The effect of bonus-sharing and cohesion on team behaviour and performance

by

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Abstract

Providing workers with a bonus pool based on team performance is a growing practice. Team-based rewards are believed to promote collaboration and, therefore, to increase the success of a team. However, when a bonus pool is equally shared, two workers can receive a same bonus, independent of their contribution to the pool or work effort compared to co-workers. Loss of motivation can result from such an undifferentiated bonus sharing method due to the classic free-rider problem. This paper investigates how different rules for sharing the bonus - equal sharing (ES), sharing based on individual performance (IP), and sharing based on relative performance (RP) – affect the level and mix of helping versus individualistic effort in teams. Team cohesion is incorporated as a mediator between rules and efforts.

This paper develops an agency model of team performance in which each member is accountable for a particular task and in which helping effort increases production and improves efficiency. The model shows the ES rule induces an efficient mix of effort but low levels of both helping and individualistic effort due to free-rider problems. Sharing based on IP induces an efficient level of individualistic effort but low levels of helping effort. Sharing based on RP results in more help than the individual performance case and higher individualistic effort than the equal sharing case. Prior research discourages attempts to differentiate the contributions of various individual team members because it can undermine collective effort. In my model, however, the reduction in collective effort is counterbalanced by the increase in total effort, causing the IP and RP rules to outperform the ES rule.

I incorporate a cohesion parameter in the model; the basic assumption being that cohesion increases the level of effort response among team members. The model shows that, as cohesion increases, the total level of effort and the team performance increases under all three sharing rules, which is consistent with the resources invested by firms to stimulate team spirit. The cohesion parameter increases effort levels and/or improves effort mix, depending on the sharing-rules considered i.e. there is an interaction between cohesion and sharing-rule. In particular, low levels of cohesion are associated with great differences in outcomes - mix and level of effort as well as performance. With high levels of cohesion, however, all bonus-sharing schemes produce similar (optimal) levels of effort and performance.

Hypotheses from the model are subsequently tested with a between-subjects experiment in which teams of students are randomly assigned to a specific bonus-sharing condition. The experiment was conducted with the participation of 487 undergraduate students from a large public university. Each team performed a computerised task for which each member had a distinct knowledge and could interact with other team members. As predicted, the experimental results suggest that individual effort, total effort, and performance are greater under the RP rule than under the ES rule. However, the results suggest no differences (i) in the levels of effort or performance between the ES and IP rules; and (ii) in the mix of effort across all three sharing rules. Only under the RP rule is cohesion positively related to performance. The differences across

rules are not reduced as cohesion increases as hypothesized. On the contrary, the experiment shows that the RP rule outperforms both other rules when cohesion is high.

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Introduction

The popular and academic press frequently notes the increasing use of teamwork in organizations. 68% of Fortune 1000 companies reported that they used self-managing teams and 91% reported that they used employee participation groups in 1993 compared to 28% and 70% respectively in 1987 (Lawler, Mohrman, and Ledford [1995]). Providing workers with a bonus pool based on team performance is also a growing practice. In surveys of the Fortune 1000 companies in 1990, and then in 1993, team-based pay has increased its prevalence in organizations from 59% to 70% in three years time (Anfuso [1995]). However, only 1 to 20% of the workforce in these organizations are included in team-based incentives. Most reports of team-based incentives actually refer to the profit-sharing plans offered to high level managers.

Team-based rewards are believed to promote team-oriented behaviour such as collaboration and communication and, therefore, to increase the success of a team (Cohen [1993], Ledford [1993], Mohrman [1993]). Recent field studies, however, provide little evidence that group incentives are superior to individual incentives. Although group incentives did improve performance when combined with comprehensive performance measurement and team member participation (Scott and Tiessen [1999]), team reward has no significant relationship with manager rating of team performance (Cohen et al. [1996], Campion [1993], Magjuka and Balwin [1991]).

Results from several experiments suggest the relationship between pay scheme and group performance is mediated by a structural element, the task interdependence given by a firm technology. Task interdependence is the degree to which a task induces interaction among group members (Shaw and Guzzo [1987]). In contexts of high task interdependence, group incentives were more productive than individual (French et al. [1977]) and competitive incentives (Miller and Hamblin [1963], Weinsteen and Holzbach [1972], Scott and Cherrington [1974], French et al. [1977], Rosenbaum et al. [1980]). In contexts of low task interdependence, competitive incentives are more productive than group incentives (Weinsteen and Holzbach [1972], Scott and Cherrington [1974]). Miller and Hamblin [1963], French et al. [1977], and Rosenbaum et al. [1980], however, found no relationship between pay schemes and performance.

Group incentives are important if people interact with one another in the course of their work and if interactions are productive. Few behavioural studies, however, attempt to assess interaction levels and productivity. Mitchell and Silver [1990] find that cooperative behaviour is about twice as likely to occur when subjects are given group goals rather than individual goals. Ravenscroft and Haka [1996] find that information is shared more frequently and productivity is higher when cooperative incentives are combined with information sharing opportunities. Competitive incentives combined with information sharing opportunities do not yield productivity gains (Ravenscroft and Haka, 1996).

Similarly, economic models show that collective rewards promote information sharing and helping behaviour. Groves [1972] shows that collective rewards are required to induce managers to convey private information about their division's production capacity. Experimental studies address this issue in contexts of resource allocation and transfer-pricing decisions (e.g. Greenberg, Greenberg, and Mahenthiran [1994], Waller and Bishop [1990]). Although the models deal with division managers rather than workers, sharing information to attain collective well-being remains an issue. In the context of teamwork, Drago and Turnbull [1988] show that group rewards always promote helping effort. The offered rationale being that helping behaviour occurs if an individual receives a share of the outcome he has indirectly contributed to. In Drago and Turnbull's model, individual reward can lead to an optimal mix of effort, but only if workers collude (i.e. if they reciprocate help). Rank-order tournaments, however, always prevent helping behaviour. In this case, workers could even collude to expend less effort without reducing their chance of winning (Drago and Turnbull, 1988).

An argument highlighting a dysfunctional aspect of group reward - the free-riding problem - emerges from economic models. Belcher [1987] reports that about 50% of bonus plans distribute the bonus pool based on individual salary; the remainder is shared equally or distributed based on the number of hours worked. Using the number of hours worked in the sharing rule attempts to discriminate based on individual contributions to the bonus pool. However, workers might not control their time schedule and, even if they do, the number of hours worked can be a poor signal of an employee's level of effort. Similarly, salaries can signal the overall value of an employee's contribution to a firm (and therefore to team outcomes) but, again, can be a poor signal of effort.

Such sharing-rules can provide two team members with the same bonus, independent of their contribution to the bonus pool or work effort compared to co-workers. Loss of motivation can result from such an undifferentiated bonus sharing method. Agency models show that collective rewards result in sub-optimal levels of effort due to free-riding problems (Holmstrom [1982]).[1] Free-riding problems are also found in experimental settings (e.g., Nalbantian and Schotter [1997]; Weldon and Mustari [1988]).

Under certain circumstances, free-riding problems can be reduced with monitoring (Alchian and Demsetz [1972]) or budget-breaking contracts (Holmstrom [1982]). Free-riding can also be mitigated with the help of team members. Because groups of workers have better information on individual contributions than the employer, group incentives motivate employees to monitor one another (Milgrom and Roberts [1992]). Besides motivation, team members need a means of motivating each other. In the Arya, Fellingham, and Grover [1997] model, the two-period incentive-contract provides support for peer monitoring. That is, the second-period incentives are designed to allow multiple equilibria such that a manager can credibly punish a first period free rider with the aid of his co-workers. In the Kandel and Lazear [1992] model, social pressures affect team members. Members feel guilt or shame from shirking and cheaters are harassed and eventually excluded from the team. Social pressure provides an implicit incentive in the model, so that collective rewards alone can induce optimal effort levels.

