilemma precludes applying the backwards-induction argument that establishes that the players must confess each period. Players can credibly threaten to take
suboptimal actions if there is some (small) probability that the action is indeed optimal, because they have an interest in maintaining their reputation for possible "irrationality".

Fudenberg and Maskin [1986] (FM) analyzed the outcome of the Folk Theorem in repeated games with discounting or incomplete information. The incomplete information is not on the outcomes obtained by the players but on the player type. FM varies the kind of irrationality specified but still keeps the probability of irrationality arbitrarily small in tracing out the entire set of infinite-horizon equilibria. The actions taken by each player are completely observable. However, FM demonstrates that multiple equilibria, including cooperation, may result.

An important hypothesis of the standard Folk Theorem is that the players can observe one another's actions in each repetition, so that deviations from equilibrium strategies are detectable. Fudenberg, Levine, and Maskin [1994] considers games in which players observe only a public outcome that is a stochastic function of the actions played. However, for any profile of effort levels, the corresponding expected output has pairwise full rank for that pair. This implies that deviations from a specific pair of actions will give rise to distributions over public outcomes that depend on the identity of the deviator. Therefore, symmetric outcomes do not allow for pairwise identifiability. The experiment in this paper utilizes symmetric outcomes. Therefore, the Folk Theorem result described by Fudenberg, Levine, and Maskin does not hold.

Experimental testing of repeated prisoner's dilemmas has been prevalent for a considerable length of time. One of the pinnacle experimental studies of repeated prisoner's dilemmas is that done by Axelrod [1980]. Using a computer simulation,
Axelrod matches various strategies as submitted by experts from economics, psychology and sociology in a finite period, repeated prisoner's dilemma. He finds that Tit-for-Tat is the most effective strategy. This is the simplest rule submitted: cooperate on the first move and then do whatever the other player did on the previous move. Punishment for each defection is only for one period. Axelrod finds that the more forgiving a strategy, the better the performance in the computer simulation.

Because of the theoretical implications of a finite number of periods, work has been done examining the impact of an unknown endpoint. Roth and Murnaghan [1978] show that a prisoner's dilemma with a given probability $p$ of continuation to at least the next round is analytically equivalent to an infinitely repeated game with $p$ as a discount factor. Murnaghan and Roth [1983] then conduct an experiment in which they manipulate the probability that an interaction will be repeated along with the payoffs obtainable by the players and the strategy of one's opponent. The 1983 paper extends the earlier work done in their 1978 paper that focuses on the values that the probability of the game terminating will take as a determinant of the presence of cooperative equilibria within a game.

The 1983 Murnaghan and Roth paper defines an equilibrium as one that results when both players follow strategies that give the opponent no incentive to adopt a different strategy. They conjecture that if a game is to be played many times, consideration of the cooperative choice may increase, since players can attempt to influence their opponent's future behavior. However, with a known end-point, the cooperative choice on the last trial has no possibility of influencing future play. When
there is a nonzero probability of continuing the game after any trial, however, consideration of end-game play is less critical and it becomes less critical as the probability of continuing play increases. They present data from a dozen different games that supports the basic prediction of their theory. Their findings demonstrate that as the probability of continued play increases, cooperation also increases. However, the prisoner's dilemma used in their experiment provides complete information with respect to the actions taken by the opponent on the previous round.

A paper by Bendor, Kramer, and Stout [1991] (BKS) examines cooperation in a noisy prisoner's dilemma. Noise is introduced in the environment by adding a small random variable, distributed normally, with a mean of zero and a standard deviation of eight. The noise term is independent across players and over periods. A player's payoff or benefit is a function of his opponent's cooperation minus a cost factor of cooperation plus a random error. To investigate which strategy performs best in a noisy prisoner's dilemma, the authors conduct a computer tournament in much the same fashion as Axelrod [1980]. The result indicates that strategies that are generous (i.e. cooperate more than their partners do) are the most effective.

Another experiment dealing with a noisy prisoner's dilemma is that done by Kahn and Murnighan [1993] (KM). KM provides an experimental investigation of work done by Kreps, Milgrom, Roberts, and Wilson [1982] by examining the type of prior expectations players have about their opponents' strategy and the presence of uncertainty about payoffs. In particular, KM looks at how these factors influence strategy choices and, in particular, whether they lead to cooperation. Uncertainty leads to decreased
cooperation when compared to players who are certain about payoffs. However, results show that players choose to cooperate much more than analytically predicted for all manipulations. Another observation is that end-game play, while evident, typically does not begin until the second to last trial.

An experiment using people for both sides of the experiment (rather than programming a computer to execute decisions) is performed by Andreoni and Miller [1993]. Their paper manipulates the pairings of individuals to see if cooperation varies depending on whether partners are strangers or if pairs have the opportunity to develop reputations. The endpoint of the game is common knowledge. While cooperation is observed for all groupings, Andreoni and Miller find evidence that partners help sustain cooperation.

Current accounting research that addresses some of these issues in a prisoner's dilemma is done by Wallin [1992]. In his research, Wallin investigates the demand for auditing in environments both with and without legal recourse. The mechanisms introduced to encourage managers and investors to achieve cooperative solutions include an audit function and legal liability. Wallin uses both incomplete information and an unknown time horizon in his study. He finds that both legal recourse and auditing serve to increase cooperation. This dissertation actually looks at a much simpler setting in an effort to examine the impact of accounting within a firm. Wallin examines the complexities of a market setting with multiple participants. Various strategies such as signalling are available in his study. On the other hand, this dissertation looks at the issue of accounting information and how it affects cooperation.
CHAPTER II

MODEL AND THEORY DEVELOPMENT

2.1 THEORY DESCRIPTION AND MODEL PARAMETERS

Firms use internal accounting systems for two primary purposes: to provide information for planning and decision making and to help motivate and monitor people within the organization (Zimmerman [1995]). This dissertation focuses on the use of accounting information as a motivational tool to elicit cooperation among employees. Employees working together to coordinate activities may provide an explanation as to the existence of the firm (Alchian and Demsetz [1972]). However, many organizations are plagued by an interesting irony. If employees work together, everyone will be better off. Yet, there are clear incentives for people not to act cooperatively: as in the theory of public goods, there may be a free rider problem.

A prisoner's dilemma is used because the model illustrates a situation where gains can be obtained from cooperation. A hierarchical structure and ability to contract are not definitive in describing the organizational structure of a firm. Therefore, the model and experiment are constructed within a firm in the absence of the ability to contract. This complicates the relationship between the two parties to the joint production function. It may also be thought of as a partnership or joint venture with each party having equal
power in the relationship. This model captures the essence of the residual problems of hierarchies that exist in organizations. There may be instances where it is difficult to make a commitment. There may be implicit and explicit costs that accrue to a residual claimant making it less desirable to be structured hierarchically.

The prisoner's dilemma problem may still exist in firms with hierarchical structures. While the model used to parameterize the experiment abstracts away from the details of the firm, it is still an interesting problem. Studying how the manipulations help alleviate the problem demonstrates the importance of accounting within the firm.

Unlike most previous studies involving prisoner's dilemmas (for example see Axelrod [1984]; Roth and Murnighan [1978]; Murnighan and Roth [1983]; Andreoni and Miller [1993]), this paper considers an environment in which players' actions map into observed outcomes through a stochastic process (i.e., there is "noise" or "imperfect information"). Informational asymmetries exist because neither manager can observe the other's effort. Both managers are better off if each chooses high effort. Yet, the dominant strategy is for both managers to shirk in a single encounter. Each manager is better off not cooperating if the other manager cooperates. However, when managers interact repeatedly, cooperation may be possible. By using accounting information to coordinate activities in a repeated setting, the managers may be better able to achieve the cooperative solution.

The underlying model for the prisoner's dilemma consists of a single firm operated by two risk-neutral managers over many periods with an unknown horizon. Each manager's compensation is based on a joint output that is publicly observable.
Because effort is not observable (or is too costly to observe), contracts on effort are not possible. This eliminates the first-best solution.

The joint production process utilizes inputs from the two division managers to generate earnings. The inputs of the two division managers may be thought of as independent assets with two possible quality levels. At the beginning of each period, each manager selects between two effort levels: low effort ($e_l$) and high effort ($e_h$) (where $i \in \{1,2\}$). Low effort is costless; high effort has a cost of $\tau$. By selecting low effort, the manager receives a high quality (low quality) asset with probability $\pi_0 (1-\pi_0)$. The asset quality is denoted $q^i (i \in \{1,2\}, j \in \{l,h\}$, where $q^h > q^l$. By selecting high effort, the probability that the high (low) quality asset is generated is $\pi_1 (1-\pi_1)$. High effort gives a higher probability of a high quality asset ($\pi_1 > \pi_0$). The outputs are combined to produce joint earnings according to the joint production function, defined below. The expected earnings of the firm, shared equally by both managers, depends on the joint output obtained from the combined inputs of both managers.

The joint production process takes the asset obtained from each manager and produces earnings $\Theta$. Earnings are a function of the two assets received and a synergistic parameter obtained due to the combining of resources. This synergy factor ($\lambda$) is a constant such that $1 < \lambda < 2$. The factor is designed to obtain benefits from interacting within a firm. It may be thought of as providing synergy due to repeated interaction.

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3 The synergy factor ($\lambda$) is selected so that benefits are obtained from joint production ($\lambda > 1$) but the dominant, single period strategy is to select low effort ($\lambda < 2$). This results in the prisoner's dilemma to be studied.
rather than transacting outside the firm (Alchian and Demsetz [1972]). Therefore, total firm earnings in any period will be $\Theta = \lambda (q_f^j + q_f^h) \ (j \in \{1,h\})$. The expected value of earnings generated from the joint production function if both managers select high effort is: $E[\Theta|e_h', e_h^2] = 2\lambda [q_h\pi_1 + (q_h + q_l)\pi_1(1-\pi_1) + q_l(1-\pi_1)^2]$. The increase in expected earnings from both managers selecting $e_h$ over $e_l$ is $2\lambda (q_h - q_l)(\pi_1 - \pi_0) > 0$. The benefits obtained from selecting high effort must exceed the cost of effort (i.e., $2\lambda (q_h - q_l)(\pi_1 - \pi_0) > 2\tau$) in order for high effort to be preferred. Continuing analysis assumes there is increased economic efficiency from both managers selecting high effort.

The analysis of the prisoner's dilemma using noncooperative game theory in a single period is straightforward. The "low effort" row or column for each participant strictly dominates the cooperative ("high effort") row or column, respectively. Therefore, the solution, by application of one round of strict dominance, is the cell where both players exert low effort. This also is the unique Nash equilibrium. However, from the perspective of all participants, this outcome is inferior to the cooperative cell where both players exert high effort. An example of a prisoner's dilemma is presented in Figure 1.
In a Prisoner's dilemma, the following conditions hold: $a < b < c < d$; $2b < (a + d) < 2c$.

**FIGURE 1**
*Prisoner's Dilemma*

Repeating games, however, can lead to cooperation. The idea that strategic rivalry in a long-term relationship may differ from that of a one-shot game is a familiar one (Fudenberg and Maskin [1986]). Repeated interaction allows players to respond to each other's actions, so each must consider his opponent's reaction in making subsequent choices. Therefore, cooperative behavior can result as a Nash equilibrium in an infinitely repeated game or one with an unknown horizon. For example, a player's strategy could be one of cooperate until first defection, then defect forever. Neither player has any incentive to defect from the cooperative cell. Each player's strategy is a best response to the other, and, together, they produce the cooperative outcome.

The time horizon is important in determining a game-theoretic solution with no noise in the basic environment. Cooperation can be sustained only over multiple periods. In the one period case, an equilibrium cannot exist where a manager selects $e$, as he always has a motive to "defect" and save $\tau$. The only Nash equilibrium has both
managers selecting \( e_r \). The same is true when there are multiple periods but a known endpoint. Players can use backward induction and the resulting equilibrium has both managers selecting \( e_r \). However, when the parties operate in an environment with an unknown horizon and complete information, solutions in a non-zero sum game ruled out in a single-period world (or one with a known endpoint) become possible Nash equilibria (Roth and Murnighan [1978]). In particular, this prisoner's dilemma supergame can have a Pareto-efficient, cooperative Nash equilibrium.

Recent studies find that cooperation does not always result when there is no noise in the environment and the horizon is unknown (Roth and Murnighan [1978], Murnighan and Roth [1983]). When there is noise in the environment, but the horizon is known, cooperation is not frequently observed (Dopuch et al. [1989], Kachelmeier [1991]). In an environment with both noise and an unknown horizon, Wallin [1992] finds little evidence of cooperation. However, other experimental studies have found evidence of cooperation in repeated prisoner's dilemmas (Axelrod [1980]; Bendor et al [1991]; Murnighan and Roth [1983]; Andreoni and Miller [1993]). Therefore, it is interesting to study mechanisms that will possibly foster cooperation and to look at what strategies players will choose in equilibrium.

2.2 **Asset Measurement**

The first accounting manipulation addressed in this dissertation is that of asset measurement. Asset measurement is defined as the ability of the accounting system to measure the individual inputs of each division into the joint production process. Asset measurement is introduced as a refinement to the imperfect information available from
the commonly observed output obtained from the joint production function. It is designed to reduce noise in the environment. Players with asset measurement observe the asset value generated from their effort choice \((q, j \in \{1, h\})\) based on the appropriate probabilities of \(\pi_i\) and \(1-\pi_i\) \((i \in \{0, 1\}\) for 0 = low effort; 1 = high effort). This observation may be thought of as increasing the quality of the accounting system through different cells in the experiment. Asset measurement may illustrate different types or varying qualities of accounting systems. For example, one system could compile standard reports with respect to financial accounting purposes and only provide information on the joint output. Activity based costing, which has been described as more accurate, may employ a less noisy system.

2.3 Pre-play Communication

The second accounting mechanism studied in this experiment is that of budgeting or forecasting. Pre-play communication is introduced to simulate a budgeting or forecasting technique and thus allow for coordination of strategies between players. A player is given the opportunity to communicate an intended effort choice to his partner. Pre-play communication is considered a coordination mechanism since its use depends on the strategies chosen by each player. However, it may be instrumental in sustaining cooperation in a prisoner's dilemma as it serves to reduce the level of imperfect information or amount of noise in the environment. Pre-play communication is costless, nonbinding, and payoff irrelevant. Therefore, when this mechanism is available, players can make disclosures (or assertions) with respect to their intended effort choices.
However, since this disclosure may or may not be truthful, its effectiveness will depend on how it is utilized by the players.

2.4 Correlation

Correlation is the third manipulation introduced in the experiment. It may be that in a friendly environment, such as a firm, accounting mechanisms are more (or less) beneficial due to environmental factors that already reduce imperfect information. In fact, correlation may be an explicit choice made by companies in order to exploit benefits obtained from integration. It may also be thought of as a natural phenomenon that is exploited by companies to obtain information about similar divisions. Either way, benefits from correlation can be exploited by companies. Accounting mechanisms, in conjunction with correlation may therefore be redundant or may enhance cooperation.

The correlation coefficient for a dichotomous variable can be calculated using a contingency table of joint probabilities. This is because correlation is defined as a measure of association between attributes. Higher correlation levels provide better information with respect to unobservable information (effort choices) based on observable attributes. The observable attributes for this experiment are low output and high output. Therefore, these attributes provide information on the unobservable variable of interest, effort choice. The contingency tables are illustrated in Appendix A for all possible effort choices and for both correlated and uncorrelated environments.

The correlation coefficients chosen in this experiment are such that the joint probability of both receiving a certain asset type are different depending on the effort level selected by each manager. The correlation coefficients available when both
managers select the same effort level, given the experimental parameters, can range from -1/3 to 1. However, the range available when participants select different effort levels is from -1/3 to 1/3. A correlation coefficient of 2/3 is used when both managers select the same effort level. The correlation coefficient is 1/3 when one manager selects low and the other manager selects high effort. A higher correlation level, when both players make the same effort choice, is used to increase the benefits obtained from correlation. This reduces the noise for any combination of effort choices without eliminating all noisy observations. Positive correlations are used because they relate to correlated divisions within a firm. See Appendix A for numerical details using the experimental parameters.

2.5 Strategy Choices and Noise Reduction

The mechanisms of asset measurement, pre-play communication, and correlation serve to manipulate the levels of imperfect information in the experiment. Analytic models in prisoner's dilemma settings often result in multiple equilibria (Fudenberg and Maskin [1986]; Fudenberg, Levine, and Maskin [1989]). Little theory has been developed to determine which equilibrium will be sustained. The factors that affect play are not known with certainty. Therefore, game theorists find it necessary to make assumptions about the strategies used by players in such a game in order to derive an equilibrium (Ordeshook [1986]). Strategies commonly used to solve unknown-horizon, nonzero-sum, noncooperative games include (1) always defect, (2) cooperate until first defection, and (3) tit for tat (Ordeshook [1986]). These strategies typically are used to describe situations where players' defections can immediately be detected.
A trigger strategy is used when there are noisy observables. The threat of punishment (defection) must be real and severe enough to deter the other party from cheating (defecting) but not so severe that it mitigates the gains made from repeated cooperation (Kreps [1990]). Punishment must be employed often enough to ensure repeated cooperation. The optimal trigger strategy will weigh the costs and benefits from this strategy and punish when observations merit punishment. This implies that punishment is used when the other party did not, in fact, defect. Both parties know the other's strategy in equilibrium and punish even though the other was cooperating. This implies that punishment is used when the other party did not, in fact, defect.