Similarly, social psychology research suggests that group cohesion can provide implicit incentives in teamwork. In a cohesive group, members are attracted to one another and desire to remain part of the group (Cartwright [1968]). According to social psychologists, interaction among team members affects behaviour through mutual influence or through peer pressure. Earlier studies show that group cohesion affects these two phenomena. That is, cohesiveness is associated with communication among group members (Moran [1966], Lott and Lott [1961]), the readiness of group members to be influenced by others in the group (Berkowitz [1954], Schachter [1951]), and the tendency to respond positively to the actions of other group members (French [1941]). Cohesiveness exerts a strong influence upon members to behave in accordance with group expectations (Wyer [1966], Lott and Lott [1961]).

This thesis builds on the behavioural and economic studies above to investigate the effect of bonus sharing and cohesion on team behaviour and performance. Following Drago and Turnbull [1988, 1991], I developed a team model in which each member is accountable for a particular task and in which helping behaviour increases production and improves efficiency. The model is extended to include a team cohesion parameter; the basic assumption being that cohesion increases the level of response among team members. Hypotheses from the model are tested with a between-subjects experiment in which teams of students are randomly assigned to a specific bonus-sharing condition. Each team performs a computerised task for which each member has distinct knowledge and where team members can help each other. A questionnaire is used to assess team cohesion, along with a computer program that records measures of effort and performance during the experiment.

The notion of task interdependence (discussed in behavioural studies above) is central in this model because synergy is created through members' interactions. I consider a technology in which members can provide two types of effort: individual effort that increases their own output and helping effort that increases their co-workers' outputs. As in the Ravenscroft and Haka [1996] and Mitchell and Silver [1990] experiments, I measure and analyse interaction level or assistance among members. However, progress on individual work is also assessed so that a mix of helping and individual effort and total effort can be investigated. This allows investigating the dual effect of group incentives, that is the promotion of helpful

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[1] The rationale is that when team production is equally (arbitrarily) shared among members, each member receives

interactions and mitigating the free-riding problem. The productivity of both effort types is modeled, included in my experimental task, and measured during experimental sessions.[2]

I compare the case where the bonus pool is equally shared with those where the bonus pool is shared based on individual performance and relative performance.[3] Under the individual and the relative performance rules, team members are differentiated by their individual performance; however, individual performance uses an absolute measure of individual performance while relative performance uses a relative measure of performance. In particular, the relative performance rule distributes the bonus pool based on a rank-order of the team members' individual performance.[4] This is not a typical rank-order tournament as in Lazear [1989], Drago and Turnbull [1991], or Ravenscroft and Haka [1996], in which members compete for pre-determined payoffs. I consider a tournament in which members compete for pre-determined shares of the team payoff.

My model produces the following hypotheses. An equally shared bonus pool induces an efficient mix of effort but low levels of both helping and individualistic effort due to free-rider problems. Sharing based on individual performance induces an efficient level of individualistic effort but low levels of helping effort. Sharing based on relative performance results in more help than the individual performance case, and in higher individualistic effort than the equal sharing case did. Attempts to differentiate the contributions of various team members have been discouraged in the literature because it can undermine collective effort (e.g., Hackman [1990]; Shea and Guzzo [1987]). In my model, however, the reduction in collective effort is counterbalanced by the increase in total effort. The introduction of a cohesion parameter to the model shows cohesion increases effort levels and/or improves effort mix, depending on the sharing-rules

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only a share of his contribution to the pool and, therefore, supplies sub-optimal level of effort.

[2] The use of a particular production function in my model allows me to specify the productivity of both effort types that are directly implemented in my experiment.

[3] Equally shared bonus pool is used as a benchmark because it constitutes the status quo in terms of both what is observed in practice (Belcher [1987]) and what is commonly praised in the business press and academic literature.

[4] Basically, the three bonus sharing rules - equal sharing, sharing based on individual performance, and sharing based on relative performance - considered in my thesis correspond, respectively, to a group, individual, and competitive

considered. That is, there is an interaction between cohesion and sharing-rule. In particular, the model shows low levels of cohesion are associated with great differences in outcomes - mix and level of effort as well as performance. With high levels of cohesion, however, all bonus-sharing schemes produce similar (optimal) levels of effort and performance. These findings are consistent with the resources invested by firms to stimulate team spirit.

This thesis contributes to the experimental incentive-contracting literature in management accounting which studies and experimentally tests the ability of different pay schemes to alleviate the adverse selection and moral hazard problems. While most of this literature focuses on single-agent settings (e.g. Chow et al., 1991; Dillard and Fisher, 1990), the papers focussing on multiple-agent settings are typically concerned with inducing managers to convey private information (e.g. Greenberg, Greenberg, and Mahenthiran [1994]; Chalos and Haka [1990]). This thesis differs in that it considers a cohort of workers rather than division managers and focuses on moral-hazard problems rather than on adverse selection problems. Frederickson [1992] considers the moral-hazard problem in a triad of workers, but in a technology where workers are independent of each other. In contrast, I study a technology where helping effort has a positive effect on the team performance.

The remainder of this thesis is organized as follows. Chapter 1 reviews the literature on incentives in teams. Chapter 2 presents a mathematical economic model on teams. The model is used to develop hypotheses to be tested in the experiment. Chapter 3 describes the experimental design and the regression model. Chapter 4 reports the regression results. Finally, the modelled and experimental results are discussed in the conclusion.

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incentive types. These are the three types of incentive commonly discussed in both economic and behavioural literatures.

Chapter 1 - Literature review

As indicated in the introduction, team incentives are the focus of this thesis. Team incentives are directly related to the experimental incentive-contracting literature in management accounting and to the two related bodies of research on teams: one emerging from economics and the other from the social psychology literature. This thesis builds upon these bodies of literature as follows.

The thesis studies and experimentally tests moral-hazard problems in teams, contributing to the experimental incentive-contracting literature in management accounting. Following Drago and Turnbull [1988; 1991], the thesis develops a mathematical economic model on teams in which help increases production and improves efficiency. Based on social psychology (e.g. Shaw [1981]; Deutsch [1968]), a cohesion parameter is incorporated in the model. Since a model's conclusions are essentially driven by its behavioural assumptions, using economic and social insights broadens the scope of the resulting hypotheses. The bonus-sharing rules investigated are typically considered in both economic, and behavioural studies and the modelled results find theoretical and empirical support in both bodies of literature (e.g., Nalbantian and Schotler [1997]; Ravenscroft and Haka [1996]). Combining knowledge from economic and behavioural research allows me to enrich my comprehension of the subject due to the different methodologies and focus used by both disciplines, as discussed below.

This literature review is organised as follows. Section 1.1 provides a brief review of the experimental incentive-contracting literature in management accounting. Sections 1.2 and 1.3 review, respectively, behavioural and economic studies on incentives in teams. Section 1.4 draws evidence from behavioural and economic studies, highlights gaps in the literature, and discusses the contribution of this thesis.

1.1 The experimental incentive-contracting literature in management accounting

The experimental incentive-contracting literature in management accounting focuses on two types of information problems. The first is the moral-hazard problem arising when the agents' actions are unobservable (e.g. unobservable effort).[5] The second is the adverse selection problem arising when the agents possess hidden information (e.g. their skill level or the division's production capacity).[6] The papers in this literature study experimentally test the ability of different pay schemes to alleviate the moral hazard and/or adverse selection problems.