The level of noise in the environment affects this strategy. In the game theoretic solution there is no drawing of inference as to the other player's behavior because information is perfect. However, when there is imperfect information in the environment, participants are less likely to achieve a cooperative equilibrium. This is because punishment phases are triggered more easily and less cooperation results. As noise increases, it is more difficult to disentangle an opponent's actions from the results of nature. Accounting mechanisms available to reduce noise in the environment are the focus of this dissertation. The mechanisms proposed for use in this dissertation are therefore hypothesized to reduce noise in the environment and therefore provide more accurate information about players' actions.

It can be shown mathematically that two of the mechanisms employed in this dissertation allow more accurate belief revision about the other player's choice. If each player is thought of as Bayesian, he holds a belief at the beginning of each period over the
likelihood that the other player will choose high or low effort that can be stated in terms of the probability of choosing high effort. The observables, along with the common knowledge probability structure, allow the player to form a posterior belief that the other player did, in fact, choose high effort. The posterior probability will depend on the prior probability for the other player's effort choice and the individual and common observables.

For a set of observables or probability structures to reduce noise, it should allow the player to more accurately revise his beliefs toward a belief of the actual effort choice made by the other manager on average. More accurate belief revision implies that the posterior belief over effort choice is closer to one. In this dissertation, one can interpret the problem in terms of Bayesian inference, and use Bayes' theorem to calculate a measure for a set of observables and a given probability structure. The result is reduced noise in the environment resulting in more accurate posterior beliefs about the other player's effort choice.

Expectations are used to calculate posterior beliefs in order to facilitate comparisons between cells. Various realizations are available that are "state" dependent. The posteriors cannot be compared on a state-by-state basis. When the other player makes an effort selection, noise in the environment allows for observables that are inconsistent with that effort choice. This implies that sometimes a player may believe the other player chose low effort when in fact he did not (and vice versa). With additional information (asset measurement or correlation), observables are available that will make the posterior belief even more inconsistent with the other player's actual effort choice.
However, across the possible realizations of observables (in expectation), the addition of an observable that reduces noise in the environment yields a more accurate posterior. The additional observables allow players to more accurately revise their beliefs toward that of the actual effort choice made by their partner, on average.

When comparing cells, the expected posterior for asset measurement alone (or correlation alone) is greater than when asset measurement (or correlation) are not available for all prior probabilities. Also, the expected posterior probability that the other manager selects a certain effort level (given he actually chooses that effort level) when asset measurement is available and environments are correlated is greater than the expected posterior probability with asset measurement alone.

The benchmark case is one of zero correlation without asset measurement. The output obtained from the joint production function is the only ex post observable. The independent probability structure is also known ex ante. In comparison, when asset qualities are also ex post observable, this new set of observables is less noisy in the sense of the definition given earlier for any prior probabilities. Second, when environments are correlated, the new probability structure leads to more accurate belief revision. Third, when both environments are correlated and asset measurement is available, there is less noise when compared with either asset measurement or correlation alone. An example, using prior probabilities of 60:40 (high effort:low effort) results in the expected posteriors shown in Figure 2 (calculations shown in Appendix B):
| Actual Effort Choice                  | E[pr(High|High)] | E[pr(Low|Low)] |
|--------------------------------------|------------------|---------------|
| No Asset Measurement/No Correlation  | 0.659            | 0.488         |
| Asset Measurement/No Correlation     | 0.697            | 0.545         |
| No Asset Measurement/Correlation     | 0.687            | 0.530         |
| Asset Measurement & Correlation      | 0.725            | 0.587         |

Greater noise reduction results in higher numbers. Therefore, No Asset Measurement/No Correlation < Asset Measurement/No Correlation and No Asset Measurement/Correlation < Asset Measurement & Correlation.

**Figure 2**

*Example of Noise Reduction*

In the experiment, there are two cells where environments are correlated, but the marginal probabilities, given a certain effort choice, are unchanged. However, the probability of receiving a high type asset, having selected a certain effort level, and given that the other manager also received a high type asset, is manipulated.

Correlation is not the only manipulation of probabilities that will reduce noise. It is also possible to manipulate the marginal probability of obtaining a certain asset type. Changing the marginal probabilities is a manipulation of $\pi_i$ (where $i \in \{0,1\}$) in the model. For example, with independent divisions, changing the marginal probabilities of $\pi_i (1 - \pi_i)$ from 75% (25%) to 80% (20%) changes the joint probability of both managers receiving high quality assets (if both select high effort) from 56.25% to 64% ($\pi_i^2$).

However, this type of manipulation is not as intuitively appealing as environmental correlation. It also says nothing about the typical organizational design where
information may be correlated across divisions. Therefore, environmental correlation is manipulated in this experiment to reduce noise. (See Tables 1 and 2 for joint and marginal probabilities with correlation as used in the experiment.)

**Table 1**

<table>
<thead>
<tr>
<th>Asset Quality Received</th>
<th>Marginal Probabilities</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Low</td>
</tr>
<tr>
<td>Low</td>
<td>0.1875</td>
</tr>
<tr>
<td>High</td>
<td>0.0625</td>
</tr>
</tbody>
</table>

*Marginal Probabilities*

<table>
<thead>
<tr>
<th></th>
<th>Low</th>
<th>High</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>0.25</td>
<td>0.75</td>
<td>1.00</td>
</tr>
</tbody>
</table>

(Correlation Coefficient = 2/3)

**Table 2**

<table>
<thead>
<tr>
<th>Asset Quality Received</th>
<th>Marginal Probabilities</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Low</td>
</tr>
<tr>
<td>Low</td>
<td>0.25</td>
</tr>
<tr>
<td>High</td>
<td>0.50</td>
</tr>
</tbody>
</table>

*Marginal Probabilities*

<table>
<thead>
<tr>
<th></th>
<th>Low</th>
<th>High</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>0.75</td>
<td>0.25</td>
<td>1.00</td>
</tr>
</tbody>
</table>

(Correlation Coefficient = 1/3)
While it can be mathematically shown that asset measurement and correlation allow more accurate belief revisions, the same technique does not directly correspond to the use of pre-play communication. Asset measurement and correlation provide additional information about which to make inferences about the other player's strategy choice. However, no Bayesian inferences can be drawn without prior knowledge of the intended use of the disclosure when pre-play communication is the manipulation. This communication, though, may be a form of accounting information that will reduce noise in the environment and encourage sustained cooperation between managers.

2.6 SUMMARY

These three manipulations may influence strategy choices by subjects in an experimental setting or by managers within a firm. Since periods of non-cooperation are often triggered by observations falling below some threshold level, accounting information may allow triggers to be employed more strategically. Therefore, it is possible that more cooperation will result. The detection of non-cooperation, rather than noise in the environment, will lead to less punishment when choosing a trigger point to be implemented for a trigger strategy. In order to operationalize testing of these three manipulation, experiments were designed as described in the following section.
3.1 Experimental Design

Various works influence the experimental design employed in this dissertation. The recent laboratory study of Andreoni and Miller [1993] (AM) examining cooperation in a finitely repeated prisoner's dilemma, finds evidence of cooperation. This is a complete information prisoner's dilemma and does not have stochastic probabilities for outcomes. Therefore, defection is immediately apparent. However, AM manipulates the repeated interaction of participants.

AM runs an experiment using the same pairings for 10 rounds and then changing partners for 20 different 10-period sessions. Another cell has individuals matched with different players each round. These players play 200 different iterations. Andreoni and Miller find that, while cooperation is evident in both cells, partners help sustain cooperation at a higher level. Because of the results of the Andreoni and Miller study, this experiment uses repeated interaction with two players (partners) in its experimental design. This is the setting typically observed within the firm and provides the best evidence with respect to cooperation available in this experiment.
A limitation of most empirical and theoretical work utilizing the prisoner's dilemma is the assumption that each player has perfect information about his partner's action even with repeated play (Axelrod [1980], Shubik [1970], Aumann [1981], Camerer and Weigelt [1988], Andréoni and Miller [1993], Cooper, DeJong, Forsythe, and Ross [1989], Murnighan and Roth [1983]). This allows flawless inferences with respect to the other player's moves.

However, when the prisoner's dilemma setting is used to describe large and complex firms, it must consider that division managers are often physically removed from each other, and are consequently unable to observe each other's behavior directly. Moreover, the payoffs they obtain may reflect exogenous shocks from the economy, the behavior of customers, suppliers, the workforce, etc. that may not be perfectly known by their colleagues. As a result of these disturbances that are external to the organization's dyadic relationship, decision makers may occasionally draw incorrect inferences about their peers' actions. Therefore, this experiment utilizes a stochastic nature of asset. This implies that while the manager in the setting for this dissertation is immediately aware of his own effort choice, each manager is never certain of the value of \( e \) for the other manager in any one period.\(^4\) By observing the stream of outputs over multiple periods, each manager can make inferences about the frequency with which \( e_h \) is selected.

Because each party cannot immediately determine when defection has taken place (i.e., a

\[\text{\footnotesize \(^4\) Because both asset types may obtain with either effort choice, any joint output combination } [\lambda(q_i + q_j); i \in \{l,h\}, j \in \{l,h\}] \text{ is available with any combination of effort choices.}\]
manager selected \( e_i \), this environment differs from the typical unknown-horizon prisoner's dilemma.

Most of the theoretical work dealing with a repeated prisoner's dilemma finds that the Folk theorem holds for infinitely repeated games or games with a certain discount factor. The Folk theorem allows the consideration of cooperation as a theoretical equilibrium. However, the findings of Roth and Murnighan [1978] demonstrate that a prisoner's dilemma with a given probability \( p \) of continuation to at least the next round is analytically equivalent to an infinitely repeated game with \( p \) as a discount factor. Therefore, a probabilistic ending to the experiment will be used since an infinitely repeated game is not operationally feasible. The probability of continuing the experiment was chosen such that it was equivalent to an infinitely repeated game with discounting.

Using the techniques of experimental economics, experiments were designed to have student subjects facing economic incentives consistent with those faced by managers in a firm. The environment was designed to create a microeconomy in the laboratory that captured the essential economic characteristics of the theory. Six experimental cells were tested in a partial 2X2X2 design that contrasted the presence/absence of observing the quality of input obtained (measurement) both with and without correlation, and the presence/absence of pre-play communication (Figure 3.)
3.2 Overview of the Experiment

The basic economy consists of two managers within a firm. The managers undertake a private, productive act at a private cost. This act is referred to as effort, although other interpretations are possible. A selection of high effort is associated with a greater likelihood of obtaining a high quality asset to be contributed to the joint production process. Cell manipulations include the observability of the result of an individual's effort choice (measurement of asset quality), correlation between asset qualities received given certain effort choices, and the ability to use cheap talk for pre-play communication (budgeting). The interactions of asset measurement and pre-play communication, as well as asset measurement and correlation, are also tested.
3.2.1 **Subject Motivation and Information**

Each experimental cell had an unknown time horizon of at least 25 days. On day 25, and each day thereafter, the experimenter rolled a pair of dice (in the presence of subjects). If the two dice matched (a "pair") the experiment ended. Otherwise, the experiment proceeded to the next period. Subjects were informed of a maximum time limit for each experimental session. They were asked to return to complete the experiment should it be necessary.

Subjects were recruited from undergraduate business classes. Twelve subjects were used for each cell. The average amount of cash earned by each subject was $17.76. The amount varied between subjects and cells due to the decisions made by each subject, the states of nature that obtained, and the number of days in each cell. A "best case" scenario (always cooperate) was set such that expected earnings were approximately $19 for each subject participating in the experiment at an expected length of 30 days.

The parameters selected for the experiment conformed to the model described previously. A high quality asset \( (q_h) \) generated an asset value of 50 points. A low quality asset \( (q_l) \) generated an asset value of 30 points. (See Table 3 for a summary of

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5 Thus, there was a one-sixth chance of the experiment ending any day after day 24. This essentially produced a discount factor of 16.67% \( [p = 1/6] \) for the subjects. The expected number of experimental days was 30 days per session.

6 The time allotment for each cell was sufficient to complete each session.

7 Cells C and D were run in two separate sessions due to an inadequate number of subjects recruited for the initial sessions.

8 Cell A ran for 33 days; Cell B ran for 25 days; Cell C ran for 32 days; Cell D ran for 27 days; Cell E ran for 31 days; Cell F ran for 28 days.
experimental parameters.) Each market day, each manager had two choices regarding "effort," implemented as "bins." When the "default" bin (corresponding to low effort) was selected, a low quality asset ($q_l$) obtained 75% of the time; a high quality asset ($q_h$) obtained 25% of the time. The "alternate" bin (high effort) returned a high quality asset ($q_h$) 75% of the time and a low quality asset ($q_l$) 25% of the time. The default bin could be selected without cost. The cost for the alternate bin was 10 points. If actual effort selection could be observed, the expected benefits from both managers selecting high effort versus both selecting low effort would be increased earnings of 30 points \([ (0.75 - 0.25) (150 - 90)]\).

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9 This operationalized the cost of effort. According to analytic theory (Baiman [1982]; Namazi [1985]), physical exertion is not required for an action to be considered effort.
<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
<th>Experimental Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$e_l$</td>
<td>Low effort</td>
<td>0</td>
</tr>
<tr>
<td>$e_h$</td>
<td>High effort</td>
<td>10</td>
</tr>
<tr>
<td>$q_l$</td>
<td>Low quality asset</td>
<td>30</td>
</tr>
<tr>
<td>$q_h$</td>
<td>High quality asset</td>
<td>50</td>
</tr>
<tr>
<td>$\pi_0$</td>
<td>Prob ($q_l</td>
<td>e_l$)</td>
</tr>
<tr>
<td>$1 - \pi_0$</td>
<td>Prob ($q_h</td>
<td>e_l$)</td>
</tr>
<tr>
<td>$\pi_1$</td>
<td>Prob ($q_l</td>
<td>e_h$)</td>
</tr>
<tr>
<td>$1 - \pi_1$</td>
<td>Prob ($q_h</td>
<td>e_h$)</td>
</tr>
<tr>
<td>$\lambda$</td>
<td>Growth factor</td>
<td>1.5</td>
</tr>
</tbody>
</table>

**3.3 Experimental Session**

Each experimental session consisted of the same sequence of events: instructions and training, market days, and the post-experimental phase.

**3.3.1 Instructions and Training**

Upon arrival at the computer lab, subjects were given written instructions. The instructions were also read aloud; instructions for all cells A through F are in appendices C through H respectively. Following the instructions, a training phase began that consisted of two "example" days in which the subjects were given the bin disclosure and selection information to enter where applicable. This was followed by four "training" days in which subjects made their own decisions with respect to disclosure and selection. The purpose of the example and training days was to familiarize the subjects with the
computer terminal and the experiment's structure. The example days were used to
demonstrate the possible outcomes that could obtain given the effort choice. The training
days allowed subjects to become familiar with the experiment structure when different
decisions were entered. Points earned in the training phase had no value.

3.3.2 **Market Days**

In the experiment, the following available actions and rules were common knowledge. Market days proceeded in the following sequence for those cells as noted:

1. *Cells C and D only*: Participants communicated an intended effort choice to their partners (simultaneous, two-way communication).
2. *Cells C and D only*: Participants received a report of intended effort choices sent and received.
3. Participants selected an effort choice. (Bin Selection)
4. *Cells B, D, and F only*: Participants received a report of the input generated by the effort choice made in step 3 ($q_h$ or $q_d$).
5. Reports were received with respect to the joint output (earnings) for the day.
6. Individual payments were calculated according to the 50:50 sharing rule.
7. Points were updated.

**Steps 1 and 2.** *(Cells C and D)* Each manager was asked to disclose an effort choice (bin selection) to his experimental partner. Each manager then received a report of the other manager's disclosure. There was no cost to this disclosure, and it was non-binding.

**Step 3.** Each manager made an effort selection. Selection from the DEFAULT bin was at no cost with a 25% chance of obtaining a high type asset. Selection from the ALTERNATE bin cost 10 points and returned a high type asset 75% of the time. For Cells C and D this effort choice was independent of the disclosure made in Step 1. For
Cells E and F, the incidence of asset type was generated based on the environmental correlation.

**Step 4. (Cells B, D, and F)** After making an effort selection, the manager observed the asset type obtained, as determined from the appropriate bin probabilities. The opportunity to observe the asset type an individual player received made detection of non-cooperation easier (although not perfect).

**Step 5.** All participants in all cells observed the joint output obtained from the two assets received (one from each manager). For Cells B, D, and F, this allowed participants to perfectly determine the asset quality received by the other manager. For Cells A, C, and E, participants could only infer the asset quality obtained by each manager.

**Step 6.** The joint sharing rule of equal allocation of the joint output was then used to calculate the new point balances for each participant.

**Step 7.** The point balances were updated to prepare for the next market day. Those participants that selected from the ALTERNATE bin had ten points subtracted from their point balance. The computer mechanism permitted the results of the previous 17 market days to remain displayed on the screen. For day 25 and each day after, the dice roll determined whether the experiment ended.

### 3.3.3 Post-Experimental Phase

At the end of the market days, the subjects' screens informed them that the experiment was complete and displayed their cash earnings. Subjects received 1¢ for each point in their ending point balances. Prior to payment, subjects filled in a
post-experimental questionnaire in an effort to elicit information with respect to strategy choices. Sessions lasted approximately one hour for each cell. Subjects received their payments in cash as they left the computer lab.
CHAPTER IV

RESEARCH HYPOTHESES

4.1 HYPOTHESIS DEVELOPMENT

In the experiment's environment, managers may affect the value of π (the probability that the asset will be of high quality) by the selection of an effort level (e). However, the joint output realized does not convey complete information about managerial effort. Therefore, a manager cannot differentiate between when the other manager is shirking and when the other manager is selecting high levels of effort but realizing a low quality asset. While the single period dominant strategy is for both managers to shirk, in a multi-period environment with an unknown horizon, each manager has information that may be used to infer previous effort choices by observing outcomes. An equilibrium where shirking is reduced or eliminated becomes possible in the experiment with an unknown horizon.

Several works, both theoretical and experimental, impacted the hypotheses developed in this dissertation. Kreps [1990] contends that the reduction of noise in a prisoner's dilemma leads to greater cooperation. Bendor et al. [1991] finds that increased cooperation in a noisy prisoner's dilemma is the most effective strategy in an experimental setting with repeated play. These two findings, together, contribute to one
of the questions of interest in this paper; that of mechanisms available to achieve greater cooperation.

4.2 **Outline of Hypotheses**

Repeated play allows players to respond to each other's actions. This enables each player to consider the reactions of his opponent in making decisions. By using prior information to infer the other manager's strategy, cooperation may be an evolving process that increases due to the repeated interaction used for each cell in the experiment. The first hypothesis therefore states that cooperative efforts will increase over time.

\[ H_1: \text{Participants choose to exert high effort more often in later rounds of the experiment.} \]

The second hypothesis addresses the usefulness of accounting information as a measurement function in reducing noise in a firm's environment. Asset measurement is operationalized by letting each participant observe his own \( q \). This allows each manager to perfectly determine the other manager's \( q \) by observing total earnings (\( \Theta \)). This, in turn, may allow the manager to better infer the other manager's effort choice in order to evaluate his appropriate strategy choice. Without asset measurement, a manager cannot always tell the value of \( q \) that he receives from his effort selection. He can only observe joint output. Therefore, in cells without asset measurement, when the joint output obtained is \( \lambda(q_i + q_j^*) \) (\( i \in \{1, h\}, j \in \{1, h\} \ i \neq j \)), it is impossible for the manager to determine his asset quality. The ability of asset measurement to encourage cooperation between managers is tested by comparing the data obtained from cells with asset measurement (Cells B, D, and F) to cells without asset measurement (Cells A, C, and E).
Stated in the alternative, the second hypothesis is:

\[ H_2: \text{Participants choose to exert high effort more often when input asset values can be measured.} \]

The third hypothesis deals with the importance of pre-play communication in developing cooperation between managers. Pre-play communication consists of a single occurrence of two-way communication repeated over multiple periods. This type of communication is similar to division managers submitting periodic budgets that are available within the company for planning purposes. While the opportunity to cooperate is available without this accounting function, its presence may enhance the ability to sustain cooperation over extended periods. This implies that effort levels will be greater in cells where pre-play communication is available (Cells C and D) than in cells without pre-play communication (Cells A and B). Therefore, the third hypothesis states:

\[ H_3: \text{Participants choose to exert high effort more often when pre-play communication is available.} \]

It is further hypothesized that the interaction of these two main effects may also create increased effort on the part of the participants. The fourth hypothesis states:

\[ H_4: \text{Participants choose to exert high effort more often when both input asset values can be measured and pre-play communication is available.} \]

The third technique employed to reduce noise in the environment is correlation between asset qualities given certain effort levels. The correlation between managers' environments in cells A, B, C, and D is zero. The individual asset realizations of each manager are independent, based on his own effort choice. However, correlation allows
for more accurate belief revision with respect to the other manager's effort choice. This leads to the fifth hypothesis:

\( H_5: \) Participants choose to exert high effort more often when environments are correlated.

There may also be an interaction effect. Noise is less for any prior probability that the other manager selected a certain effort level when both asset measurement and correlation are available than when correlation alone, or asset measurement alone are available. Therefore, the sixth hypothesis states:

\( H_6: \) Participants choose to exert high effort more often when environments are correlated and asset measurement is available.

Cell A is used as a baseline cell in order to aid in the evaluation of the manipulations necessary to test the hypotheses. Cell B incorporates the measurement function of accounting in order to test the hypothesis that participants will choose to exert high effort more often when input asset values can be measured. Cell C enables testing of the hypothesis that questions whether participants will choose to exert high effort more often when pre-play communication is available. Cell D is used to test the interaction of the two main effects and how they compare to the baseline cell. Cells E and F allow testing of correlation and the interaction between correlation and asset measurement.

4.3 Summary

The hypotheses examined in this dissertation enable examination of issues of cooperation and repeated play within a firm. While the experiment is necessarily limited in its realism, it is concrete enough to provide information with respect to these issues. These issues have (to the author's knowledge) not been addressed specifically in previous
studies and yet the concept of teamwork within a firm has been present in the literature for a significant length of time (Alchian and Demsetz [1972]).
CHAPTER V

ANALYSIS OF RESULTS\textsuperscript{10}

5.1 MEASURING RESULTS

There are several different ways in which the results of this experiment can be examined. Each individual's data can be examined or, because individuals are paired together for the entire experiment, results can be examined in pairs. This second option is chosen because pairs can be thought of as forming strategies together and observations of individuals may not be independent. Therefore, each pair is considered a single observation for each day. For analysis, observations are categorized 0 (both select low effort), 1 (one selects high effort, one selects low effort), or 2 (both select high effort).\textsuperscript{11} These three categories are chosen to represent cooperation by both managers (2), cooperation by one manager (1), and cooperation by neither manager (0).

\textsuperscript{10} The statistical analysis in this chapter was done using non-parametric procedures and counting the average effort level for all pairs each day as a separate observation. One may argue that in order to analyze the data, one should look at each pair's average effort choices over a given number of days. The statistical results should therefore be considered with this possibility in mind.

\textsuperscript{11} Analysis was also done with paired observations categorized as 0 (both do not select high effort) or 1 (both select high effort). Results are not qualitatively different from those reported here. Analysis assuming independent (not paired) observations was also done; results are not qualitatively different for most results from those reported.
5.2 THE EVOLUTION OF COOPERATION

The first hypothesis looks at the incidence of high effort over time. The rounds are grouped into three categories: Days 1 to 10; Days 11 to 20; and Days 21 to End (due to the variable ending used in the experiment). (See Table 4 for mean effort choices for each of the three groups of days.) Using a large sample approximation of the Kruskal-Wallis test, the mean effort levels of the three groups, using paired observations, are not equal (p value < 0.001). Multiple comparisons of the three groups shows that effort is higher in the last group (Days 21 to End) than in the first group of days (Days 1 - 10) (p value < 0.02). The difference between the second group of days (Days 11 - 20) and the third group of days (Days 21 - End) is not statistically significant. H₁ is supported as high effort is chosen more often in later rounds of the experiment for all cells.

**TABLE 4**

*Experimental Results*

<table>
<thead>
<tr>
<th></th>
<th>CELL A</th>
<th>CELL B</th>
<th>CELL C</th>
<th>CELL D</th>
<th>CELL E</th>
<th>CELL F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Days 1-10</td>
<td>1.183</td>
<td>1.350</td>
<td>1.083</td>
<td>1.300</td>
<td>1.367</td>
<td>1.650</td>
</tr>
<tr>
<td>Days 11-20</td>
<td>1.333</td>
<td>1.483</td>
<td>1.033</td>
<td>1.267</td>
<td>1.283</td>
<td>1.650</td>
</tr>
<tr>
<td>Days 21-End</td>
<td>1.385</td>
<td>1.500</td>
<td>1.444</td>
<td>1.500</td>
<td>1.257</td>
<td>1.625</td>
</tr>
</tbody>
</table>

Average effort levels for each cell grouped by days, based on (0,1,2) pairings.

However, this result is not consistent across all cells. The following cells show significantly increased effort across time: Cells A, C, and D. Other cells are not significantly different at all conventional levels. This result may be driven by two
different explanations. Cells C and D are the cheap talk cells where results are contrary to the hypothesized predictions. The initial effort levels in Cells C and D are lower than in later rounds, perhaps indicative of participants learning to cooperate or learning of the game over time. On the other hand, it is possible that pre-play communication increases noise initially. Then the fact that cooperation is lower in early rounds in cells C and D is consistent with the original hypothesis that less noise leads to greater cooperation. It is also possible that the instructions encourage participants to act uncooperatively (see Appendices E and F). However, as the number of interactions increase, participants recognize benefits from cooperation and move to playing a cooperative strategy. See the discussion of results for $H_4$ and $H_5$ for further analysis.

The significance found in Cell A may be indicative of the higher level of noise present in this cell. Cell A is the noisiest environment tested in the experiment (no asset measurement/no correlation). Other cells may not have shown increased effort over time due to the reduced noise created by the experimental manipulations.

These results lend support to the study by demonstrating that cells with less noise achieve higher initial levels of effort; the experimental manipulations are successful in affecting strategy choices. The results may also say something about the abilities of asset measurement and correlation to encourage cooperation from the outset, making them potentially valuable tools to be exploited within the firm. This implies that, depending on the environment, cooperation does evolve over time and may indicate that managers eventually learn to cooperate when doing so is in their own best interests. It also demonstrates that repeated play is not the driving force toward cooperation in
environments with less noise. This is consistent with previous studies using a prisoner's dilemma setting in an environment with no noise.

Because the average effort levels in Days 11 - 20 are not significantly different from Days 20 - End (as indicated by the analysis of \( H_1 \)), hypotheses 2 through 6 are analyzed using these two groups of data. This cutoff is chosen to remove the potential interaction effects of learning the game with the desired manipulations to be examined. After day 10, stability is apparent in most cells (except Cells C and D, discussed later) across all remaining days (Table 2). Therefore, analysis of these results should focus on the experimental manipulations within cells and not changes over time.

5.3 Asset Measurement

The second hypothesis examines the effect of asset measurement on cooperation (measured as increased selection of high effort). The effect of asset measurement is tested by comparing the mean effort levels of Cells A, C, and E (where asset measurement is not available) to the mean effort levels of Cells B, D, and F (where asset measurement is available) both in aggregate and by comparing pairs of cells to control for interaction. (Cell A is compared to B; Cell C is compared to D; Cell E is compared to F.) The comparisons are done using distribution-free multiple comparisons based on the large sample approximation of the Wilcoxon signed rank test. The \( p \) value for the aggregate data is less than 0.002. Similar significance is found for the cell comparisons made to control for interaction. This supports \( H_2 \) as effort choices are higher in Cells B, D, and F than in Cells A, C, and E (see Figure 4 - aggregate data). Therefore, asset measurement does affect effort choices.
Asset Measurement

* Average effort levels are based on paired observations and categorized as described in Section 5.1 Measuring Results.

**Figure 4**
Comparison of Results

*Asset Measurement*
This result is consistent with the earlier discussion regarding asset measurement and noise reduction. Asset measurement reduces noise and allows more accurate belief revisions between partners. Participants utilize this information to achieve greater cooperation than when asset measurement is not available. Revenues, in terms of average daily earnings per person, are higher in Cells B, D, and F than in Cells A, C, and E ($0.615 vs. $0.597 per day) illustrating that accounting information also potentially increases social welfare. This can be translated into increased firm revenues. The accounting function of asset measurement is, therefore, an important vehicle to encourage cooperation among managers.

5.4  Pre-play Communication

Little support is found for the third hypothesis which states that effort levels will be higher in cells where cheap talk is available. Effort is actually lower in Cells C and D (where participants disclose an effort choice) than Cells A and B (where no disclosures are made) for aggregate data across all cells (p value <0.012) (see Figure 5). Results are then examined using Days 11 - End, and comparing Cell C to A and Cell D to B, to control for interaction. These results are not significant. Therefore, early on, pre-play communication appears to add noise to the environment rather than eliminate noise. However, later rounds mitigate this problem.
Pre-play Communication

* Average effort levels are based on paired observations and categorized as described in Section 5.1 Measuring Results.

FIGURE 5
Comparison of Results
Pre-play Communication
There are several possible interpretations to this finding. The first is that the pre-play communication mechanism may require additional learning before participants fully understand how they might use it to develop cooperation. This is evident from the results obtained when examining H₁ and from additional analysis of disclosures when compared to actual effort selections made.

Disclosures are compared to actual effort selections made by partitioning data into three groups (Days 1 - 10, Days 11 - 20, and Days 21 - End) and using individual observations. The results show that disclosure and selection choices are equal more often in Group 3 (Days 21 - End) than in Group 2 (Days 11 - 20) (p value < 0.015) for Cell C. This indicates less "lying" in later rounds of the experiment. Similar results are found in Cell D. Disclosure and selection choices made by individuals move to being more consistent with each other in later rounds in Cell D also. However, this movement happens more quickly than in Cell C. Group 1 is statistically different from Groups 2 and 3 (p value < 0.015) but Groups 2 and 3 are not statistically different from each other.

Consider this result in conjunction with the fact that effort choices in Cells C and D increase over time. These two findings imply that while using pre-play communication to coordinate activities may involve learning over time, it may still be a valuable tool to elicit cooperation from managers after its use is fully understood by managers. The idea of specific coordination of strategies, as found in a "Battle of the Sexes" game (Cooper et al, [1989]), is not relevant to a noisy prisoner's dilemma. Individuals may use pre-play communication as a mechanism to "set up" their partners in early rounds. Once
participants acknowledge the benefits obtained from coordinated actions, they may recognize the uses available for pre-play communication.

Other possible explanations for the lack of results have been noted in the literature. Behavioral research discusses the importance of accountability on decision making (Tetlock [1985]). Recent accounting research finds that accountability motivates effort and may improve judgment consistency and consensus (Ashton [1992]; Johnson and Kaplan [1991]). This dissertation does not impose any accountability on its subjects when asking them to make a disclosure. This is unlike Kachelmeier et al. [1994] who uses cheap talk as a coordination mechanism implemented from a central manager to the division manager. Therefore, in that study, the budget (cheap talk) may be perceived as coming from an authority figure. In this dissertation, it is plausible that participants do not initially recognize (or choose to ignore) the benefits to be derived from cooperation and, therefore, do not utilize the disclosures they make to form a coordination strategy.

There is evidence of some pairs explicitly using cooperation in the cells with pre-play communication. However, this does not carry over in to aggregate data. Data analysis shows that some pairs disclose selection from the alternate bin and maintain that disclosure in their selection throughout the experiment. Anecdotal evidence that this is, indeed, a strategy choice is obtained through analysis of the post-experimental questionnaires. One participant in Cell D wrote in the Additional Comments section that he and his partner were 'on the same wavelength' and disclosed and selected from the alternate bin each day.
Due to the inability to determine definitive results with respect to pre-play communication, conclusions on the fourth hypothesis, which examines the interaction of pre-play communication and asset measurement, are difficult to obtain. Statistical results that examine the interaction effect are not significant. Therefore, while it appears that these two mechanisms do not interact, this could be as a result the inability of the experiment to obtain results from the pre-play communication manipulation.

5.5 Correlation

Hypotheses five and six introduce correlation into the environment. Two separate tests are done to determine if correlation alone is enough to influence effort choices. All cells without correlation (Cells A, B, C, and D) are compared to both cells with correlation (Cells E and F) for Days 11 to end. Results are not significant at conventional levels. To ensure interactions between asset measurement, pre-play communication and correlation are not driving this finding, Cell E (only) is compared to Cell A (only). Again, results are not significant.

This finding appears puzzling. However, the Bayesian updating required of individuals to update prior beliefs is probably most complex in this cell. Participants must first infer an asset quality and then infer an effort choice in order to find an expected posterior probability for the effort choice made by the other manager. Intuitively, these calculations are difficult to perform. Problems with calculations using Bayes formula are found in previous psychology research (Tversky and Kahnemann [1973]; Bar-Hillel [1980]; Cohen [1981]; de Dombal [1988]). Bar-Hillel [1973] finds that as complexities
increase, the ability to correctly update deteriorates. With the additional complexities apparent in this cell, perhaps the results are not so puzzling.

Behavioral factors have to be considered in developing an accounting system. Managerial control involves interactions among human beings. Lack of results in the correlation cell may indicate that the experimental accounting system is not "good enough" to influence the behavior of the participants. This may highlight the difference between rationality and bounded rationality. Therefore, the additional calculations required in this cell may be beyond the limits of the participants. With asset measurement, the calculation is more intuitive.

Testing H₆ involved comparing results in cell F with those obtained in cell B. This comparison is significant at a p value of less than 0.001. This implies that correlation is effective in reducing noise in the environment when asset measurement is available. There is also a significant difference between cells E and F (p value < 0.0001) illustrating that asset measurement is informative, relative to correlation alone. (Figure 6 illustrates the relationship between Cells A, B, E, and F.) Both results are consistent with the definition of noise reduction and the fact that Bayesian updating only requires inference of an effort choice in Cell F in order to find an expected posterior probability for the actual effort choice made by the other manager. Asset measurement reduces noise, both with and without correlation.
* Average effort levels are based on paired observations and categorized as described in Section 5.1 Measuring Results.
When the results from \( H_5 \) and \( H_6 \) are analyzed in conjunction, they imply that asset measurement and correlation, together, are more beneficial in encouraging cooperation that either one alone. The communication of information with respect to correlated events is therefore a necessary function. Correlation alone does not appear to be sufficient. While asset measurement, as a communication mechanism alone, enhances cooperation, when it is coupled with correlation, benefits are even greater. The fact that an observation of asset quality provides better information with respect to the other manager's effort choice when environments are correlated may be interpreted as the ability of participants to coordinate activities when noise in the environment is reduced. These results also say something about activities within a firm when events, or divisions, are correlated. If accounting systems are designed to communicate information to managers that work in separate, but correlated environments, the ability to sustain cooperation may be enhanced. However, a friendly environment that introduces correlation alone, without accounting information, may not be helpful in enhancing cooperation.