The literature focusing on adverse selection problems is concerned with inducing agents to convey their private information. The papers that consider single-agent settings focus on "self-selection", i.e. offering a menu of contracts such that the agent's selection reveals his information (e.g. Chow [1983], Waller and Chow [1985], Shields et al. [1989], Dillard and Fisher [1990], Shields and Waller [1988]) or on the participatory budget-setting process, in which the agent reveals his information by helping set his performance standard (e.g. Young [1985], Waller [1988], Chow et al. [1988], Chow et al. [1991a][1991b]).[7]

The papers focusing on multiple-agent settings typically consider the divisional versus firm wide performance measurement. In Chalos and Haka [1990] and Greenberg, Greenberg, and Mahenthiran [1994], buying and selling division managers negotiate transfer-prices while possessing private information. In Waller and Bishop [1990], a central manager allocates resources between two divisions based on its production capacity as reported by the division managers. All three papers studied whether alternative pay-

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[5] Moral hazard refers to the case where agents do not supply an optimal level of effort because of personal cost of effort and the difficulty in monitoring effort by managers.

[6] Adverse selection refers to the case where resources are sub-optimally allocated due to lack of information.

[7] These papers look at whether the subordinate creates budgetary slack either by building excess resources in the budget or knowingly underestimating their production capacities. They typically compare truth-inducing with more traditional pay schemes.

schemes (division incentive versus firm incentive schemes) affect the profit of the firm as a whole.[8] The theoretical argument being that division incentives motivate managers to maximise the performance of their division (implying the possibility of hidden information) at the expense of each other or the firm as a whole. On the other hand, firm incentives motivate managers to reveal private information in order to maximise the firm's benefit, which aligns the interests of both managers and owners. Experimental results were mixed.[9]

The second part of the literature focuses on the moral-hazard problem and is concerned with inducing agents to supply the optimal level of effort. Some papers consider single-agent settings and look at whether alternative pay schemes affect an agent's performance, while attempting to control for his skill levels and risk-preference (e.g., Chow [1983]; Dillard and Fisher [1990]). Frederickson [1992] considers a multiple-agent setting. In his paper, production is organized into three separate shifts and agents decide on the amount of units to produce during their own shift (taking into account their personal cost of effort). Workers are paid based on their individual performance (piece-rate scheme) or on their relative performance i.e. when compared to the workers in the two other shifts. Frederickson [1992] studies whether pay scheme and common uncertainty affect agents' level of effort.

Consistent with economic theory, his results suggest that the agent's level of effort is higher under the competitive scheme than under the individual scheme. In addition, increasing the degree of common uncertainty does not affect the agent 's level of effort under the individual scheme but increased it under a competitive scheme. The latter result is not consistent with economic theory but provides evidence for social influence theory - behavioral research. Note that Frederickson [1992] considers a technology where

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[8] More precisely, Chalos and Haka [1990] consider division incentive and mixed-division and firm-incentive schemes. Greenberg, Greenberg, and Mahenthiran [1994] consider division incentive versus firm incentive schemes. Waller and Bishop [1990] consider division profit, division profit-plus-penalty when unfavourable profit variance occurs, and Groves scheme i.e. own division actual profit plus others' division budgeted profit.

[9] In Chalos and Haka [1990], division-incentive induces higher firm profit than mixed-incentive did whereas in Greenberg, Greenberg, and Mahenthiran [1994], firm-incentive induces higher firm profit in cases of both high and low interdependence between the trading divisions. In Waller and Bishop [1990], misrepresentation of private information

workers are independent of each other and uses anonymity to control for social pressures and peer influences.

In conclusion, despite the growing use of teamwork and team-related pay in organizations, most of the experimental incentive-contracting literature in management accounting focuses on single-agent settings. Young and Lewis [1995] highlight the need for more studies on teams: "A relevant aspect for incentive-contracting research relates to how new business practices are affecting the design of compensation schemes. . . . Consistent with the movement to teams, gainsharing incentive mechanisms represent a largely unexplored area of research" (74). Building upon evidence from both behavioural and economic research on incentives in teams, this thesis investigates moral-hazard problems in a technology where mutual help is productive. The contribution from the behavioural research is reviewed next.

1.2 Contributions from behavioral research

This section is organized as follows. Sub-sections 1.2.1, 1.2.2, and 1.2.3 review studies that investigate the relationship between pay scheme and group performance. In particular, sub-section 1.2.2 introduces the notion of task interdependence and presents studies using this notion to mediate the relationship between pay and performance. In sub-section 1.2.3, studies stress the effect of incentives on individual versus collective action in group production. Finally, sub-section 1.2.4 reviews the literature on group cohesion and discusses how it relates to incentives in teams.

1.2.1 Relationship between pay scheme and group performance

Recent field studies investigating the relationship between group incentives and team performance show mixed results. In particular, team rewards have no significant relationship with manager ratings of performance (Campion et al. [1993]; Cohen et al. [1996]; Magjuka and Baldwin [1991]) or team ratings of performance (Campion et al. [1993]; Magjuka and Baldwin [1991]). Cohen et al. [1996] did find however,

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and resource consumption rather than investment of resources were both higher under the Groves scheme than under that management recognition (including performance-contingent rewards) is positively associated with team ratings of performance. Shea and Guzzo [1987] studied the effect of implementing team bonuses (using pre-and post- intervention measures) and found that team rewards increase customer service, but not sales. Finally, Scott and Tiessen [1999] found that team performance substantially improves when comprehensive performance measurement is combined with the participation of team members and a larger weight on team performance in compensation schemes. One explanation for these mixed results is differences in technology, as discussed in the following sub-section.

1.2.2 Task interdependence given by a firm technology

Researchers argue that the relationship between pay scheme and group performance is moderated by a structural element, the task interdependence given by a firm technology (e.g., Shaw and Guzzo [1987]). Task interdependence can be defined as the degree to which a task induces interaction among the members of a group (Shaw and Guzzo [1987]). Thompson [1967] identifies three categories of structural interdependence: pooled, sequential, and reciprocal. In a pooled technology, group members work in parallel, having little or no contact with one another. In a sequential technology, each member completes part of a task and passes it along to another member. In a reciprocal technology, members interact frequently in order to do their work. The degree of interaction required among group members depends on how production is organised.

Deutsch [1949] provides strong support for group reward and highlights the inefficient aspects of competition. That is, group rewards are posited to promote mutual assistance, information sharing, and the development of positive feelings among the members of a group.[10] On the contrary, competition is believed

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the division profit-plus-penalty scheme.

[10] Deutsch's [1949] theory of cooperation and competition provides the underlying hypotheses for most behavioural research on rewards in teams. In short, Deutsch states that group rewards (cooperation) result on "promotive" interdependence, i.e. an individual's effective action promotes his co-workers' success. On the other hand, competition results on "contrient" interdependence, i.e. an individual's effective action obstructs his co-workers. Deutsch argues that group rewards motivate more skilled individuals to help and guide less skilled fellow members, whereas

to obstruct such behavior and to stimulate jealousy, suspicion, and even sabotage. Researchers recommend incorporating task interdependence in Deutsch theory because the benefits of group rewards only occur if people interact with one another in the course of their work and if interactions are productive. In the case where people work in parallel, for example, there is no need for mutual assistance or information sharing. Here, competitive rewards could be even more productive if workers are motivated by larger pay. Therefore, it is generally hypothesized that group and competitive rewards would be more productive, respectively, in a context of high task interdependence and in a context of low task interdependence.