5.6 **Strategy Choices**

One aspect of the prisoner's dilemma that has been discussed throughout this paper is that of the strategy choices made by the participants. The repeated interaction between players allows for the use of various strategies among the participants. The most obvious strategy to test is that of punishment for non-cooperation as in a Tit-for-Tat strategy.
Due to the imperfect information in the experiment, non-cooperation may take on different meanings in different cells. When asset measurement is available, as in Cells B, D, and E, non-cooperation may be inferred if the other player receives a low outcome. However, in those cells without asset measurement, non-cooperation may be inferred when the joint output is made up of either two low quality assets or a combination of one high and one low quality asset. Therefore, tests are performed using both possible scenarios.

Testing for non-cooperation of the second player assumes cooperation on the part of the first player. The first player then moves from cooperation (selecting high effort) to punishment (selecting low effort) when it appears the other player did not cooperate (as defined above).

Using days 11 to end for strategy observations, two different strategies are tested. The first determines whether a player punishes after one observation that the other player does not appear to cooperate. Using a joint output of two low quality assets only for Cells A, C, and E, a binomial test is not significant at all conventional levels (p < 0.8767). Using a joint output of one low and one high quality asset as well as two low quality assets for Cells A, C, and E, the p value is less than 0.1422 for the binomial test. Again, this is not significant at conventional levels.

However, it may make sense to look at a more generous punishment strategy (Bendor, et al. [1991]). Therefore, a second test is done to see if punishment is inflicted after two consecutive observances of non-cooperation by the other player. Using a joint output of two low quality assets only and then of two low quality assets and one low and
one high quality asset to define non-cooperation, binomial tests for both are significant (p < 0.05 for each test).

Therefore, it appears that participants do punish when the other player seems to play non-cooperatively. However, this punishment is meted out sparingly. This is consistent with the computer-programmed results of Bendor et al. [1991] who finds that generous strategies are more successful in a noisy, repeated prisoner's dilemma.

5.7 Summary

Strong support is found for several of the hypotheses. The use of accounting mechanisms to reduce noise within a firm may be beneficial in its goal of increasing cooperation. The accounting mechanism of asset measurement is useful in eliciting cooperative efforts from individuals. This result obtains with asset measurement alone and when it works in conjunction with a correlated environment.

The form of pre-play communication utilized in this experiment is not effective in achieving greater cooperation among participants. This may be because pre-play communication increases noise, thereby making coordination of efforts more difficult for participants. If this is the case, the premise that increased noise leads to less cooperation still holds. However, the examination of an accounting mechanism such as budgeting to reduce noise warrants further study.

The evolution of cooperation over time appears to be of importance in noisy environments. However, when appropriate mechanisms are in place that effectively mitigate the effect of noise, cooperation appears to take little, if any, time to develop. This suggests that accounting mechanisms may be useful in eliciting cooperation
immediately. Since cooperation increases over time in the noisier cells, the experimental manipulation of the end-of-game stochastic process appears to be effective. There is also little evidence of end-gaming on the part of the participants in other cells.

The result of studying strategy choices of the participants indicates that participants are generous in their punishment of perceived defections on the part of their partners. In a review of the post-experimental questionnaires, individuals perceive the other player as a partner and understand that cooperation is mutually beneficial. They also indicate that punishment is not necessarily the immediate reaction to a low realization on the part of their partner. Individuals made comments that indicated a thorough understanding of the importance of the other person's play in determining their payments. Some discussed the perceived interaction of the two players with comments indicating that both were on the same 'wave length' and discussing the importance of considering his or her partner's choices. Post-experimental questionnaires are included in Appendix I (Cells A and E), Appendix J (Cells B and F), Appendix K (Cell C), and Appendix L (Cell D).

Overall, the experiment appears successful as some hypotheses are supported and results are generally interesting. From examination of the post-experimental questionnaires, subjects appear to have a thorough understanding of their roles and the conclusions to be drawn from the experiment are meaningful.
CHAPTER VI

SUMMARY AND CONCLUSIONS

6.1 IMPLICATIONS

The role of an accounting information system within a firm is to provide information for decision making and to help motivate and monitor its employees. Organizations may choose institutional features designed to elicit cooperative behavior as a strategy to lower the amount of managerial information processing required due to uncertainties and complexities within the organization. The design of the accounting information system may allow for easier cooperation between parties, especially if there is correlation between the divisions' environments. Cooperation, as examined through asset measurement, provides benefits by complementing such tasks as managerial planning and information processing at higher levels. Cooperation may also result from communication between the parties (as in preparing budgets). This dissertation explicitly tests the ability of an accounting system to enhance cooperative efforts within the firm.

The information provided by accounting information is shown to elicit greater effort from participants and obtain greater returns for them. Repeated interaction also increases the amount of effort put forth by participants. Asset measurement and correlation together have the greatest impact on effort choices. These findings may
impact the design of accounting systems by recognizing the importance of accounting, in
the form of asset measurement, to help as a coordination mechanism within the firm.
Reducing noise in the environment, through providing accounting information, aids in
finding a cooperative equilibrium. The fact that pre-play communication results are not
definitive suggests that non-informative budgeting alone may not be enough to encourage
cooperation, or its use as a cooperative tool may take time to develop.

The idea of cooperation within a firm is not new to businesses, but its usefulness
may not be appropriately considered in managerial accounting, especially from the
perspective of compensation. The team (or cooperative) approach to management is
gaining popularity among businesses (Shipper and Manz [1992]). The innovation of
teams is credited with increased productivity, better attendance, less turnover, and
improvement in product quality. This is important from an accounting perspective
because increased productivity and product quality may be a result of better information
provided by divisions to central management. This information is supplied because
division managers recognize the importance of a team effort for optimal company
performance and the importance of individual contributions to the team.

The experimental manipulations in this experiment isolate how accounting might
be used to increase cooperative efforts among employees. Confounding factors such as
interactions among individuals in face-to-face situations are removed in order to examine
the impact from accounting manipulations alone. As a result of the findings, it may be
said that accounting systems do not fully exploit the impact they may have on teams and
cooperation within the firm. This may be true even for those firms that utilize quality
circles or stress the importance of teamwork for its employees through sources other than accounting information.

6.2 Limitations

The use of experimental markets allows control over the environment of the firm, including the joint production function and level of noise within the firm. However, these factors cannot be controlled in a naturally occurring setting. The absence of personal interaction in a team setting may also introduce biases in an effort to maintain a controlled environment. Therefore, it is difficult to assess the external validity of the laboratory results.

A simplifying assumption is made that the various mechanisms introduced in the experiment are costless. As a result, noise in the environment is manipulated without consideration of the cost to do so. If the noise in the environment can only be reduced at an increasing cost, managers must trade off the cost to reduce noise with the benefit available from that information. This may impact the ability of participants to achieve higher cooperation in a noisy environment.

The central purpose of this dissertation is to compare effort choices when the level of noise in various environments is manipulated. Therefore, the research hypotheses are comparative or directional in form. A specific, repeated model is not developed using the experimental parameters that thereby allows a precise calculation of an optimal cooperation level. None of the cells in the experiment find participants cooperating all the time. While this is not surprising, it cannot be determined from this dissertation if the theoretically "correct" level of cooperation is achieved in any cells.
6.3 Future Research

This dissertation shows that different forms of accounting may be mechanisms used by firms to reduce noise and increase cooperation among managers. Extensions of this work may consider more complex environments where accounting information is even more valuable as a noise filter. The joint production function can be more complex and thereby not allow managers to ever perfectly determine each other's asset quality both without asset measurement and when asset measurement is available. The importance of pre-play communication as a coordination mechanism also warrants further study. Behavioral issues, such as accountability for one's disclosure, may demonstrate the benefits of pre-play communication (budgeting) as an accounting tool to coordinate managers' actions.

Experimental markets may also be used to see if individuals are willing to pay for asset measurement in order to choose to reduce noise in the firm's environment. This may be implemented by allowing each manager to make the choice separately, or requiring both managers to agree to improve the reporting system. This study would provide some insight into the trade off between costs and benefits of various levels of accounting systems.

This dissertation represents a first, simplified attempt to provide insight on how accounting mechanisms can impact firms. Accounting systems vary greatly from firm to firm. This variability may be attributed to the different needs for information of firms. However, it seems clear that some of the elements of most firms are captured in this
simple setting and this dissertation may help explain another use of accounting systems besides that of record keeping.
APPENDIX A

Contingency Tables illustrate the joint probabilities of events occurring.

No Correlation (Events are Independent)

**Table 5**

Both Select High Effort

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Low</th>
<th>High</th>
<th>Marginal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>0.0625</td>
<td>0.1875</td>
<td>0.25</td>
</tr>
<tr>
<td>High</td>
<td>0.1875</td>
<td>0.5625</td>
<td>0.75</td>
</tr>
<tr>
<td>Marginal</td>
<td>0.25</td>
<td>0.75</td>
<td>1.00</td>
</tr>
</tbody>
</table>

**Table 6**

Column Selects Low Effort and Row Selects High Effort

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Low</th>
<th>High</th>
<th>Marginal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>0.1875</td>
<td>0.0625</td>
<td>0.25</td>
</tr>
<tr>
<td>High</td>
<td>0.5625</td>
<td>0.1875</td>
<td>0.75</td>
</tr>
<tr>
<td>Marginal</td>
<td>0.75</td>
<td>0.25</td>
<td>1.00</td>
</tr>
</tbody>
</table>
**Table 7**

Both Select Low Effort

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Low</th>
<th>High</th>
<th>Marginal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>0.5625</td>
<td>0.1875</td>
<td>0.75</td>
</tr>
<tr>
<td>High</td>
<td>0.1875</td>
<td>0.0625</td>
<td>0.25</td>
</tr>
<tr>
<td>Marginal</td>
<td>0.75</td>
<td>0.25</td>
<td>1.00</td>
</tr>
</tbody>
</table>

**Table 8**

Both Select High Effort

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Low</th>
<th>High</th>
<th>Marginal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>0.1875</td>
<td>0.0625</td>
<td>0.25</td>
</tr>
<tr>
<td>High</td>
<td>0.0625</td>
<td>0.6875</td>
<td>0.75</td>
</tr>
<tr>
<td>Marginal</td>
<td>0.25</td>
<td>0.75</td>
<td>1.00</td>
</tr>
</tbody>
</table>

**Table 9**

Column Selects Low Effort and Row Selects High Effort

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Low</th>
<th>High</th>
<th>Marginal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>0.25</td>
<td>0</td>
<td>0.25</td>
</tr>
<tr>
<td>High</td>
<td>0.50</td>
<td>0.25</td>
<td>0.75</td>
</tr>
<tr>
<td>Marginal</td>
<td>0.75</td>
<td>0.25</td>
<td>1.00</td>
</tr>
</tbody>
</table>
**Table 10**

Both Select Low Effort

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Low</th>
<th>High</th>
<th>Marginal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>0.6875</td>
<td>0.0625</td>
<td>0.75</td>
</tr>
<tr>
<td>High</td>
<td>0.0625</td>
<td>0.1875</td>
<td>0.25</td>
</tr>
<tr>
<td>Marginal</td>
<td>0.75</td>
<td>0.25</td>
<td>1.00</td>
</tr>
</tbody>
</table>

Labeling the joint probabilities in the contingency table in the following manner:

```
   a | b
  ---|---
   c | d
```

The measure of correlation is calculated with the following formula:

\[
\frac{ad - bc}{\sqrt{(a + b)(c + d)(a + c)(b + d)}}
\]  
(1)

Therefore, the measure of correlation for the independent Contingency Tables (5, 6, and 7) is zero; the measure of correlation for Contingency Tables 8 and 10 is 2/3 and for Table 9 is 1/3.
APPENDIX B

EXAMPLE OF NOISE REDUCTION

E[pr(High|High)] :

{This is the expected posterior probability that Manager 2 chose a high effort level after seeing the outcome and given that Manager 1 chose high effort. Since the probabilities are symmetric, the same technique can be used to calculate E[pr(Low|Low)].}

No Asset Measurement/No Correlation:

Expected posterior:

P(ll|e_h^1, e_h^2)*(Pe_h^2|e_h^1, ll) + P(lh, hl|e_h^1, e_h^2)*(Pe_h^2|e_h^1, lh, hl) + P(hh|e_h^1, e_h^2)*(Pe_h^2|e_h^1, hh)

Asset Measurement/No Correlation:

Expected posterior:

P(ll|e_h^1, e_h^2)*(Pe_h^2|e_h^1, ll) + P(lh|e_h^1, e_h^2)*(Pe_h^2|e_h^1, lh) + P(hl|e_h^1, e_h^2)*(Pe_h^2|e_h^1, hl) +
P(hh|e_h^1, e_h^2)*(Pe_h^2|e_h^1, hh)

No Asset Measurement/Correlation

Expected posterior:

P^c(ll|e_h^1, e_h^2)*(Pe^c_h|e_h^1, ll^c) + P^c(lh, hl|e_h^1, e_h^2)*(Pe^c_h|e_h^1, lh^c, hl^c) + P^c(hh|e_h^1, e_h^2)*(Pe^c_h|e_h^1, hh^c)
Asset Measurement & Correlation

Expected posterior:

\[ P(e^c_{fl}|e_h^1, e_h^2) * (P(e^{2c}_{f, h}|e_{h}^1, ll)^c) + P(e_{fl}|e_h^1, e_h^2) * (P(e^{2c}_{f, h}|e_{h}^1, lh)^c) + P(e_{fl}|e_h^1, e_h^2) * (P(e^{2c}_{f, h}|e_{h}^1, hl)^c) + P(e_{ff}|e_h^1, e_h^2) * (P(e^{2c}_{f, h}|e_{h}^1, hh)^c) \]

Where:

\[ P(e^{jk}|e_{h}^1, e_h^2) = \text{Joint probability of obtaining } jk \text{ (for } j, k \in \{1, h\}) \text{ given both managers selected high effort; } c = \text{correlated environments.} \]

\[ (P(e_{m}^{2c}|e_{m}^1, jk) = \text{Probability that Manager 2 selected effort level } m \text{ (for } m \in \{1, h\}) \text{ given that Manager 1 selected effort level } n \text{ (for } n \in \{1, h\} \text{) and the joint output obtained was } jk \text{ (for } j, k \in \{1, h\}) \text{; } c = \text{correlated environments.} \]

\[ (P(e_{m}^{2c}|e_{m}^1, jk) \text{ is calculated using Bayes' formula in the following manner:} \]

\[ (P(e_{m}^{2c}|e_{m}^1, jk) = \frac{P(jk|e_{m}^1, e_{m}^2) \cdot P(e_{m}^2)}{P(jk|e_{m}^1, e_{m}^2) \cdot P(e_{m}^2) \cdot P(jk|e_{m}^1, e_{m}^2) \cdot P(e_{m}^2)} \]

Where:

\[ P(jk|e_{m}^1, e_{m}^2) = \text{Joint probability of obtaining } jk \text{ (for } j, k \in \{1, h\}) \text{ given manager 1 selected high effort and manager 2 selected effort level } m \text{ (for } m \in \{1, h\}). \]

\[ P(e_{m}^2) = \text{Prior probability that manager 2 selected effort level } m \text{ (for } m \in \{1, h\}). \]

Similar calculations are used for correlated environments. Also, similar calculations are used to determine \( E[pr(Low|Low)] \).

For \( P(e_{h}^2) = 60\% \) (and \( P(e_{h}^2) = 40\% \)), and using the correlated probabilities in Tables 1 and 2 (independent probabilities are calculated from the experimental values in Table 3), the expected posterior probabilities that Manager 2 selected high (low) effort are listed in Figure 2.
APPENDIX C

EXPERIMENTAL INSTRUCTIONS
CELL A
INSTRUCTIONS

Cell A

GENERAL

Thank you for your participation in this experiment.

This is an experiment in the economics of decision-making. These are the instructions and, if you follow them carefully, you can earn a considerable sum of money which will be paid to you in cash at the conclusion of this experiment. A variety of organizations have provided funding for this project. Feel free to earn as much of their money as possible.

There will be five parts to the experiment.

1. These instructions;
2. Six markets days for training;
3. Market days in which you earn points;
4. A post-experimental questionnaire;
5. Payment of your earnings.

OVERVIEW

Your role in this experiment is to act as the manager of a division in a company. The company has two divisions that combine their resources to produce a joint product. The decisions made by you and the other division manager will determine the number of points you earn. These points will determine how much money you make.

The experiment proceeds in time intervals called markets days (or simply days). At the beginning of the experiment you will be randomly matched with another participant here in the lab. Your identity will remain anonymous. You will remain
matched with the same player for the duration of the experiment. (You will be matched with one person for training and then randomly matched again for the actual market days.) Your task is to decide whether or not to make an investment decision which will affect the joint output of the two divisions. The other manager will make a similar investment decision.

LENGTH OF SESSION

There will be two parts to the actual experiment. Six training rounds will be conducted to help familiarize you with the computer. The training phase will be followed by many rounds of trading in which you will actually earn cash. The training phase will be identical to the phase in which cash is earned in all ways except that it is shorter and you will not be paid the amounts you accumulate in the training rounds. You will be randomly paired with different people for the training days and for the actual experiment.

The actual experiment will be indefinite in length. On day 25 and each day after (if necessary) the experimenter will roll a pair of dice. If the two dice match, the experiment will end and you will be paid the winnings you have accumulated to date. If the pair of dice do not match, the experiment will proceed to the next day. [Should the experiment exceed two hours, you will be asked to return to continue the study.]

EVALUATING YOUR INVESTMENT DECISION

Your company has two divisions. Each division has the opportunity to make an investment in a bin. This bin contains two asset types: HIGH or LOW. A LOW type asset generates earnings of 30 points. A HIGH type asset pays earnings of 50 points. Should you select to invest in the ALTERNATE bin (at a cost of 10 points) you will have
a 75% chance of obtaining a \textit{HIGH} type asset (and a 25% chance of obtaining a \textit{LOW} type asset). An investment in the \textbf{DEFAULT} bin (at no cost) will have a 25% chance of obtaining a \textit{HIGH} type asset (and a 75% chance of obtaining a \textit{LOW} type asset). (You will be given an initial point balance of 100 points which you can use during the experiment. These points will be added to the total points you accumulate in determining your payment.) The asset obtained from each division manager will be used in the joint production process. The value of the two assets (one from each division manager) will combine to generate a joint payout. The joint payout will take the earnings from each asset and increase the total by half.

Examples:

If both managers receive \textit{HIGH} type assets, the joint payout will equal 150 points \( (50 + 50 = 100); \ 100 + (100\times0.5) = 150 \). This joint output will be shared equally. Each manager will get 75 points \( 150/2 = 75 \).

If one manager receives a \textit{HIGH} type asset and the other manager receives a \textit{LOW} type asset, the joint payout will equal 120 points \( (50 + 30 = 80); \ 80 + (80\times0.5) = 120 \). Each manager will get 60 points \( 120/2 = 60 \).

If both managers receive \textit{LOW} type assets, the joint payout will equal 90 points \( (30 + 30 = 60); \ 60 + (60\times0.5) = 90 \). This joint output will be shared equally. Each manager will get 45 points \( 90/2 = 45 \).
**How to Play the Game**

**Selection**

You will be asked whether you want to make an investment in either the *Alternate* bin or the *Default* bin. Selection from the *Alternate* bin will cost 10 points. The *Alternate* bin returns a *High* type asset 75% of the time and a *Low* type asset 25% of the time. Selection is made by answering the prompt on the screen and typing either D (for *Default* bin) or A (for *Alternate* bin).

The computer will determine the asset type you receive based on the probabilities for the *Default* and *Alternate* bins.

The assets received by each manager will be combined to determine the payment you will get each period. If you selected from the *Alternate* bin, your point balance will be decreased by 10 points and increased by the sharing of the joint payout. You will observe the joint payout realized from the joint production function.

Examples: *Although you will not see the actual asset type you receive, points will be calculated based on the following:*

If both managers receive *High* type assets, the joint payout will equal 150 points \[50 + 50 = 100\]; \[100 + (100*0.5) = 150\]. This joint output will be shared equally. Each manager will get 75 points \[150/2 = 75\]. If you selected from the *Alternate* bin, your net increase will be 65 points \[75 - 10 = 65\]. If you selected from the *Default* bin, your net increase will be 75 points \[75 - 0 = 75\].

If one manager receives a *High* type asset and the other manager receives a *Low* type
asset, the joint payout will equal 120 points \[ (50 + 30 = 80); \ 80 + (80*0.5) = 120 \]. Each manager will get 60 points \[ 120/2 = 60 \]. If you selected from the \textit{ALTERNATE} bin, your net increase will be 50 points \[ 60 - 10 = 50 \]. If you selected from the \textit{DEFAULT} bin, your net increase will be 60 points \[ 60 - 0 = 60 \].

If both managers receive \text{LOW} type assets, the joint payout will equal 90 points \[ (30 + 30 = 60); \ 60 + (60*0.5) = 90 \]. This joint output will be shared equally. Each manager will get 45 points \[ 90/2 = 45 \]. If you selected from the \textit{ALTERNATE} bin, your net increase will be 35 points \[ 45 - 10 = 35 \]. If you selected from the \textit{DEFAULT} bin, your net increase will be 45 points \[ 45 - 0 = 45 \].

Due to the availability of each asset type in each bin, each of the above scenarios is possible. They depend on the bin selection made by each manager. If both managers select from the \textit{ALTERNATE} bin and you receive a \textit{HIGH} type asset, the probability that the other manager also receives a \textit{HIGH} type asset is 75\%. Therefore, if you select from the \textit{ALTERNATE} bin and you receive a \textit{HIGH} type asset, the probability that the other manager receives a \textit{LOW} type asset (if he or she also selects from the \textit{ALTERNATE} bin) is 25\%. (See attached Probability Disagrams for all possible permutations.)

The computer will calculate all the necessary information and then display the results on the right-hand side of your screen until you hit <Enter>. The day number, joint payout, asset types, and your payment (net of any \textit{ALTERNATE} bin selection costs) will be shown. Your updated total point balance will also be displayed.

The left-hand side of the screen will contain the information for the latest market
days (up to 15 days). This information will include the day number, your selection, and the joint payout realized. Your current point balance will also be displayed at the bottom of the screen.

COMPUTATION OF PAYMENT

All participants will be paid in cash at the end of the experiment. You will be paid $.01 for each point you accumulate in the experiment (including the opening balance of 100 points). Payments will be rounded to the next highest nickel. For example, if your point balance is 1688, you will receive $16.90. You will receive your payment, in cash, upon completion of the post-experimental questionnaire.
**Probability Diagrams:**

Both select from the *Alternate* bin:

<table>
<thead>
<tr>
<th>Your asset quality</th>
<th>Other Manager's asset quality</th>
<th>Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>HIGH</td>
<td>HIGH with Probability</td>
<td>75%</td>
</tr>
<tr>
<td>LOW</td>
<td>LOW with Probability</td>
<td>25%</td>
</tr>
</tbody>
</table>

You select from the *Alternate* bin; the other manager selects from the *Default* bin:

<table>
<thead>
<tr>
<th>Your asset quality</th>
<th>Other Manager's asset quality</th>
<th>Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>HIGH</td>
<td>HIGH with Probability</td>
<td>25%</td>
</tr>
<tr>
<td>LOW</td>
<td>LOW with Probability</td>
<td>75%</td>
</tr>
</tbody>
</table>

You select from the *Default* bin; the other manager selects from the *Alternate* bin:

<table>
<thead>
<tr>
<th>Your asset quality</th>
<th>Other Manager's asset quality</th>
<th>Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>HIGH</td>
<td>HIGH with Probability</td>
<td>75%</td>
</tr>
<tr>
<td>LOW</td>
<td>LOW with Probability</td>
<td>25%</td>
</tr>
</tbody>
</table>

Both select from the *Default* bin:

<table>
<thead>
<tr>
<th>Your asset quality</th>
<th>Other Manager's asset quality</th>
<th>Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>HIGH</td>
<td>HIGH with Probability</td>
<td>25%</td>
</tr>
<tr>
<td>LOW</td>
<td>LOW with Probability</td>
<td>75%</td>
</tr>
</tbody>
</table>
APPENDIX D

EXPERIMENTAL INSTRUCTIONS
CELL B
INSTRUCTIONS

Cell B

GENERAL

Thank you for your participation in this experiment.

This is an experiment in the economics of decision-making. These are the instructions and, if you follow them carefully, you can earn a considerable sum of money which will be paid to you in cash at the conclusion of this experiment. A variety of organizations have provided funding for this project. Feel free to earn as much of their money as possible.

There will be five parts to the experiment.

(1) These instructions;
(2) Six markets days for training;
(3) Market days in which you earn points;
(4) A post-experimental questionnaire;
(5) Payment of your earnings.

OVERVIEW

Your role in this experiment is to act as the manager of a division in a company. The company has two divisions that combine their resources to produce a joint product. The decisions made by you and the other division manager will determine the number of points you earn. These points will determine how much money you make.

The experiment proceeds in time intervals called markets days (or simply days). At the beginning of the experiment you will be randomly matched with another participant here in the lab. Your identity will remain anonymous. You will remain
matched with the same player for the duration of the experiment. (You will be matched with one person for training and then randomly matched again for the actual market days.) Your task is to decide whether or not to make an investment decision which will affect the joint output of the two divisions. The other manager will make a similar investment decision.

LENGTH OF SESSION

There will be two parts to the actual experiment. Six training rounds will be conducted to help familiarize you with the computer. The training phase will be followed by many rounds of trading in which you will actually earn cash. The training phase will be identical to the phase in which cash is earned in all ways except that it is shorter and you will not be paid the amounts you accumulate in the training rounds. You will be randomly paired with different people for the training days and for the actual experiment.

The actual experiment will be indefinite in length. On day 25 and each day after (if necessary) the experimenter will roll a pair of dice. If the two dice match, the experiment will end and you will be paid the winnings you have accumulated to date. If the pair of dice do not match, the experiment will proceed to the next day. [Should the experiment exceed two hours, you will be asked to return to continue the study.]

EVALUATING YOUR INVESTMENT DECISION

Your company has two divisions. Each division has the opportunity to make an investment in a bin. This bin contains two asset types: HIGH or LOW. A LOW type asset generates earnings of 30 points. A HIGH type asset pays earnings of 50 points. Should you select to invest in the ALTERNATE bin (at a cost of 10 points) you will have
a 75% chance of obtaining a HIGH type asset (and a 25% chance of obtaining a LOW type asset). An investment in the DEFAULT bin (at no cost) will have a 25% chance of obtaining a HIGH type asset (and a 75% chance of obtaining a LOW type asset). (You will be given an initial point balance of 100 points which you can use during the experiment. These points will be added to the total points you accumulate in determining your payment.) The asset obtained from each division manager will be used in the joint production process. The value of the two assets (one from each division manager) will combine to generate a joint payout. The joint payout will take the earnings from each asset and increase the total by half.

Examples:

If both managers receive HIGH type assets, the joint payout will equal 150 points \((50 + 50 = 100)\); \(100 + (100*0.5) = 150\). This joint output will be shared equally. Each manager will get 75 points \([150/2 = 75]\).

If one manager receives a HIGH type asset and the other manager receives a LOW type asset, the joint payout will equal 120 points \((50 + 30 = 80)\); \(80 + (80*0.5) = 120\). Each manager will get 60 points \([120/2 = 60]\).

If both managers receive LOW type assets, the joint payout will equal 90 points \((30 + 30 = 60)\); \(60 + (60*0.5) = 90\). This joint output will be shared equally. Each manager will get 45 points \([90/2 = 45]\).
HOW TO PLAY THE GAME

SELECTION

You will be asked whether you want to make an investment in either the
ALTERNATE bin or the DEFAULT bin. Selection from the ALTERNATE bin will cost
10 points. The ALTERNATE bin returns a HIGH type asset 75% of the time and a LOW
type asset 25% of the time. Selection is made by answering the prompt on the screen and
typing either D (for DEFAULT bin) or A (for ALTERNATE bin).

After all participants have made their selection for the period, you will find out
the value of the asset you received. The computer will determine the asset type you
receive based on the probabilities for the DEFAULT and ALTERNATE bins.

The assets received by each manager will be combined to determine the payment
you will get each period. If you selected from the ALTERNATE bin, your point balance
will be decreased by 10 points and increased by the sharing of the joint payout.

Examples:

If both managers receive HIGH type assets, the joint payout will equal 150 points [ (50 +
50 = 100); 100 + (100*0.5) = 150]. This joint output will be shared equally. Each
manager will get 75 points [ 150/2 = 75]. If you selected from the ALTERNATE bin,
your net increase will be 65 points [ 75 - 10 = 65]. If you selected from the DEFAULT
bin, your net increase will be 75 points [ 75 - 0 = 75].

If one manager receives a HIGH type asset and the other manager receives a LOW type
asset, the joint payout will equal 120 points [ (50 + 30 = 80); 80 + (80*0.5) = 120]. Each
manager will get 60 points \[ 120/2 = 60 \]. If you selected from the \textit{ALTERNATE} bin, your net increase will be 50 points \[ 60 - 10 = 50 \]. If you selected from the \textit{DEFAULT} bin, your net increase will be 60 points \[ 60 - 0 = 60 \].

If both managers receive \textit{LOW} type assets, the joint payout will equal 90 points \[ (30 + 30 = 60) \]; \[ 60 + (60*0.5) = 90 \]. This joint output will be shared equally. Each manager will get 45 points \[ 90/2 = 45 \]. If you selected from the \textit{ALTERNATE} bin, your net increase will be 35 points \[ 45 - 10 = 35 \]. If you selected from the \textit{DEFAULT} bin, your net increase will be 45 points \[ 45 - 0 = 45 \].

Due to the availability of each asset type in each bin, each of the above scenarios is possible. They depend on the bin selection made by each manager. If both managers select from the \textit{ALTERNATE} bin and you receive a \textit{HIGH} type asset, the probability that the other manager also receives a \textit{HIGH} type asset is 75\%. Therefore, if you select from the \textit{ALTERNATE} bin and you receive a \textit{HIGH} type asset, the probability that the other manager receives a \textit{LOW} type asset (if he or she also selects from the \textit{ALTERNATE} bin) is 25\%. (See attached Probability Diagrams for all possible permutations.)

The computer will calculate all the necessary information and then display the results on the right-hand side of your screen until you hit <Enter>. The day number, joint payout, asset types, and your payment (net of any \textit{ALTERNATE} bin selection costs) will be shown. Your updated total point balance will also be displayed.

The left-hand side of the screen will contain the information for the latest market days (up to 15 days). This information will include the day number, your selection, the
asset quality you received, and the joint payout realized. Your current point balance will also be displayed at the bottom of the screen.

COMPUTATION OF PAYMENT

All participants will be paid in cash at the end of the experiment. You will be paid $.01 for each point you accumulate in the experiment (including the opening balance of 100 points). Payments will be rounded to the next highest nickel. For example, if your point balance is 1688, you will receive $16.90. You will receive your payment, in cash, upon completion of the post-experimental questionnaire.
**Probability Diagrams:**

Both select from the *Alternate* bin:

<table>
<thead>
<tr>
<th>Your asset quality</th>
<th>Other Manager’s asset quality:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>HIGH with Probability</td>
</tr>
<tr>
<td>HIGH</td>
<td>75%</td>
</tr>
<tr>
<td>LOW</td>
<td>75%</td>
</tr>
</tbody>
</table>

You select from the *Alternate* bin; the other manager selects from the *Default* bin:

<table>
<thead>
<tr>
<th>Your asset quality</th>
<th>Other Manager’s asset quality:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>HIGH with Probability</td>
</tr>
<tr>
<td>HIGH</td>
<td>25%</td>
</tr>
<tr>
<td>LOW</td>
<td>25%</td>
</tr>
</tbody>
</table>

You select from the *Default* bin; the other manager selects from the *Alternate* bin:

<table>
<thead>
<tr>
<th>Your asset quality</th>
<th>Other Manager’s asset quality:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>HIGH with Probability</td>
</tr>
<tr>
<td>HIGH</td>
<td>75%</td>
</tr>
<tr>
<td>LOW</td>
<td>75%</td>
</tr>
</tbody>
</table>

Both select from the *Default* bin:

<table>
<thead>
<tr>
<th>Your asset quality</th>
<th>Other Manager’s asset quality:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>HIGH with Probability</td>
</tr>
<tr>
<td>HIGH</td>
<td>25%</td>
</tr>
<tr>
<td>LOW</td>
<td>25%</td>
</tr>
</tbody>
</table>
APPENDIX E

EXPERIMENTAL INSTRUCTIONS
CELL C
INSTRUCTIONS

Cell C

GENERAL

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(5) Payment of your earnings.

OVERVIEW

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The experiment proceeds in time intervals called markets days (or simply days).

At the beginning of the experiment you will be randomly matched with another participant here in the lab. Your identity will remain anonymous. You will remain
matched with the same player for the duration of the experiment. (You will be matched with one person for training and then randomly matched again for the actual market days.) Your task is to decide whether or not to make an investment decision which will affect the joint output of the two divisions. The other manager will make a similar investment decision.

LENGTH OF SESSION

There will be two parts to the actual experiment. Six training rounds will be conducted to help familiarize you with the computer. The training phase will be followed by many rounds of trading in which you will actually earn cash. The training phase will be identical to the phase in which cash is earned in all ways except that it is shorter and you will not be paid the amounts you accumulate in the training rounds. You will be randomly paired with different people for the training days and for the actual experiment.

The actual experiment will be indefinite in length. On day 25 and each day after (if necessary) the experimenter will roll a pair of dice. If the two dice match, the experiment will end and you will be paid the winnings you have accumulated to date. If the pair of dice do not match, the experiment will proceed to the next day. [Should the experiment exceed two hours, you will be asked to return to continue the study.]

EVALUATING YOUR INVESTMENT DECISION

Your company has two divisions. Each division has the opportunity to make an investment in a bin. This bin contains two asset types: HIGH or LOW. A LOW type asset generates earnings of 30 points. A HIGH type asset pays earnings of 50 points. Should you select to invest in the ALTERNATE bin (at a cost of 10 points) you will have
a 75% chance of obtaining a *HIGH* type asset (and a 25% chance of obtaining a *LOW* type asset). An investment in the *DEFAULT* bin (at no cost) will have a 25% chance of obtaining a *HIGH* type asset (and a 75% chance of obtaining a *LOW* type asset). (You will be given an initial point balance of 100 points which you can use during the experiment. These points will be added to the total points you accumulate in determining your payment.) The asset obtained from each division manager will be used in the joint production process. The value of the two assets (one from each division manager) will combine to generate a joint payout. The joint payout will take the earnings from each asset and increase the total by half.