Results of experimental studies are fairly consistent with each other and with theory. Miller and Hamblin [1963] find an inverse relation between group productivity and differential rewarding in a context of high task interdependence, but there is no relationship between reward and performance in a context of low task interdependence.[11] The authors conclude that competition provides small incentives at best. However, Weinsteen and Holzbach [1972] and Scott and Cherrington [1974] find that group performance is greater under competitive incentives than under group incentives in contexts of low task interdependence. French et al. [1977] find that subjects increase their performance through group-individual-competitive incentives in the context of high task interdependence.[12] However, Rosenbaum et al.[1980], in a replication of French et

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competition discourages it. Cooperation stimulates the development of positive feelings among people, e.g. friendship and trust, whereas competition induces jealousy and suspicion. Cooperation induces mutual influence, i.e. encourages or pressures people to supply effective actions, whereas competition prohibits such behavior. Finally, individual rewards imply no interdependence. Therefore, individual rewards do not generate suspicion or sabotage, but nor do they induce the positive effects of cooperation i.e. mutual help and assistance.

[11] Miller and Hamblin [1963] considered group, intermediate, and extreme competitive schemes. Under group incentives, members share the group reward equally. Under extreme competition, the most successful member receives two thirds of the group reward, the next most successful member receives one third, and the least successful member receives nothing. Under intermediate competition, the most successful member receives half of the reward, the next most successful member receives one third, and the least successful member receives one sixth.

[12] French et al. [1977] also investigated group, individual, and (extreme) competitive incentives in contexts of high and low task interdependence. Rewards are distributed equally (group incentive), in relation to the contribution (individual incentive), or only to the most productive group member who is rewarded according to his own contribution (extreme competitive incentive).

al. [1977], find that group and individual incentives are associated with greater productivity than competitive incentives, but group and individual incentives do not differ from each other. There is no relationship between reward and performance in the context of low task interdependence. This result is compelling given that an extreme competitive incentive is provided i.e. only the best member gets rewarded.

Rosenbaum et al. [1980] extended French et al. [1977] to include work process variables. In the context of high task interdependence, three subjects worked together to build a single tower and in the context of low task interdependence, each subject builds his / her own tower. Each subject receives blocks of a specific colour allowing the assessment of individual contributions. Performance is measured by the number of blocks in a tower standing at the end of the exercise. Rosenbaum et al. [1980] assess process variables such as total blocks handled, efficiency of work, falls, turn taking, and differential input by individual group member. Their results indicate that in the context of low task interdependence, the number of blocks handled increased through the group-individual-competitive incentives. Efficiency (the number of blocks in a tower divided by the total number of blocks handled) was significantly higher under group and individual incentives than under competition. Falling towers were significantly more frequent under individual and competitive incentives. These results can suggest a negative effect of competition on the quality of work; alternatively, they can underline the use of an experimental task for which rapidity (potential proxy for motivation to succeed) is counter-productive due to the risk of falls.

A central element in these studies is the consideration of two "pure" forms of technology. That is, a technology where each subject works alone on an individual task and a technology where subjects work together on a common task. Results strongly suggest group rewards to be more productive with collective production and competitive rewards appear weakly superior with individual work. However, few insights are provided on the best reward for a more "hybrid" technology i.e. a technology requiring both collective and individual action.

In a field study, Wageman [1995] intervened in the reward system at a large U.S. corporation, creating group, individual, and hybrid (a mixture of group and individual) rewards for 150 existing teams of technicians with group, individual, and hybrid tasks. Results suggest that the highest performing groups are those whose rewards and tasks has either pure group or pure individual designs. Groups with hybrid designs (where tasks and / or rewards have both individual and group elements) performed poorly, and had low quality interaction along with low member satisfaction. Wageman [1995] was unable to identify a superior scheme with hybrid designs, nor could she find a theoretical argument from the literature to explain her results. Overall, Wageman [1995] deplored the little attention given to hybrid technology in the literature, despite the prevalence of jobs requiring both collective and individual action (151). In the following sub-section, I review studies that distinguish between collective and individual behaviour in workgroups and look at how these behaviours are affected by alternative incentives.

1.2.3 Incentive effect on collective versus individual behaviour

Mitchell and Silver [1990] investigate collective and individualistic behaviour in workgroups. Using the same task as French et al. [1977] and Rosenbaum et al. [1980] (in a context of high task interdependence), Mitchell and Silver differentiate between cooperative behaviour such as taking turns or balancing the tower from competitive behaviour such as trying to go first or putting blocks on quickly without regard for the others.[13] Results suggest that cooperative behaviour is about twice as likely to occur when subjects are given group, mixed (group and individual), or no goals than when they are given individual goals. Moreover, the number of falls is significantly higher when subjects are given individual goals than in the other three conditions, whereas turn taking is significantly lower.

Ravenscroft and Haka [1996] studied whether (group and competitive) incentives and information sharing opportunities affect task-related information sharing and team productivity. In their experiment, subjects are assigned to three-person teams in which each member must complete a series of progressive

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[13] Mitchell and Silver [1990] investigate whether alternative goal setting conditions (individual goal, group goal, mixed – individual and group, and no specific goal conditions affect task strategies (cooperative and competitive strategies) and group performance.

matrices.[14] In the cooperative condition, subjects are rewarded based on the performance of their team, whereas in the competitive condition, team members are rewarded based on their relative performance (a rank-order tournament). Specifically, members receive pre-determined payoffs based on their rank-ordering performance within the team. Finally, a group of subjects are allowed to exchange information (answers or explanations) with the other team members, while a second group of subjects worked in isolation.[15] Results suggest that information is shared more frequently and productivity is higher when cooperative incentives are combined with opportunity to share information. Competitive incentives combined with information sharing opportunities did not yield productivity gains.

The results above suggest that group reward is positively related to cooperation and to group productivity. Such results depend on the use of experimental tasks for which cooperation is productive. In Young et al. [1993], four-person teams were organised into production lines to build Lego-castles and all subjects are rewarded based on team performance. In the cooperative condition, subjects are allowed to move along the production line to help other members of their team, whereas in the non-cooperative condition team members worked in isolation. Contrary to expectations, subjects in the non-cooperative condition outperformed subjects in the cooperative one. According to Young et al [1993], subjects spent time walking from their work stations to help and encourage each other instead of focusing on their task. Their results can be due to the nature of the experimental task, that is, a Lego-like construction task for which all the subjects are well-trained (Ravenscroft and Haka [1996] 125). Advantages to interacting are possible only if members can share some resource - knowledge or expertise (Libby and Luft [1993] 439).

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[14] A progressive matrix task presents a visual sequence of abstract shapes or symbols that the subject is required to complete by making one of several choices.

[15] Progressive matrices are chosen because they can benefit from information sharing, yet can be completed individually. Actually, pilot-testing shows that fairly brief explanations could significantly improve performance.

1.2.4 The effect of cohesiveness

A cohesive group is one in which members are attracted to one another and want to remain part of the group (Cartwright [1968]). This definition captures the basic understanding of cohesion in the literature. However, many definitions can be found (Murdack [1989] provides a chronological review). The first set of definitions appeared in the 1950s, as group cohesiveness became a popular theme in the social psychology literature. After being almost forgotten in the mid-1960s, the theme of group cohesiveness reappeared in contemporary literature. However, contemporary studies describe cohesiveness in different ways, often focusing on specific dimensions of the concept. Muller and Cooper [1994] identify three dimensions of cohesiveness in the literature: interpersonal attraction, commitment to the task, and group pride.