Examples:

If both managers receive *HIGH* type assets, the joint payout will equal 150 points \[ (50 + 50 = 100); \quad 100 + (100 \times 0.5) = 150 \]. This joint output will be shared equally. Each manager will get 75 points \[ 150/2 = 75 \].

If one manager receives a *HIGH* type asset and the other manager receives a *LOW* type asset, the joint payout will equal 120 points \[ (50 + 30 = 80); \quad 80 + (80 \times 0.5) = 120 \]. Each manager will get 60 points \[ 120/2 = 60 \].

If both managers receive *LOW* type assets, the joint payout will equal 90 points \[ (30 + 30 = 60); \quad 60 + (60 \times 0.5) = 90 \]. This joint output will be shared equally. Each manager will get 45 points \[ 90/2 = 45 \].
How to Play the Game

Disclosure

The first decision you will be required to make is what you want to tell the other manager about your asset investment. You can tell the other manager that you intend to invest in either the Alternate or the Default bins. The choice you make in this step may or may not correspond to the actual choice you make in the following step. This is done by answering the prompt on the screen and typing either D (for Default bin) or A (for Alternate bin). After all participants enter their selection, you will receive the information that the other manager chose to disclose to you. This information will displayed on the right hand side of your screen until you hit <Enter>.

Selection

After receiving the disclosure information, you will be asked whether you want to make your actual selection from the Alternate bin or the Default bin. Selection from the Alternate bin will cost 10 points. The Alternate bin returns a High type asset 75% of the time and a Low type asset 25% of the time. Selection is made by answering the prompt on the screen and typing either D (for Default bin) or A (for Alternate bin). Remember, the bin selection you make is independent of the disclosure you made in the previous step.

The computer will determine the asset type you receive based on the probabilities for the Default and Alternate bins.

The assets received by each manager will be combined to determine the payment
you will get each period. If you selected from the alternate bin, your point balance will be decreased by 10 points and increased by the sharing of the joint payout. You will observe the joint payout realized from the joint production function.

Examples: Although you will not see the actual asset type you receive, points will be calculated based on the following:

If both managers receive high type assets, the joint payout will equal 150 points [(50 + 50 = 100); 100 + (100*0.5) = 150]. This joint output will be shared equally. Each manager will get 75 points [150/2 = 75]. If you selected from the alternate bin, your net increase will be 65 points [75 - 10 = 65]. If you selected from the default bin, your net increase will be 75 points [75 - 0 = 75].

If one manager receives a high type asset and the other manager receives a low type asset, the joint payout will equal 120 points [(50 + 30 = 80); 80 + (80*0.5) = 120]. Each manager will get 60 points [120/2 = 60]. If you selected from the alternate bin, your net increase will be 50 points [60 - 10 = 50]. If you selected from the default bin, your net increase will be 60 points [60 - 0 = 60].

If both managers receive low type assets, the joint payout will equal 90 points [(30 + 30 = 60); 60 + (60*0.5) = 90]. This joint output will be shared equally. Each manager will get 45 points [90/2 = 45]. If you selected from the alternate bin, your net increase will be 35 points [45 - 10 = 35]. If you selected from the default bin, your net increase will be 45 points [45 - 0 = 45].

Due to the availability of each asset type in each bin, each of the above scenarios is possible. They depend on the bin selection made by each manager. If both managers
select from the *ALTERNATE* bin and you receive a *HIGH* type asset, the probability that the other manager also receives a *HIGH* type asset is 75%. Therefore, if you select from the *ALTERNATE* bin and you receive a *HIGH* type asset, the probability that the other manager receives a *LOW* type asset (if he or she also selects from the *ALTERNATE* bin) is 25%. (See attached Probability Diagrams for all possible permutations.)

The computer will calculate all the necessary information and then display the results on the right-hand side of your screen until you hit <Enter>. The day number, joint payout, asset types, and your payment (net of any *ALTERNATE* bin selection costs) will be shown. Your updated total point balance will also be displayed.

The left-hand side of the screen will contain the information for the latest market days (up to 15 days). This information will include the day number, your disclosure, the other player’s disclosure, your selection, and the joint payout realized. Your current point balance will also be displayed at the bottom of the screen.

**COMPUTATION OF PAYMENT**

All participants will be paid in cash at the end of the experiment. You will be paid $.01 for each point you accumulate in the experiment (including the opening balance of 100 points). Payments will be rounded to the next highest nickel. For example, if your point balance is 1688, you will receive $16.90. You will receive your payment, in cash, upon completion of the post-experimental questionnaire.
PROBABILITY DIAGRAMS:

Both select from the **ALTERNATE** bin:

<table>
<thead>
<tr>
<th>Your asset quality:</th>
<th>Other Manager's asset quality:</th>
</tr>
</thead>
<tbody>
<tr>
<td>HIGH</td>
<td>HiGH with Probability: 75%</td>
</tr>
<tr>
<td></td>
<td>LOW with Probability: 25%</td>
</tr>
<tr>
<td>LOW</td>
<td>HiGH with Probability: 75%</td>
</tr>
<tr>
<td></td>
<td>LOW with Probability: 25%</td>
</tr>
</tbody>
</table>

You select from the **ALTERNATE** bin; the other manager selects from the **DEFAULT** bin:

<table>
<thead>
<tr>
<th>Your asset quality:</th>
<th>Other Manager's asset quality:</th>
</tr>
</thead>
<tbody>
<tr>
<td>HIGH</td>
<td>HiGH with Probability: 25%</td>
</tr>
<tr>
<td></td>
<td>LOW with Probability: 75%</td>
</tr>
<tr>
<td>LOW</td>
<td>HiGH with Probability: 25%</td>
</tr>
<tr>
<td></td>
<td>LOW with Probability: 75%</td>
</tr>
</tbody>
</table>

You select from the **DEFAULT** bin; the other manager selects from the **ALTERNATE** bin:

<table>
<thead>
<tr>
<th>Your asset quality:</th>
<th>Other Manager's asset quality:</th>
</tr>
</thead>
<tbody>
<tr>
<td>HIGH</td>
<td>HiGH with Probability: 75%</td>
</tr>
<tr>
<td></td>
<td>LOW with Probability: 25%</td>
</tr>
<tr>
<td>LOW</td>
<td>HiGH with Probability: 75%</td>
</tr>
<tr>
<td></td>
<td>LOW with Probability: 25%</td>
</tr>
</tbody>
</table>

Both select from the **DEFAULT** bin:

<table>
<thead>
<tr>
<th>Your asset quality:</th>
<th>Other Manager's asset quality:</th>
</tr>
</thead>
<tbody>
<tr>
<td>HIGH</td>
<td>HiGH with Probability: 25%</td>
</tr>
<tr>
<td></td>
<td>LOW with Probability: 75%</td>
</tr>
<tr>
<td>LOW</td>
<td>HiGH with Probability: 25%</td>
</tr>
<tr>
<td></td>
<td>LOW with Probability: 75%</td>
</tr>
</tbody>
</table>
INSTRUCTIONS

*Cell D*

GENERAL

Thank you for your participation in this experiment.

This is an experiment in the economics of decision-making. These are the instructions and, if you follow them carefully, you can earn a considerable sum of money which will be paid to you in cash at the conclusion of this experiment. A variety of organizations have provided funding for this project. Feel free to earn as much of their money as possible.

There will be five parts to the experiment.

1. These instructions;
2. Six markets days for training;
3. Market days in which you earn points;
4. A post-experimental questionnaire;
5. Payment of your earnings.

OVERVIEW

Your role in this experiment is to act as the manager of a division in a company. The company has two divisions that combine their resources to produce a joint product. The decisions made by you and the other division manager will determine the number of points you earn. These points will determine how much money you make.

The experiment proceeds in time intervals called markets days (or simply days). At the beginning of the experiment you will be randomly matched with another participant here in the lab. Your identity will remain anonymous. You will remain
matched with the same player for the duration of the experiment. (You will be matched with one person for training and then randomly matched again for the actual market days.) Your task is to decide whether or not to make an investment decision which will affect the joint output of the two divisions. The other manager will make a similar investment decision.

LENGTH OF SESSION

There will be two parts to the actual experiment. Six training rounds will be conducted to help familiarize you with the computer. The training phase will be followed by many rounds of trading in which you will actually earn cash. The training phase will be identical to the phase in which cash is earned in all ways except that it is shorter and you will not be paid the amounts you accumulate in the training rounds. You will be randomly paired with different people for the training days and for the actual experiment.

The actual experiment will be indefinite in length. On day 25 and each day after (if necessary) the experimenter will roll a pair of dice. If the two dice match, the experiment will end and you will be paid the winnings you have accumulated to date. If the pair of dice do not match, the experiment will proceed to the next day. [Should the experiment exceed two hours, you will be asked to return to continue the study.]

EVALUATING YOUR INVESTMENT DECISION

Your company has two divisions. Each division has the opportunity to make an investment in a bin. This bin contains two asset types: HIGH or LOW. A LOW type asset generates earnings of 30 points. A HIGH type asset pays earnings of 50 points. Should you select to invest in the ALTERNATE bin (at a cost of 10 points) you will have
a 75% chance of obtaining a \textit{HIGH} type asset (and a 25% chance of obtaining a \textit{LOW} type asset). An investment in the \textbf{DEFAULT} bin (at no cost) will have a 25% chance of obtaining a \textit{HIGH} type asset (and a 75% chance of obtaining a \textit{LOW} type asset). (You will be given an initial point balance of 100 points which you can use during the experiment. These points will be added to the total points you accumulate in determining your payment.) The asset obtained from each division manager will be used in the joint production process. The value of the two assets (one from each division manager) will combine to generate a joint payout. The joint payout will take the earnings from each asset and increase the total by half.

Examples:

If both managers receive \textit{HIGH} type assets, the joint payout will equal 150 points \[(50 + 50 = 100); \ 100 + (100*0.5) = 150\]. This joint output will be shared equally. Each manager will get 75 points \[150/2 = 75\].

If one manager receives a \textit{HIGH} type asset and the other manager receives a \textit{LOW} type asset, the joint payout will equal 120 points \[(50 + 30 = 80); \ 80 + (80*0.5) = 120\]. Each manager will get 60 points \[120/2 = 60\].

If both managers receive \textit{LOW} type assets, the joint payout will equal 90 points \[(30 + 30 = 60); \ 60 + (60*0.5) = 90\]. This joint output will be shared equally. Each manager will get 45 points \[90/2 = 45\].
**HOW TO PLAY THE GAME**

**DISCLOSURE**

The first decision you will be required to make is what you want to tell the other manager about your asset investment. You can tell the other manager that you intend to invest in either the *ALTERNATE* or the *DEFAULT* bins. The choice you make in this step may or may not correspond to the actual choice you make in the following step. This is done by answering the prompt on the screen and typing either D (for *DEFAULT* bin) or A (for *ALTERNATE* bin). After all participants enter their selection, you will receive the information that the other manager chose to disclose to you. This information will displayed on the right hand side of your screen until you hit <Enter>.

**SELECTION**

After receiving the disclosure information, you will be asked whether you want to make your actual selection from the *ALTERNATE* bin or the *DEFAULT* bin. Selection from the *ALTERNATE* bin will cost 10 points. The *ALTERNATE* bin returns a *HIGH* type asset 75% of the time and a *LOW* type asset 25% of the time. Selection is made by answering the prompt on the screen and typing either D (for *DEFAULT* bin) or A (for *ALTERNATE* bin). **Remember, the bin selection you make is independent of the disclosure you made in the previous step.**

After all participants have made their selection for the period, you will find out the value of the asset you received. The computer will determine the asset type you receive based on the probabilities for the *DEFAULT* and *ALTERNATE* bins.
The assets received by each manager will be combined to determine the payment you will get each period. If you selected from the *ALTERNATE* bin, your point balance will be decreased by 10 points and increased by the sharing of the joint payout.

Examples:

If both managers receive *HIGH* type assets, the joint payout will equal 150 points \[ (50 + 50 = 100); \ 100 + (100*0.5) = 150 \]. This joint output will be shared equally. Each manager will get 75 points \[ 150/2 = 75 \]. If you selected from the *ALTERNATE* bin, your net increase will be 65 points \[ 75 - 10 = 65 \]. If you selected from the *DEFAULT* bin, your net increase will be 75 points \[ 75 - 0 = 75 \].

If one manager receives a *HIGH* type asset and the other manager receives a *LOW* type asset, the joint payout will equal 120 points \[ (50 + 30 = 80); \ 80 + (80*0.5) = 120 \]. Each manager will get 60 points \[ 120/2 = 60 \]. If you selected from the *ALTERNATE* bin, your net increase will be 50 points \[ 60 - 10 = 50 \]. If you selected from the *DEFAULT* bin, your net increase will be 60 points \[ 60 - 0 = 60 \].

If both managers receive *LOW* type assets, the joint payout will equal 90 points \[ (30 + 30 = 60); \ 60 + (60*0.5) = 90 \]. This joint output will be shared equally. Each manager will get 45 points \[ 90/2 = 45 \]. If you selected from the *ALTERNATE* bin, your net increase will be 35 points \[ 45 - 10 = 35 \]. If you selected from the *DEFAULT* bin, your net increase will be 45 points \[ 45 - 0 = 45 \].

Due to the availability of each asset type in each bin, each of the above scenarios is possible. They depend on the bin selection made by each manager. If both managers select from the *ALTERNATE* bin and you receive a *HIGH* type asset, the probability that
the other manager also receives a HIGH type asset is 75%. Therefore, if you select
from the ALTERNATE bin and you receive a HIGH type asset, the probability that the
other manager receives a LOW type asset (if he or she also selects from the
ALTERNATE bin) is 25%. (See attached Probability Diagram for all possible
permutations.)

The computer will calculate all the necessary information and then display the
results on the right-hand side of your screen until you hit <Enter>. The day number, joint
payout, asset types, and your payment (net of any ALTERNATE bin selection costs) will
be shown. Your updated total point balance will also be displayed.

The left-hand side of the screen will contain the information for the latest market
days (up to 15 days). This information will include the day number, your disclosure, the
other player's disclosure, your selection, the asset quality you received, and the joint
payout realized. Your current point balance will also be displayed at the bottom of the
screen.

COMPUTATION OF PAYMENT

All participants will be paid in cash at the end of the experiment. You will be
paid $.01 for each point you accumulate in the experiment (including the opening balance
of 100 points). Payments will be rounded to the next highest nickel. For example, if
your point balance is 1688, you will receive $16.90. You will receive your payment, in
cash, upon completion of the post-experimental questionnaire.
**Probability Diagrams:**

Both select from the *Alternate* bin:

<table>
<thead>
<tr>
<th>Your asset quality:</th>
<th>Other Manager's asset quality:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>HIGH with Probability</td>
</tr>
<tr>
<td>HIGH</td>
<td>75%</td>
</tr>
<tr>
<td>LOW</td>
<td>75%</td>
</tr>
</tbody>
</table>

You select from the *Alternate* bin; the other manager selects from the *Default* bin:

<table>
<thead>
<tr>
<th>Your asset quality:</th>
<th>Other Manager's asset quality:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>HIGH with Probability</td>
</tr>
<tr>
<td>HIGH</td>
<td>25%</td>
</tr>
<tr>
<td>LOW</td>
<td>25%</td>
</tr>
</tbody>
</table>

You select from the *Default* bin; the other manager selects from the *Alternate* bin:

<table>
<thead>
<tr>
<th>Your asset quality:</th>
<th>Other Manager's asset quality:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>HIGH with Probability</td>
</tr>
<tr>
<td>HIGH</td>
<td>75%</td>
</tr>
<tr>
<td>LOW</td>
<td>75%</td>
</tr>
</tbody>
</table>

Both select from the *Default* bin:

<table>
<thead>
<tr>
<th>Your asset quality:</th>
<th>Other Manager's asset quality:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>HIGH with Probability</td>
</tr>
<tr>
<td>HIGH</td>
<td>25%</td>
</tr>
<tr>
<td>LOW</td>
<td>25%</td>
</tr>
</tbody>
</table>
INSTRUCTIONS

Cell E

GENERAL

Thank you for your participation in this experiment.

This is an experiment in the economics of decision-making. These are the instructions and, if you follow them carefully, you can earn a considerable sum of money which will be paid to you in cash at the conclusion of this experiment. A variety of organizations have provided funding for this project. Feel free to earn as much of their money as possible.

There will be five parts to the experiment.

(1) These instructions;
(2) Six markets days for training;
(3) Market days in which you earn points;
(4) A post-experimental questionnaire;
(5) Payment of your earnings.

OVERVIEW

Your role in this experiment is to act as the manager of a division in a company. The company has two divisions that combine their resources to produce a joint product. The decisions made by you and the other division manager will determine the number of points you earn. These points will determine how much money you make.

The experiment proceeds in time intervals called markets days (or simply days). At the beginning of the experiment you will be randomly matched with another participant here in the lab. Your identity will remain anonymous. You will remain
matched with the same player for the duration of the experiment. (You will be matched with one person for training and then randomly matched again for the actual market days.) Your task is to decide whether or not to make an investment decision which will affect the joint output of the two divisions. The other manager will make a similar investment decision.

LENGTH OF SESSION

There will be two parts to the actual experiment. Six training rounds will be conducted to help familiarize you with the computer. The training phase will be followed by many rounds of trading in which you will actually earn cash. The training phase will be identical to the phase in which cash is earned in all ways except that it is shorter and you will not be paid the amounts you accumulate in the training rounds. You will be randomly paired with different people for the training days and for the actual experiment.