The social psychology literature shows that cohesiveness can significantly affect group performance. Three recent meta-analyses of the relationship between cohesiveness and group performance (Evans and Dion [1991], Muller and Cooper [1994], and Gully et al. [1995]) find a significant and positive relationship between the two concepts. Moreover, recent field studies (not included in the meta-analyses) suggest consistent results. Cohesiveness is found to be a positive predictor of hospital treatment team performance (Vinokur-Kaplan [1995]), customer service behaviour in retail sales groups (George and Bettenhausen [1990]), and departmental efficiency (Seers et al. [1995]). Moreover, Mullen and Cooper [1994] and Karayaman and Nath [1984] find that *task requirement* moderates the relationship between group cohesion and performance. Cohesive groups are particularly productive when the task involves a high degree of interaction, communication, and mutual monitoring. This literature suggests that group cohesion can be particularly important with technologies where assistance is efficient.

Social psychologists clearly distinguish between a group and a set of individuals. According to Shaw [1981], "there must be a minimum degree of cohesiveness if the group is to continue functioning as a group. To the extent that this minimum requirement is exceeded, one could expect that the degree of cohesiveness will be related to the other aspect of group processes" (p.216). Functioning as a group implies that workers affect each other's behaviour. This effect can culminate through *mutual influence* or through *peer pressure* - two phenomena affected by group cohesion in earlier studies.

Members of high-cohesive groups have a higher level of communication than members of low-cohesive groups, despite similar opportunities to interact (Back [1951], French [1941], Lott and Lott [1961], Moran [1966]). Members of high-cohesive groups are more influenced by other group members (Berkowitz [1954]; Schachter et al. [1951]), change their opinions in the direction of their partner's opinions (Back 1951), and conform to the judgement of the majority more often than do members of low-cohesive groups (Bovard 1951, Lott and Lott 1961, Wyer 1966). Deutsch [1968] notes that cohesiveness is associated with communication among group members, the readiness of group members to be influenced by others in the group, and the tendency to respond positively to the actions of other group members.

Convergent behaviours could also result from peer pressure. Team members know more about the individual contributions of their cohort than the employer does. Group incentives than motivate the employees to monitor one another and to encourage effort provision or other appropriate behaviour (Milgrom and Roberts [1992] p.416). French [1941] suggests that cohesiveness exerts strong influences upon members to behave in accordance with group expectations. French notes that members of cohesive groups are motivated to respond positively to others in the group, and their behaviour should reflect this motivation.

In conclusion, the behavioural studies reviewed highlight the importance of "task interdependence" in studying compensation schemes. While competitive rewards are more productive with individual production (e.g., Scott and Cherrington [1974]), group rewards are more productive with collective production (e.g., Rosenbaum et al. [1980]), which might be due to the fact that group rewards promote cooperative behaviour (e.g., Ravenscroft and Haka [1996]). In addition, workers who interact may develop some level of cohesion, which should provide additional incentives in production.

The next section reviews studies on incentives in teams from economics. In these studies, the team technology is formally defined (i.e. using a mathematical function) and the effects of incentive schemes systematically derived from a series of modelled assumptions, as discussed below.

1.3 Contributions from economics

This section is organised as follows. Sub-section 1.3.1 describes the specifications used in economic models to reflect team technology. Sub-section 1.3.2 reviews studies addressing free-riding issues in teams. Sub-section 1.3.3 reviews studies that highlight the trade-off between individual and collective action and demonstrate how incentive schemes affect this trade-off.

1.3.1 Team technology specification

In economic models, the characteristics of a technology are captured by the production function.[16] Various functions can be used to reflect team production. Broadly, team technology can refer to any set of individuals contributing to a common output (e.g., people working for the same firm). Some studies on teams focus on firms with two divisions or business unit managers and are usually concerned with resource allocation or transfer pricing decisions when managers have private knowledge about their own divisions (e.g., Greenberg, Greenberg, and Mahenthiran [1994]; Chalos and Haka [1990]; Waller and Bishop [1990]).[17] Other studies focus on cohorts of workers. Below is a review of the team technology specifications developed in such studies.[18]

Holmstrom [1982] proposes the following general specification for a team technology. Consider a team composed of n members (indexed $i = 1,...,n$) and define Q as the team production, e_i as the effort

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16 The production function specifies the productivity of firm factors of production such as labour i.e. effort, machines, materials, etc.

17 The division managers are usually concerned with making a decision (investment decision or decision concerning the technology) and/or communicating private knowledge to either the principal or the other division manager. The models focus on the incentive for the managers to make optimal decisions and to truthfully communicate knowledge.

18 Of course, some intuitive parallels could exist between both types of models, especially when there are interdependencies among the two divisions investigated (e.g., Anctil [1995]; Bushman, Indjejikian, and Smith [1995]).

provided by member i, and **e** as the N-dimensional vector of members' effort. A team technology is defined as Q = f(**e**) which is non-separable in e_i. Technological interdependence is implicit in Holmstrom's definition since members' efforts are non-separable. However, the nature of such interdependence is not specified in the function.

Fisher [1994] proposes specifications for Thompson [1967] group structural categories. In a pooled technology, each member (individually) contributes to the group performance given his or her skill level. Fisher modelled this technology using an additive function $Q = \sum a_i e_i$ where a_i captures member i 's skills level. In a sequential technology, group performance is constrained by the less skilled member. In a maximum technology, however, it is the more skilled member who drives group performance. [19] The sequential technology is captured by a conjunctive production function $Q = \min [a_i e_i]$ where min is the minimum element of the function, and the maximum technology is captured by a disjunctive function $Q = \max [a_i e_i]$ where max is the maximum element of the function.

Assuming various skill levels, Fisher [1994] identifies key members in team productivity for each specifications. [20] Fisher does not specify a particular production function for reciprocal technology (which is the technology investigated in this thesis), mentioning that a function of any form – additive, disjunctive, conjunctive, Cobb-Douglass, etc. – could be used. Given that members working with reciprocal technologies interact frequently in the course of their work, the technology specification should reflect the nature and productivity of these interactions.

In Tjosvold [1990], employees described recent interactions with co-workers and identify specific resources of the other person they valued the most. Results indicate that the information-knowledge, effort-assistance, emotional support, authority, funding, and evaluation accounted for the vast majority of valued resources. Information sharing and help are the most cited reasons for interaction. From an economic

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[19] Fisher [1994] adds a "maximum technology" to Thompson[1967] original structural category. High performers are the determinant members in maximum technologies (e.g., a research team).

[20] Based on economics rationale, Fisher [1994] argues that individual incentives motivate all agents given their skills levels, and that group incentives motivate high skilled agents to monitor low skilled agents to work harder.

perspective, the main difference between sharing information and helping a co-worker is that helping is costly in terms of effort (cost from which results the free-riding problem discussed in sub-section 1.3.2).

Models including both individual and helping efforts were developed in the tournament literature (a branch of game theory). In these models (e.g., Drago and Turnbull [1988; 1991]), each member has a production function $q_i = f(e_i, h_j)\ \forall\ j \neq i$, where e_i is worker i's individual effort and h_j is the help from his co-workers, and team performance is the sum of all q_i. This specification makes explicit the interactions among members through helping effort. It also allows for testing the effect of pay schemes on both individual and collective actions, which is the focus of sub-section 1.3.3. Thus, before presenting this research, the next section describes the free-riding problem.

1.3.2 Free riding problem and social influences

Alchian and Demsetz's [1972] seminal paper on teamwork describes the free-riding problem implicit to team production. Alchian and Demsetz [1972] define a team as a group of people working in a co-operative way and illustrate this definition with the example of two people jointly lifting heavy cargo into trucks (779). According to the authors, a team has two dominant characteristics: (i) it has a production function that dominates (at least at one point) the sum of the separate production functions of its members, and (ii) individual contributions cannot be identified.[21] The first characteristic provides a reason for teamwork, i.e. the creation of synergies among the members of the team. The second characteristic creates the setting for the free-rider problem.[22]

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[21] There are two main definitions of a team used in the economic literature: one is from Marschak [1955] and the other from Alchian and Demsetz [1972]. In Marschak's model, each manager makes local decisions using observed information as well as information communicated by the other team members. Team theory assumes that people unilaterally behave in the best interest of the team, and the team is concerned with the information structure that facilitates optimal decisions. Although more recent studies extended team theory to consider incentives issues, the focus usually remains on decision making and information sharing (e.g. Groves [1973]).

[22] In a teamwork setting, the free-rider problem refers to situations where workers provide sub-optimal levels of effort at the expense of their co-workers.

Holmstrom [1982] formally demonstrates the free-riding problem implicit in teamwork, i.e. there is no way to share the team production Q among the members that induces optimal effort e_i. When team production is equally (arbitrarily) shared among members, each member receives only a share of his contribution. Optimal effort levels are provided when members receive their marginal contribution. Agency problems occur because marginal contribution cannot be identified. Note that the Cournot assumption (i.e. the assumption that team members do not react to each other's effort) is necessary to demonstrate the free-riding problem.

Several ways to reduce the free-riding problem in team production are proposed in the literature. Alchian and Demsetz [1972] propose a monitoring solution in which the principal supervises the workers. Holmstrom [1982] propose an incentive-pay solution. In particular, Holmstrom shows that under certainty and when the workers' utility function is known, a standard-based contract can induce the first best solution. Other researches (e.g., Arya, Fellingham, and Grover [1997]; Kandel and Lazear [1992]) consider peer influences as another way to reduce free-riding problem. As pointed out by Milgrom and Roberts [1992], "Groups of workers often have much better information about their individual contributions than the employer is able to gather. Group incentives then motivate the employees to monitor one another and to encourage effort provision or other appropriate behaviour" (416). Studies that rely on peers to reduce free-riding are described next.

Arya, Fellingham, and Grover [1997] develop a two-period incentive contract which induces peer monitoring and offsets free-riding problems. In their model, each member works in the first period and promises to work in the second only if the other member does not free-ride in the first period. In other words, managers monitor each other's first-period action and threaten to punish deviant behaviour during the second period. The first period compensation is minimal and would normally induce both managers to shirk. However, the second-period incentives are designed to allow multiple equilibria such that a manager can credibly punish a first period free-rider. Moreover, the penalty in the second period is so high that a manager prefers to work in both periods rather than to free-ride in the first period and be punished in the second. Arya, Fellingham, and Grover [1997] show that peer monitoring provides implicit incentives reducing the need for explicit incentives, and thus the cost of contracting for the firm (as in the first period of their model).[23]

Kandel and Lazear [1992] explore how peer pressure and mutual monitoring can prevent free-rider problems in a profit-sharing context. In Kandel and Lazear's model, the team members could be affected by social pressures. This is reflected in the workers' utility function, so that it becomes $Q(\mathbf{e})/N - C(e_i) - P(e_i)$, where $C(e_i)$ is the usual cost of effort and $P(e_i)$ is the cost of social pressure.[24] In this model, shirking increases moral or social deprivation so that everyone has the incentive to work hard. Peer pressure could arise from the guilt felt by a member who shirks at the expense of his co-workers or from the shame felt by a member who is caught shirking. Peer pressure might also arise from some penalty imposed on a cheater by his peers (e.g., mental or physical harassment that can eventually lead to the exclusion of the cheater from the team).

The studies above analyse the free-riding problem in a technology where all effort directly contributes to the group outcome. The next sub-section considers technologies where agents can provide individual and collective effort and where individual and collective outcomes are produced.

1.3.3 Trade-off between individual and collective effort

Studies from the tournament literature have investigated the effect of pay scheme on the mix of individual and helping effort. Drago and Turnbull [1988] investigated whether group and individual pay schemes affect the mix of individual and helping effort for two different types of workers: those who reciprocate help and those who do not. According to Drago and Turnbull, Japanese workers are the first

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[23] By stipulating rewards allowing multiple equilibria in the second period, the incentive contract provides the workers with the opportunity and means to monitor and punish shirking.

[24] $Q(\mathbf{e})$ and N remain as in Holmstrom [1982]. That is, N is the number of team members, Q is the team production, and $\mathbf{e}$ is the N-dimensional vector of members' effort.

type of workers while Americans are the second type. Their results suggest that optimal effort levels would be induced by different pay schemes, depending on the type of workers. In particular, workers that reciprocate help can obtain an efficient mix of effort under an individual pay scheme. However, group rewards are required for workers that do not reciprocate help.

Other research papers (e.g. Lazear [1989]; Drago and Turnbull [1991]) have also investigated the use of rank-order tournaments in technologies where workers can affect their co-workers output. Lazear [1989] investigates tournaments in technologies where sabotage is possible. Sabotage refers to costly actions by a worker that adversely affect the output of another ($\partial q_i / \partial s_j < 0$), so that it can be interpreted as the opposite of help. Lazear shows that increasing the wage spread between winners and losers increases sabotage; as a consequence, the potential for sabotage decreases the optimal spread.

Drago and Turnbull [1991] compare rank-order tournaments and an individual quota scheme (standard-based scheme) in a technology where help to co-workers is efficient. The authors consider three behavioural modelling assumptions: (i) Cournot behaviour, (ii) partial bargaining (workers bargain or exchange helping effort), and (iii) complete bargaining (workers bargain or exchange all types of effort). Their results show that rank-order tournaments prevent helping effort, regardless of the behavioural modelling assumption. Helping effort either reduces the worker's probability of winning (the Cournot case) or does not affect it (the bargaining cases). In the case where the workers bargain over all effort, tournaments cause them not to work (they collude to expend less effort without reducing their chance of winning). In the case of a Cournot quota scheme, there is no helping since a worker has no incentive to increase someone else's output when he expects nothing in return. In the cases of partial and complete bargaining quota schemes, positive effort is associated with a technically efficient mix of individual and helping effort.

These studies can be summarised as follows. In economic models, the effect of pay scheme on the mix of effort implicitly depends on behavioural assumptions. In Drago and Turnbull [1988], the best incentives for the Japanese and American workers differ because behaviour varies through cultures. In Drago and Turnbull [1991], the best incentive depends on bargaining over effort. From an economic perspective, therefore, conclusions depend on behavioural modelling assumptions. The following section draws evidence from behavioural and economic studies, highlights gaps in the literature, and discusses the contribution of this thesis.

1.4 Literature gaps and thesis contribution

Similar concerns and evidence can be drawn from the economic and behavioural studies reviewed. All studies share a common goal, that is a better understanding of the relationship between pay scheme and group performance. Studies from both literatures cover similar pay schemes, i.e. group incentives (in which individual pay depends on group performance), individual incentives (in which individual pay depends on individual performance), and competitive schemes (in which individual pay depend on individual performance relative to the performance of others). The notion of task interdependence is emphasized in both literatures; the relevance of a particular pay scheme depending on the type of technology considered, and the level of interaction required by a task.

Most studies reviewed focus on pure technology types. In several economic studies (e.g., Arya, Fellingham, and Grover [1997]; Kandel and Lazear [1992]; Holmstrom [1982]), team technology is defined as a group of people working together to a common task. The degree of interdependence is such that individual contribution cannot be identified, thus preventing the use of individual or competitive schemes. The behavioural experiments reviewed typically compare a pure group technology with a technology in which people worked individually and often isolated from one another. As an example, several studies use the classic Lego-blocks experimental tasks in which triads build a tower cooperatively (high task interdependence) or three single-towers (low task interdependence) (e.g., Mitchell and Silver [1990]; Rosenbaum et al. [1980]; French et al. [1977]).