The actual experiment will be indefinite in length. On day 25 and each day after (if necessary) the experimenter will roll a pair of dice. If the two dice match, the experiment will end and you will be paid the winnings you have accumulated to date. If the pair of dice do not match, the experiment will proceed to the next day. [Should the experiment exceed two hours, you will be asked to return to continue the study.]

EVALUATING YOUR INVESTMENT DECISION

Your company has two divisions. Each division has the opportunity to make an investment in a bin. This bin contains two asset types: HIGH or LOW. A LOW type asset generates earnings of 30 points. A HIGH type asset pays earnings of 50 points. Should you select to invest in the ALTERNATE bin (at a cost of 10 points) you will have
a 75% chance of obtaining a HIGH type asset (and a 25% chance of obtaining a LOW type asset). An investment in the DEFAULT bin (at no cost) will have a 25% chance of obtaining a HIGH type asset (and a 75% chance of obtaining a LOW type asset). (You will be given an initial point balance of 100 points which you can use during the experiment. These points will be added to the total points you accumulate in determining your payment.) The asset obtained from each division manager will be used in the joint production process. The value of the two assets (one from each division manager) will combine to generate a joint payout. The joint payout will take the earnings from each asset and increase the total by half.

Examples:

If both managers receive HIGH type assets, the joint payout will equal 150 points \[(50 + 50 = 100);\ 100 + (100*0.5) = 150\]. This joint output will be shared equally. Each manager will get 75 points \[150/2 = 75\].

If one manager receives a HIGH type asset and the other manager receives a LOW type asset, the joint payout will equal 120 points \[(50 + 30 = 80);\ 80 + (80*0.5) = 120\]. Each manager will get 60 points \[120/2 = 60\].

If both managers receive LOW type assets, the joint payout will equal 90 points \[(30 + 30 = 60);\ 60 + (60*0.5) = 90\]. This joint output will be shared equally. Each manager will get 45 points \[90/2 = 45\].
**HOW TO PLAY THE GAME**

**SELECTION**

You will be asked whether you want to make an investment in either the

*ALTERNATE* bin or the *DEFAULT* bin. Selection from the *ALTERNATE* bin will cost

10 points. The *ALTERNATE* bin returns a *HIGH* type asset 75% of the time and a *LOW*

type asset 25% of the time. Selection is made by answering the prompt on the screen and
typing either **D** (for *DEFAULT* bin) or **A** (for *ALTERNATE* bin).

The computer will determine the asset type you receive based on the probabilities

for the *DEFAULT* and *ALTERNATE* bins. The environments of the two divisions are
correlated. This means that the type of asset you receive depends on the type of asset the
other manager gets as well as both bin selections. See the attached diagrams to illustrate
the correlations.

The assets received by each manager will be combined to determine the payment

you will get each period. If you selected from the *ALTERNATE* bin, your point balance
will be decreased by 10 points and increased by the sharing of the joint payout. You will
observe the joint payout realized from the joint production function.

Examples: Although you will not see the actual asset type you receive, points will be
calculated based on the following:

If both managers receive *HIGH* type assets, the joint payout will equal 150 points [ (50 +

50 = 100); 100 + (100*0.5) = 150]. This joint output will be shared equally. Each

manager will get 75 points [ 150/2 = 75].) If you selected from the *ALTERNATE* bin,
your net increase will be 65 points \[75 - 10 = 65\]. If you selected from the \textit{DEFAULT} bin, your net increase will be 75 points \[75 - 0 = 75\].

If one manager receives a \textit{HIGH} type asset and the other manager receives a \textit{LOW} type asset, the joint payout will equal 120 points \[(50 + 30 = 80); \ 80 + (80*0.5) = 120\]. Each manager will get 60 points \[120/2 = 60\]. If you selected from the \textit{ALTERNATE} bin, your net increase will be 50 points \[60 - 10 = 50\]. If you selected from the \textit{DEFAULT} bin, your net increase will be 60 points \[60 - 0 = 60\].

If both managers receive \textit{LOW} type assets, the joint payout will equal 90 points \[(30 + 30 = 60); \ 60 + (60*0.5) = 90\]. This joint output will be shared equally. Each manager will get 45 points \[90/2 = 45\]. If you selected from the \textit{ALTERNATE} bin, your net increase will be 35 points \[45 - 10 = 35\]. If you selected from the \textit{DEFAULT} bin, your net increase will be 45 points \[45 - 0 = 45\].

Due to the availability of each asset type in each bin, each of the above scenarios is possible. They depend on the bin selection made by each manager. If both managers select from the \textit{ALTERNATE} bin and you receive a \textit{HIGH} type asset, the probability that \textbf{the other manager} also receives a \textit{HIGH} type asset is 91.67%. Therefore, if you select from the \textit{ALTERNATE} bin and you receive a \textit{HIGH} type asset, the probability that \textbf{the other manager} receives a \textit{LOW} type asset (if he or she also selects from the \textit{ALTERNATE} bin) is 8.33%. (See attached diagrams for all possible permutations.)

The computer will calculate all the necessary information and then display the results on the right-hand side of your screen until you hit <Enter>. The day number, joint payout, asset types, and your payment (net of any \textit{ALTERNATE} bin selection costs) will
be shown. Your updated total point balance will also be displayed.

The left-hand side of the screen will contain the information for the latest market days (up to 15 days). This information will include the day number, your selection, and the joint payout realized. Your current point balance will also be displayed at the bottom of the screen.

COMPUTATION OF PAYMENT

All participants will be paid in cash at the end of the experiment. You will be paid $0.01 for each point you accumulate in the experiment (including the opening balance of 100 points). Payments will be rounded to the next highest nickel. For example, if your point balance is 1688, you will receive $16.90. You will receive your payment, in cash, upon completion of the post-experimental questionnaire.
**Probability Diagrams:**

Both select from the *Alternate* bin:

<table>
<thead>
<tr>
<th>Your asset quality:</th>
<th>Other Manager's asset quality:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>HIGH with Probability</td>
</tr>
<tr>
<td>HIGH</td>
<td>91.67%</td>
</tr>
<tr>
<td>LOW</td>
<td>25%</td>
</tr>
</tbody>
</table>

You select from the *Alternate* bin; the other manager selects from the *Default* bin:

<table>
<thead>
<tr>
<th>Your asset quality:</th>
<th>Other Manager's asset quality:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>HIGH with Probability</td>
</tr>
<tr>
<td>HIGH</td>
<td>33.33%</td>
</tr>
<tr>
<td>LOW</td>
<td>0%</td>
</tr>
</tbody>
</table>

You select from the *Default* bin; the other manager selects from the *Alternate* bin:

<table>
<thead>
<tr>
<th>Your asset quality:</th>
<th>Other Manager's asset quality:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>HIGH with Probability</td>
</tr>
<tr>
<td>HIGH</td>
<td>100%</td>
</tr>
<tr>
<td>LOW</td>
<td>66.67%</td>
</tr>
</tbody>
</table>

Both select from the *Default* bin:

<table>
<thead>
<tr>
<th>Your asset quality:</th>
<th>Other Manager's asset quality:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>HIGH with Probability</td>
</tr>
<tr>
<td>HIGH</td>
<td>75%</td>
</tr>
<tr>
<td>LOW</td>
<td>8.33%</td>
</tr>
</tbody>
</table>
APPENDIX H

EXPERIMENTAL INSTRUCTIONS

CELL F

106
GENERAL

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LENGTH OF SESSION

There will be two parts to the actual experiment. Six training rounds will be conducted to help familiarize you with the computer. The training phase will be followed by many rounds of trading in which you will actually earn cash. The training phase will be identical to the phase in which cash is earned in all ways except that it is shorter and you will not be paid the amounts you accumulate in the training rounds. You will be randomly paired with different people for the training days and for the actual experiment.

The actual experiment will be indefinite in length. On day 25 and each day after (if necessary) the experimenter will roll a pair of dice. If the two dice match, the experiment will end and you will be paid the winnings you have accumulated to date. If the pair of dice do not match, the experiment will proceed to the next day. [Should the experiment exceed two hours, you will be asked to return to continue the study.]

EVALUATING YOUR INVESTMENT DECISION

Your company has two divisions. Each division has the opportunity to make an investment in a bin. This bin contains two asset types: HIGH or LOW. A LOW type asset generates earnings of 30 points. A HIGH type asset pays earnings of 50 points.

Should you select to invest in the ALTERNATE bin (at a cost of 10 points) you will have
a 75% chance of obtaining a \textit{HIGH} type asset (and a 25% chance of obtaining a \textit{LOW} type asset). An investment in the \textbf{DEFAULT} bin (at no cost) will have a 25% chance of obtaining a \textit{HIGH} type asset (and a 75% chance of obtaining a \textit{LOW} type asset). (You will be given an initial point balance of 100 points which you can use during the experiment. These points will be added to the total points you accumulate in determining your payment.) The asset obtained from each division manager will be used in the joint production process. The value of the two assets (one from each division manager) will combine to generate a joint payout. The joint payout will take the earnings from each asset and increase the total by half.

Examples:

If both managers receive \textit{HIGH} type assets, the joint payout will equal 150 points $[\ (50 + 50 = 100); \ 100 + (100*0.5) = 150]$. This joint output will be shared equally. Each manager will get 75 points $[\ 150/2 = 75]$.

If one manager receives a \textit{HIGH} type asset and the other manager receives a \textit{LOW} type asset, the joint payout will equal 120 points $[\ (50 + 30 = 80); \ 80 + (80*0.5) = 120]$. Each manager will get 60 points $[\ 120/2 = 60]$.

If both managers receive \textit{LOW} type assets, the joint payout will equal 90 points $[\ (30 + 30 = 60); \ 60 + (60*0.5) = 90]$. This joint output will be shared equally. Each manager will get 45 points $[\ 90/2 = 45]$.)
HOW TO PLAY THE GAME

SELECTION

You will be asked whether you want to make an investment in either the ALTERNATE bin or the DEFAULT bin. Selection from the ALTERNATE bin will cost 10 points. The ALTERNATE bin returns a HIGH type asset 75% of the time and a LOW type asset 25% of the time. Selection is made by answering the prompt on the screen and typing either D (for DEFAULT bin) or A (for ALTERNATE bin).

After all participants have made their selection for the period, you will find out the value of the asset you received. The computer will determine the asset type you receive based on the probabilities for the DEFAULT and ALTERNATE bins. The environments of the two divisions are correlated. This means that the type of asset you receive depends on the type of asset the other manager gets as well as both bin selections. See the attached diagrams to illustrate the correlations.

The assets received by each manager will be combined to determine the payment you will get each period. If you selected from the ALTERNATE bin, your point balance will be decreased by 10 points and increased by the sharing of the joint payout.

Examples:

If both managers receive HIGH type assets, the joint payout will equal 150 points \[ (50 + 50 = 100);\ 100 + (100*0.5) = 150 \]. This joint output will be shared equally. Each manager will get 75 points \[ 150/2 = 75 \]. If you selected from the ALTERNATE bin, your net increase will be 65 points \[ 75 - 10 = 65 \]. If you selected from the DEFAULT
bin, your net increase will be 75 points \([75 - 0 = 75]\).

If one manager receives a *HIGH* type asset and the other manager receives a *LOW* type asset, the joint payout will equal 120 points \([50 + 30 = 80]; \ 80 + (80 \times 0.5) = 120\). Each manager will get 60 points \([120/2 = 60]\). If you selected from the *ALTERNATE* bin, your net increase will be 50 points \([60 - 10 = 50]\). If you selected from the *DEFAULT* bin, your net increase will be 60 points \([60 - 0 = 60]\).

If both managers receive *LOW* type assets, the joint payout will equal 90 points \((30 + 30 = 60); \ 60 + (60 \times 0.5) = 90\). This joint output will be shared equally. Each manager will get 45 points \([90/2 = 45]\). If you selected from the *ALTERNATE* bin, your net increase will be 35 points \([45 - 10 = 35]\). If you selected from the *DEFAULT* bin, your net increase will be 45 points \([45 - 0 = 45]\).

Due to the availability of each asset type in each bin, each of the above scenarios is possible. They depend on the bin selection made by each manager. If both managers select from the *ALTERNATE* bin and you receive a *HIGH* type asset, the probability that the other manager also receives a *HIGH* type asset is 91.67%. Therefore, if you select from the *ALTERNATE* bin and you receive a *HIGH* type asset, the probability that the other manager receives a *LOW* type asset (if he or she also selects from the *ALTERNATE* bin) is 8.33%. (See attached diagrams for all possible permutations.)

The computer will calculate all the necessary information and then display the results on the right-hand side of your screen until you hit <Enter>. The day number, joint payout, asset types, and your payment (net of any *ALTERNATE* bin selection costs) will be shown. Your updated total point balance will also be displayed.
The left-hand side of the screen will contain the information for the latest market days (up to 15 days). This information will include the day number, your selection, the asset quality you received, and the joint payout realized. Your current point balance will also be displayed at the bottom of the screen.

**COMPUTATION OF PAYMENT**

All participants will be paid in cash at the end of the experiment. You will be paid $0.01 for each point you accumulate in the experiment (including the opening balance of 100 points). Payments will be rounded to the next highest nickel. For example, if your point balance is 1688, you will receive $16.90. You will receive your payment, in cash, upon completion of the post-experimental questionnaire.
**PROBABILITY DIAGRAMS:**

Both select from the *ALTERNATE* bin:

<table>
<thead>
<tr>
<th>Your asset quality:</th>
<th>Other Manager's asset quality:</th>
</tr>
</thead>
<tbody>
<tr>
<td>HIGH</td>
<td>HIGH with Probability</td>
</tr>
<tr>
<td>LOW</td>
<td>25%</td>
</tr>
</tbody>
</table>

You select from the *ALTERNATE* bin; the other manager selects from the *DEFAULT* bin:

<table>
<thead>
<tr>
<th>Your asset quality:</th>
<th>Other Manager's asset quality:</th>
</tr>
</thead>
<tbody>
<tr>
<td>HIGH</td>
<td>HIGH with Probability</td>
</tr>
<tr>
<td>LOW</td>
<td>0%</td>
</tr>
</tbody>
</table>

You select from the *DEFAULT* bin; the other manager selects from the *ALTERNATE* bin:

<table>
<thead>
<tr>
<th>Your asset quality:</th>
<th>Other Manager's asset quality:</th>
</tr>
</thead>
<tbody>
<tr>
<td>HIGH</td>
<td>HIGH with Probability</td>
</tr>
<tr>
<td>LOW</td>
<td>66.67%</td>
</tr>
</tbody>
</table>

Both select from the *DEFAULT* bin:

<table>
<thead>
<tr>
<th>Your asset quality:</th>
<th>Other Manager's asset quality:</th>
</tr>
</thead>
<tbody>
<tr>
<td>HIGH</td>
<td>HIGH with Probability</td>
</tr>
<tr>
<td>LOW</td>
<td>8.33%</td>
</tr>
</tbody>
</table>
APPENDIX I

POST-EXPERIMENTAL QUESTIONNAIRE
CELLS A AND E
POST EXPERIMENTAL QUESTIONNAIRE

Cells A and E

Payment Due: ________

Section 1:

This section deals with questions relating to the actions you expect you (or others) would have taken had the session continued longer. That is, when answering these questions imagine the dice roll did not end the experiment when it did. As in the session, you would continue for an unknown number of periods until the proper dice roll ends the session.

In many of the following questions, you will be asked to respond with an answer expressed as a percentage. Consider the following example. You are asked the probability that you will visit Toronto next year. Let's say that you think there is approximately a 62% chance this will occur. You will be asked to mark anywhere on the line the appropriate probability. The results would look like this:

What is the probability that you will visit Toronto next year? Mark an X on the appropriate place on the line:

<table>
<thead>
<tr>
<th>0%</th>
<th>10%</th>
<th>20%</th>
<th>30%</th>
<th>40%</th>
<th>50%</th>
<th>60%</th>
<th>70%</th>
<th>80%</th>
<th>90%</th>
<th>100%</th>
</tr>
</thead>
</table>

Probability Percentage

All questions of this sort should be answered in this manner.

INSTRUCTIONS: ANSWER THE FOLLOWING.

What is the probability that you would select the ALTERNATE bin this period? Mark an X on the appropriate place on the line:

<table>
<thead>
<tr>
<th>0%</th>
<th>10%</th>
<th>20%</th>
<th>30%</th>
<th>40%</th>
<th>50%</th>
<th>60%</th>
<th>70%</th>
<th>80%</th>
<th>90%</th>
<th>100%</th>
</tr>
</thead>
</table>

Probability Percentage
What is the probability that the other player would select the ALTERNATE bin this period? Mark an X on the appropriate place on the line:

Probabilty Percentage

If the joint output obtained in the last few periods was 150 points, what is the probability that you would select from the ALTERNATE bin? Mark an X on the appropriate place on the line:

Probabilty Percentage

If the joint output obtained in the last few periods was 120 points, what is the probability that you would select from the ALTERNATE bin? Mark an X on the appropriate place on the line:

Probabilty Percentage

If the joint output obtained in the last few periods was 90 points, what is the probability that you would select from the ALTERNATE bin? Mark an X on the appropriate place on the line:

Probabilty Percentage


Section II

This section deals with questions relating to your experiences in the session.
In many of the following questions, you will be asked to respond to the questions by indicating your choice on a scale. This scale will contain an extreme value at each end and a central value to help you determine the location that corresponds to your experience. Consider the following example. You are asked about today's temperature. Let's say that you felt it was just a little on the cool side, but it wasn't cold, you will be asked to mark anywhere on the line that impression. The result would look like this:

How comfortable was today's temperature? Mark an X on the appropriate place on the line:

Too Cold  Neither Cold  Nor Hot  Too Hot

All questions of this sort should be answered in this manner.