This thesis investigates a technology in which both individual and collective work is productive. According to Wageman [1995], hybrid technology receives relatively little attention in the literature, despite the prevalence of jobs requiring both collective and individual action. In particular, I investigate a technology in which each member is accountable for a particular task and in which help increases production and improves the efficiency of the whole team. The specification used in my model is similar to Drago and Turnbull [1988; 1991]; this specification makes explicit the interactions among members through helping effort. While Drago and Turnbull simply assume that help is productive, I consider a specific functional form that allows me to specify the productivity of both effort types that are directly implemented in my experiment.

What is interesting about the study of hybrid technology is the tension between cooperative behaviour and total level of effort. That is, group incentives promote an efficient mix of effort (helping versus individual effort) but generate free-riding problems (low level of both effort types). On the contrary, individual incentives promote individual effort but reduce helping behaviour. Both economic models and social psychology theory suggest that group rewards promote collective actions. This finds some empirical support in Ravenscroft and Haka [1996] and Mitchell and Silver [1990]. Although free-riding problems are rarely addressed in behavioural studies on group incentives, it is a fundamental concept in economic theory in that it derives directly from team technology specifications. This thesis reconciles both arguments in its theoretical development and experimental investigation.

This thesis also incorporates the concept of cohesion into its economic model; the basic assumption being that cohesion increases the level of responsiveness among the members of a group. This assumption is supported in the literature on group cohesiveness; studies showing communication, mutual influences and social pressures correlated with group level of cohesion. My model relaxes the Cournot assumption allowing cohesion to increase the level of responsiveness among team members; the result being that cohesiveness mitigates free-riding problems under group incentives and non-cooperative behaviour under individual rewards.[25]

In this thesis, the productivity of both effort types is modeled, included in my experimental task, and measured during experimental sessions. The review of prior research raises concerns about the choice of experimental tasks and measures of effort. The experimental results in Young et al. [1993] suggest that cooperation is not productive. However, the subjects performed simple tasks for which they were all well-trained. This training can explain why interacting was not productive. Young et al. did not assess the level of interactions among group members. Ravenscroft and Haka [1996] do not systematically record information sharing but measure it as a categorical response (i.e. yes or no) to a direct question about task-related information sharing among group members. Since they are not concerned with the trade off between cooperation and overall level of effort, the studies reviewed do not assess levels and productivity of individual or overall effort. In Ravenscroft and Haka [1996], the fact that the cooperative incentive plan outperformed the competitive one does not imply that free-riding problems did not occur, but simply that information-sharing is highly productive. In the experiments conducted by Mitchell and Silver [1990] and Rosenbaum et al. [1980], the number of blocks handled could be a proxy for total effort provided. Their results suggest that subjects under competitive incentives were more eager to succeed although this did not translate into higher productivity due to the risk of falling blocs/towers.

Finally, this thesis considers a rank-order tournament differing from Ravenscroft and Haka [1996] who use a typical rank-order tournament discussed in the economic literature (e.g., Lazear [1989] and Drago and Turnbull [1991]). In a typical rank-order tournament, members compete for pre-determined payoffs, whereas in my thesis, members compete for pre-determined shares of the team payoff. In a typical tournament, members have no incentive to help as it only decreases the probability of winning better prizes. In my model, helping decreases the probability of winning better prizes but increases the team payoff and

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25 This thesis also extends studies that explore how peer pressure and mutual monitoring can reduce free-riding problems (e.g., Arya, Fellingham, and Grover [1997] and Kandel and Lazear [1992]).

thus the bonus pool to be shared by the group. I use this particular rank-order tournament because it induces a positive level of help in my model. The specifics of this result, as well as the other results of the model, are described in the following chapter. Chapter 2 formally defines the technology investigated in this thesis, describes the modelled assumptions, and systematically derives the effects of incentive schemes on team members' effort choices and performance. The three bonus-sharing rules investigated in this thesis, which are equal sharing, sharing based on individual performance, and sharing based on relative performance, provide similar incentives to the pay schemes considered in the literature, which are, respectively, the group, the individual, and the competitive schemes. The notion of a bonus pool is used to emphasize that workers are part of a team and ultimately share the team outcome no matter which incentive-contract is offered.

Chapter 2 - Model and hypotheses

Based on the literature review, this chapter models the team workers' choices of effort and performance under different bonus-sharing rules. Section 2.1 presents a basic model where workers do not affect each other's choices of effort (i.e. Cournot behaviour). In section 2.2, the model is extended to include a group cohesiveness parameter that allows for the possibility that group members respond to each other's effort choices.

2.1 The basic model

This section is organised as follows. Sub-section 2.1.1 introduces the team technology and sub-section 2.1.2 introduces the bonus-sharing rules and workers' utility function. Sub-section 2.1.3 examines workers' optimal effort choices under specific rules and develops hypotheses comparing effort levels and performance across rules. Finally, sub-section 2.1.4 develops hypotheses regarding the effect of team size and its interaction with bonus-sharing rules.

2.1.1 Introduction to the team technology

Consider a team composed of N workers indexed i = [1, .. , N]. Each worker is given a task and can supply two types of effort: individualistic effort, e_i, directed toward his own task, and helping effort, h_i, directed toward his co-workers' tasks. In particular, h_i is the help supplied by i to all $j \neq i$ and is written $\sum_{j \neq i}^{N} h_{ij}$ where h_{ij} is the help *from* i *to* j. Each worker's individual output, q_i, is a function of his individual effort, e_i, the help received from his co-workers, $\sum_{j \neq i}^{N} h_{ji}$, and a random disturbance ε_i, such that $q_i = f(e_i, \sum_{j \neq i}^{N} h_{ji}) + \varepsilon_i$.[26] The team's output Q is the sum of the workers' individual output, i.e. $Q = \sum_{i=1}^{N} q_i$. This general technology is similar to the two-worker model of Drago and Turnbull [1988, 1991].

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[26] The random disturbance terms $\varepsilon_1, .., \varepsilon_N$ are identically and independently distributed, with the sum $\Sigma\varepsilon_i$ symmetric around zero.

My model specifically considers a production function that is additive in the two types of effort, so that $q_i = \alpha_e(e_i)^{\beta_e} + \alpha_h(\sum_{j \neq i}^{N} h_{ji})^{\beta_h} + \varepsilon_i$, and where both types of effort have identical declining marginal productivity, i.e. $\alpha_e = \alpha_h$ and $\beta_e = \beta_h$, where $0 < \beta_e = \beta_h < 1$. Specifically, I develop my arguments for the case where $\alpha_e = \alpha_h = 2\alpha$ and $\beta_e = \beta_h = .5$, so that $q_i = 2\alpha(e_i)^{.5} + 2\alpha(\sum_{j \neq i}^{N} h_{ji})^{.5} + \varepsilon_i$. I choose this specification for the following reasons. First, one of my objectives is to study the *mix* of individual and helping effort and the sensitivity of that mix to bonus-sharing rules. This specification implies that $e_i = h_i$ at the optimum and facilitates the comparison of different incentive schemes.[27] Second, the additive form makes the experiment simpler (and therefore more tractable) since participants do not have to predict the effort of their co-workers before choosing their own (this would be the case with a multiplicative form).

This technology corresponds well with Alchian and Demsetz' [1972] seminal definition of a team, which incorporates two dominant characteristics: (i) the team's production function dominates (at least at one point) the sum of the separate production functions of its members, and (ii) individual contributions cannot be identified. The first characteristic provides a rationale for teamwork and the second creates the setting for the free-rider problem. In my model, teamwork is synergistic since helping improves efficiency and free riding occurs because effort is unobservable. This technology also corresponds to the general definition of a team in behavioural studies, in that it includes interdependencies. Interdependence is a major reason for forming groups (Mintzberg [1979]). It is also a defining characteristic of teams (Cohen and Bailey [1997]). Interdependence is incorporated by the helping effort in my model.