INSTRUCTIONS: ANSWER THE FOLLOWING.

By the end of the experiment, how well did you understand the rules of the session? Mark an X on the appropriate place on the line:

Did not Understand  Had "medium" Understanding  Understood Very Well

By the end of the experiment, how comfortable did you feel using the computer? Mark an X on the appropriate place on the line:

Very Uncomfortable  Somewhat Comfortable  Very Comfortable
The computer was used to determine all random outcomes other than the one to end the session. How would you summarize your feelings during the session as to the randomness of these values? Mark an X on the appropriate place on the line:

Not Random Somewhat Random
Random

A dice roll was used to determine when the session would end. How would you summarize your feelings during the session as to the randomness of these rolls? Mark an X on the appropriate place on the line:

Not Random Somewhat Random
Random

Your point balance (which directly affected your cash balance) was affected by your decisions in the session. How would you summarize the importance of your point balance in making your decisions? Mark an X on the appropriate place on the line:

Points were of No Importance Points were one Part of Decisions
Points were of
Sole Importance

You were paired with another player throughout this session. How would you summarize your beliefs as to the quality of the other's decisions? Mark an X on the appropriate place on the line:

Poor Decisions Average Decisions Excellent Decisions
The left-hand side of the screen contained information as to the results of several previous days. How would you summarize the importance of this information in making your decisions? Mark an X on the appropriate place on the line:

Not Important  Somewhat Important  Very Important

Additional Comments:
APPENDIX J

POST-EXPERIMENTAL QUESTIONNAIRE
CELLS B AND E
POST EXPERIMENTAL QUESTIONNAIRE

Cells B and F

Section I:

This section deals with questions relating to the actions you expect you (or others) would have taken had the session continued longer. That is, when answering these questions imagine the dice roll did not end the experiment when it did. As in the session, you would continue for an unknown number of periods until the proper dice roll ends the session.

In many of the following questions, you will be asked to respond with an answer expressed as a percentage. Consider the following example. You are asked the probability that you will visit Toronto next year. Let's say that you think there is approximately a 62% chance this will occur. You will be asked to mark anywhere on the line the appropriate probability. The results would look like this:

What is the probability that you will visit Toronto next year? Mark an X on the appropriate place on the line:

```
0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%
```

Probability Percentage

All questions of this sort should be answered in this manner.

INSTRUCTIONS: ANSWER THE FOLLOWING.

If your asset was a HIGH type and the joint output obtained in the last few periods was 150 points, what is the probability that you selected from the ALTERNATE bin? Mark an X on the appropriate place on the line:

```
0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%
```

Probability Percentage
If your asset was a HIGH type and the joint output obtained in the last few periods was 120 points, what is the probability that you selected from the ALTERNATE bin? Mark an X on the appropriate place on the line:

![Probability Percentage Diagram](image)

If your asset was a LOW type and the joint output obtained in the last few periods was 120 points, what is the probability that you selected from the ALTERNATE bin? Mark an X on the appropriate place on the line:

![Probability Percentage Diagram](image)

If your asset was a LOW type and the joint output obtained in the last few periods was 90 points, what is the probability that you selected from the ALTERNATE bin? Mark an X on the appropriate place on the line:

![Probability Percentage Diagram](image)

What is the probability that you would select the ALTERNATE bin this period? Mark an X on the appropriate place on the line:

![Probability Percentage Diagram](image)
What is the probability that the other player would select the ALTERNATE bin this period? Mark an X on the appropriate place on the line:

[Diagram with probability scale from 0% to 100%]

If the joint output obtained in the last few periods was 150 points, what is the probability that you would select from the ALTERNATE bin? Mark an X on the appropriate place on the line:

[Diagram with probability scale from 0% to 100%]

If the joint output obtained in the last few periods was 120 points, what is the probability that you would select from the ALTERNATE bin? Mark an X on the appropriate place on the line:

[Diagram with probability scale from 0% to 100%]

If the joint output obtained in the last few periods was 90 points, what is the probability that you would select from the ALTERNATE bin? Mark an X on the appropriate place on the line:

[Diagram with probability scale from 0% to 100%]
Section II

This section deals with questions relating to your experiences in the session.
In many of the following questions, you will be asked to respond to the questions by indicating your choice on a scale. This scale will contain an extreme value at each end and a central value to help you determine the location that corresponds to your experience. Consider the following example. You are asked about today's temperature. Let's say that you felt it was just a little on the cool side, but it wasn't cold, you will be asked to mark anywhere on the line that impression. The result would look like this:

How comfortable was today's temperature? Mark an X on the appropriate place on the line:

Too Cold  Neither Cold  Nor Hot  Too Hot

All questions of this sort should be answered in this manner.

INSTRUCTIONS: ANSWER THE FOLLOWING.

By the end of the experiment, how well did you understand the rules of the session? Mark an X on the appropriate place on the line:

Did not Understand  Had "medium" Understanding  Understood Very Well

By the end of the experiment, how comfortable did you feel using the computer? Mark an X on the appropriate place on the line:

Very Uncomfortable  Somewhat Comfortable  Very Comfortable
The computer was used to determine all random outcomes other than the one to end the session. How would you summarize your feelings during the session as to the randomness of these values? Mark an X on the appropriate place on the line:

```
Not              Somewhat              Random
Random           Random
```

A dice roll was used to determine when the session would end. How would you summarize your feelings during the session as to the randomness of these rolls? Mark an X on the appropriate place on the line:

```
Not              Somewhat              Random
Random           Random
```

Your point balance (which directly affected your cash balance) was affected by your decisions in the session. How would you summarize the importance of your point balance in making your decisions? Mark an X on the appropriate place on the line:

```
Points were of No Importance Points were one Part of Decisions Points were of Sole Importance
```

You were paired with another player throughout this session. How would you summarize your beliefs as to the quality of the other's decisions? Mark an X on the appropriate place on the line:

```
Poor Decisions Average Decisions Excellent Decisions
```
The left-hand side of the screen contained information as to the results of several previous days. How would you summarize the importance of this information in making your decisions? Mark an X on the appropriate place on the line:

Not Important  Somewhat Important  Very Important

Additional Comments:
APPENDIX K

POST-EXPERIMENTAL QUESTIONNAIRE
CELL C
**POST EXPERIMENTAL QUESTIONNAIRE**

**Cell C**

Payment Due: 

**Section I:**

This section deals with questions relating to the actions you expect you (or others) would have taken had the session continued longer. That is, when answering these questions imagine the dice roll did not end the experiment when it did. As in the session, you would continue for an unknown number of periods until the proper dice roll ends the session.

In many of the following questions, you will be asked to respond with an answer expressed as a percentage. Consider the following example. You are asked the probability that you will visit Toronto next year. Let's say that you think there is approximately a 62% chance this will occur. You will be asked to mark anywhere on the line the appropriate probability. The results would look like this:

What is the probability that you will visit Toronto next year? Mark an X on the appropriate place on the line:

```
0%  10%  20%  30%  40%  50%  60%  70%  80%  90%  100%
```

Probability Percentage

All questions of this sort should be answered in this manner.

**INSTRUCTIONS: ANSWER THE FOLLOWING.**

*Bin Disclosure:*

*Your Actions:*

What is the probability that you would choose to disclose selection of the ALTERNATE bin this period? Mark an X on the appropriate place on the line:

```
0%  10%  20%  30%  40%  50%  60%  70%  80%  90%  100%
```

Probability Percentage
The Other Player's Actions:
What is the probability that the other player disclosed a selection from the ALTERNATE bin this period? Mark an X on the appropriate place on the line:

\[
\begin{array}{cccccccccccc}
0\% & 10\% & 20\% & 30\% & 40\% & 50\% & 60\% & 70\% & 80\% & 90\% & 100\% \\
\end{array}
\]
Probability Percentage

Bin Selection:
Your Actions:
If you disclosed selection from the ALTERNATE bin this period, what is the probability that you would select the ALTERNATE bin this period? Mark an X on the appropriate place on the line:

\[
\begin{array}{cccccccccccc}
0\% & 10\% & 20\% & 30\% & 40\% & 50\% & 60\% & 70\% & 80\% & 90\% & 100\% \\
\end{array}
\]
Probability Percentage

Given that you disclosed selection from the ALTERNATE bin:
If the other player disclosed selection from the ALTERNATE bin this period, what is the probability that you would select the ALTERNATE bin this period? Mark an X on the appropriate place on the line:

\[
\begin{array}{cccccccccccc}
0\% & 10\% & 20\% & 30\% & 40\% & 50\% & 60\% & 70\% & 80\% & 90\% & 100\% \\
\end{array}
\]
Probability Percentage

Given that you disclosed selection from the DEFAULT bin:
If the other player disclosed selection from the ALTERNATE bin this period, what is the probability that you would select the ALTERNATE bin this period? Mark an X on the appropriate place on the line:

\[
\begin{array}{cccccccccccc}
0\% & 10\% & 20\% & 30\% & 40\% & 50\% & 60\% & 70\% & 80\% & 90\% & 100\% \\
\end{array}
\]
Probability Percentage
The Other Player's Actions

If the other player disclosed selection from the ALTERNATE bin this period, what is the probability that the other player would select the ALTERNATE bin this period? Mark an X on the appropriate place on the line:

[Diagram of a scale from 0% to 100%, marked at intervals]

Probability Percentage

If the joint output obtained in the last few periods was 150 points, what is the probability that you would select from the ALTERNATE bin? Mark an X on the appropriate place on the line:

[Diagram of a scale from 0% to 100%, marked at intervals]

Probability Percentage

If the joint output obtained in the last few periods was 120 points, what is the probability that you would select from the ALTERNATE bin? Mark an X on the appropriate place on the line:

[Diagram of a scale from 0% to 100%, marked at intervals]

Probability Percentage

If the joint output obtained in the last few periods was 90 points, what is the probability that you would select from the ALTERNATE bin? Mark an X on the appropriate place on the line:

[Diagram of a scale from 0% to 100%, marked at intervals]

Probability Percentage
Section II
This section deals with questions relating to your experiences in the session.
In many of the following questions, you will be asked to respond to the questions
by indicating your choice on a scale. This scale will contain an extreme value at each end
and a central value to help you determine the location that corresponds to your
experience. Consider the following example. You are asked about today's temperature.
Let's say that you felt it was just a little on the cool side, but it wasn't cold, you will be
asked to mark anywhere on the line that impression. The result would look like this.

How comfortable was today's temperature? Mark an X on the appropriate place on the
line:

Too Cold  Neither Cold  Nor Hot  Too Hot

All questions of this sort should be answered in this manner.

INSTRUCTIONS: ANSWER THE FOLLOWING.

By the end of the experiment, how well did you understand the rules of the session?
Mark an X on the appropriate place on the line:

Did not  Had "medium"  Understood
Understand  Understanding  Very Well

By the end of the experiment, how comfortable did you feel using the computer? Mark
an X on the appropriate place on the line:

Very  Somewhat  Very
Uncomfortable  Comfortable  Comfortable
The computer was used to determine all random outcomes other than the one to end the session. How would you summarize your feelings during the session as to the randomness of these values? Mark an X on the appropriate place on the line:

Not Random
Somewhat Random

A dice roll was used to determine when the session would end. How would you summarize your feelings during the session as to the randomness of these rolls? Mark an X on the appropriate place on the line:

Not Random
Somewhat Random

Your point balance (which directly affected your cash balance) was affected by your decisions in the session. How would you summarize the importance of your point balance in making your decisions? Mark an X on the appropriate place on the line:

Points were of No Importance
Points were one Part of Decisions
Points were of Sole Importance

You were paired with another player throughout this session. How would you summarize your beliefs as to the quality of the other's decisions? Mark an X on the appropriate place on the line:

Poor Decisions
Average Decisions
Excellent Decisions
The left-hand side of the screen contained information as to the results of several previous days. How would you summarize the importance of this information in making your decisions? Mark an X on the appropriate place on the line:

[Diagram with a scale from Not Important to Very Important]

Additional Comments:
APPENDIX L

POST-EXPERIMENTAL QUESTIONNAIRE
CELL D
POST EXPERIMENTAL QUESTIONNAIRE

Celî D

Payment Due: __________

Section I:

This section deals with questions relating to the actions you expect you (or others) would have taken had the session continued longer. That is, when answering these questions imagine the dice roll did not end the experiment when it did. As in the session, you would continue for an unknown number of periods until the proper dice roll ends the session.

In many of the following questions, you will be asked to respond with an answer expressed as a percentage. Consider the following example. You are asked the probability that you will visit Toronto next year. Let's say that you think there is approximately a 62% chance this will occur. You will be asked to mark anywhere on the line the appropriate probability. The results would look like this:

What is the probability that you will visit Toronto next year? Mark an X on the appropriate place on the line:

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

Probability Percentage

All questions of this sort should be answered in this manner.

INSTRUCTIONS: ANSWER THE FOLLOWING.

*Bin Disclosure:*

*Your Actions:*

What is the probability that you would choose to disclose selection of the ALTERNATE bin this period? Mark an X on the appropriate place on the line:

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

Probability Percentage
The Other Player's Actions:
What is the probability that the other player disclosed a selection from the ALTERNATE bin this period? Mark an X on the appropriate place on the line:

```
0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%
```
Probability Percentage

Bin Selection:
Your Actions:
If you disclosed selection from the ALTERNATE bin this period, what is the probability that you would select the ALTERNATE bin this period? Mark an X on the appropriate place on the line:

```
0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%
```
Probability Percentage

Given that you disclosed selection from the ALTERNATE bin:
If the other player disclosed selection from the ALTERNATE bin this period, what is the probability that you would select the ALTERNATE bin this period? Mark an X on the appropriate place on the line:

```
0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%
```
Probability Percentage

Given that you disclosed selection from the DEFAULT bin:
If the other player disclosed selection from the ALTERNATE bin this period, what is the probability that you would select the ALTERNATE bin this period? Mark an X on the appropriate place on the line:

```
0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%
```
Probability Percentage
The Other Player’s Actions

If the other player disclosed selection from the ALTERNATE bin this period, what is the probability that the other player would select the ALTERNATE bin this period? Mark an X on the appropriate place on the line:

Probability Percentage

If your asset was a HIGH type and the joint output obtained in the last few periods was 150 points, what is the probability that you selected from the ALTERNATE bin? Mark an X on the appropriate place on the line:

Probability Percentage

If your asset was a HIGH type and the joint output obtained in the last few periods was 120 points, what is the probability that you selected from the ALTERNATE bin? Mark an X on the appropriate place on the line:

Probability Percentage

If your asset was a LOW type and the joint output obtained in the last few periods was 120 points, what is the probability that you selected from the ALTERNATE bin? Mark an X on the appropriate place on the line:

Probability Percentage
If your asset was a LOW type and the joint output obtained in the last few periods was 90 points, what is the probability that you selected from the ALTERNATE bin? Mark an X on the appropriate place on the line:

Probability Percentage

If the joint output obtained in the last few periods was 150 points, what is the probability that you would select from the ALTERNATE bin? Mark an X on the appropriate place on the line:

Probability Percentage

If the joint output obtained in the last few periods was 120 points, what is the probability that you would select from the ALTERNATE bin? Mark an X on the appropriate place on the line:

Probability Percentage

If the joint output obtained in the last few periods was 90 points, what is the probability that you would select from the ALTERNATE bin? Mark an X on the appropriate place on the line:

Probability Percentage
Section II

This section deals with questions relating to your experiences in the session.

In many of the following questions, you will be asked to respond to the questions by indicating your choice on a scale. This scale will contain an extreme value at each end and a central value to help you determine the location that corresponds to your experience. Consider the following example. You are asked about today's temperature. Let's say that you felt it was just a little on the cool side, but it wasn't cold, you will be asked to mark anywhere on the line that impression. The result would look like this:

How comfortable was today's temperature? Mark an X on the appropriate place on the line:

Too Cold  Neither Cold Nor Hot  Too Hot

All questions of this sort should be answered in this manner.

INSTRUCTIONS: ANSWER THE FOLLOWING.

By the end of the experiment, how well did you understand the rules of the session? Mark an X on the appropriate place on the line:

Did not Understand  Had "medium" Understanding  Understood Very Well

By the end of the experiment, how comfortable did you feel using the computer? Mark an X on the appropriate place on the line:

Very Uncomfortable  Somewhat Comfortable  Very Comfortable
The computer was used to determine all random outcomes other than the one to end the session. How would you summarize your feelings during the session as to the randomness of these values? Mark an X on the appropriate place on the line:

Not Random
Somewhat Random
Random

A dice roll was used to determine when the session would end. How would you summarize your feelings during the session as to the randomness of these rolls? Mark an X on the appropriate place on the line:

Not Random
Somewhat Random
Random

Your point balance (which directly affected your cash balance) was affected by your decisions in the session. How would you summarize the importance of your point balance in making your decisions? Mark an X on the appropriate place on the line:

Points were of No Importance
Points were one Part of Decisions
Points were of Sole Importance

You were paired with another player throughout this session. How would you summarize your beliefs as to the quality of the other's decisions? Mark an X on the appropriate place on the line:

Poor Decisions Average Decisions Excellent Decisions
The left-hand side of the screen contained information as to the results of several previous days. How would you summarize the importance of this information in making your decisions? Mark an X on the appropriate place on the line:

Not Important  Somewhat Important  Very Important

Additional Comments:
LIST OF REFERENCES