Team technology can also be represented by $Q = \kappa \sum_{i=1}^{N} q_i$ where $\kappa > 1$ (e.g., Sainty [1998]). In this case, individual output q_i depends only on worker i's effort so that $\kappa > 1$ is required to ensure the superadditivity of teamwork. In my model, the superadditivity follows because q_i depends on the efforts of *all* workers, such that $Q = \sum_{i=1}^{N} q_i$ is maximised when the workers interact (and $\kappa > 1$ is not required). This

[27] Different marginal productivity of effort types could be easily incorporated in the model by changing the value of the parameters. However, as long as the optimal mix includes both types of effort in a technology, the qualitative

reflects synergy from co-operation amongst employees, which arises due to the complementary nature of the workers' knowledge and abilities.[28] Note also that, although workers benefit from the help of co-workers, this help is not essential to production. This differs from models where workers are not allowed to interact and models where they are forced to interact, such as chain production models. Here, each worker has a choice.

In determining each worker's compensation, both team and individual outputs are observable by the principal but the effort supplied is not. This prevents the principal from allocating the bonus pool directly based on each worker's effort and therefore, from obtaining the first-best solution.[29] The principal 's objective is to design a second-best compensation contract based on Q, q_i, or a combination of both.

2.1.2 Introduction to the bonus-sharing rules and workers' utility function

The bonus pool, θ, earned by the team depends on their collective performance measured by Q. For simplicity, I assume that $\theta = Q$, i.e. the reward is linear in output. Each worker receives a share of θ as a bonus θ_i with $\sum_{i=1}^{N} \theta_i = \theta$. Three bonus sharing rules are considered: the equal sharing (ES), the distribution based on individual performance (IP), and the distribution based on relative performance (RP).

Under the ES rule, each worker receives an equal share of the bonus pool, i.e. $\theta_i = \theta/N$. Under the IP rule, a worker receives a share corresponding to his own production, such that $\theta_i = \theta q_i / \sum_{i=1}^{N} q_i = q_i$. Under the RP rule, a worker's bonus depends on his rank or position in terms of individual production. In

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predictions developed in this model continue to hold.

[28] This is not to be confused with economies of scale from many individuals sharing a common asset (which often justified teamwork). Neither should it be confused with synergy resulting from proximity of producers or products (e.g., doctors and pharmacists locating in the same building or complementary products displayed together). In my model, synergy arises from productive co-operation amongst agents. This technology implies not only that help is productive but that help is positive in the first-best solution.

particular, the positions indexed $z = [1, .., N]$ are attributed to the workers according to their relative performance. q^z denotes the output produced by the worker at position z (e.g. q^1 is the highest output while q^N is the lowest). Each position provides the worker with a specific share of the bonus pool ρ^z, where $\rho^1 > .. > \rho^N$ and $\rho^1 > (1/N)$. Worker i's probability of attaining position z depends on his effort levels and his co-worker's effort levels, and is written as $0 \le P^z(\mathbf{e}, \mathbf{h}) \le 1$, where **e** and **h** are effort vectors. His expected bonus is therefore $\theta_i = \sum_{z=1}^{N} [P^z(\cdot)\rho^z\theta]$ where $P^z(\cdot) = P^z(\mathbf{e}, \mathbf{h})$. The probability of winning increases with e_i and decreases with h_j as examined in section 2.1.3.3.

Each worker's expected utility is given by $W_i = EU(\theta_i) - C(e_i, h_i)$, where E is the expectation operator, U is the utility for income, and C is the cost of effort. To simplify, it is assumed that $U(\theta_i) = \theta_i$ (risk neutrality), and $C(e_i, h_i) = \delta e_i + \delta h_i$. Below, C_e and C_h denote the derivatives with respect to the first and second arguments, i.e. $C_e = C_h = \delta$ denote the constant marginal cost of e_i and h_i, respectively. Each worker continues to provide effort until the increase in his expected bonus just equals the cost of supplying the additional effort. A unique optimum is obtained since the technology exhibits declining marginal productivity of effort, i.e. $\partial\theta_i/\partial e_i$ and $\partial\theta_i/\partial h_i$, are declining.

In this section, Cournot behaviour is assumed. This means that worker i chooses his levels of effort assuming that this will not affect the level of effort of his teammates. The Cournot assumption is a common assumption in economic models.[30] The concept is most reasonable when workers have no reason to believe that they can influence or pressure their co-workers' decisions. In such cases, the only choice that remains available to a worker is to independently choose the level of effort that maximises his utility. This does not mean that workers will not help each other, but that they will only do it if it *directly* increases their

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[29] The "first best" solution would be obtained if the agents' effort levels could be contracted upon directly. The optimal contract would provide each team member with a bonus corresponding to the marginal product of his or her efforts, inducing effort choices that maximize team surplus.

[30] Nash (Cournot) equilibrium solution concept is used in the great majority of the applications of noncooperative game theory (see Kreps [1990], p.405).

own utility. This thesis argues that such behaviour reflects an absence of group cohesion. The Cournot assumption is relaxed when group cohesion is introduced (section 2.2). The next subsection considers the workers' effort choices and expected team performance under each compensation scheme. The effort choices and output levels are compared to those in the first best solution.

2.1.3 Team workers' effort choices under specific bonus-sharing rules

Before discussing the details of the effort choices and performance under the specific bonus-sharing rules, it is useful to present the first-best solution. The first-best solution occurs when the team's total surplus (i.e. $\sum W_i$) is maximized. The team's total surplus is denoted by $S = EQ(\mathbf{e}, \mathbf{h}) - C(\mathbf{e}, \mathbf{h})$. The first order conditions illustrate that S is maximized when $e_i^* = (\alpha/\delta)^2$ and $h_i^* = (\alpha/\delta)^2$ (the derivations are presented in appendix A and all results are summarized in table 2.1), so that $e_i = h_i$ in the first best solution (as mentioned above). The first best levels of e_i and h_i are determined by the productivity and cost parameters α and δ. These levels of effort would be reached if each worker received the output produced by each of his efforts at the margin, i.e. his marginal product. Ideally (in a first best world), the principal would observe the workers' effort and compensate them commensurately. Here, however, only Q, q_i, and q_j can be contracted on, so that the effort levels actually chosen depend on the specific bonus-sharing rule as follows.

2.1.3.1 Choices of effort under ES

Under the ES rule, worker i receives (1/N) of the pool and therefore maximizes $W_i(\mathbf{e}, \mathbf{h}) = \theta(\mathbf{e}, \mathbf{h})/N - C(e_i, h_i)$. His first order conditions indicate that he chooses e_i and h_i such that $e_i = (1/N^2)(\alpha/\delta)^2$ and $h_i = (1/N^2)(\alpha/\delta)^2$ (these expressions are derived in appendix B). Under this rule, the *mix* of individual work and help is efficient i.e., the level of individual effort *relative* to help remains at its first best. This is generally consistent with the argument that team-based reward induces collaboration (Cohen [1993], Ledford [1993], and Mohrman [1993]). Under ES, free-riding occurs for both types of effort, i.e. $e_i < e_i^*$ and $h_i < h_i^*$, because each worker receives only (1/N) of the income generated from his efforts (Holmstrom [1982]).[31] The expressions for e_i and h_i illustrate that free riding increases with N ($N \rightarrow \infty$; e_i and $h_i \rightarrow 0$). This is because each worker's rewards depend relatively less on their own behaviour (decreasing their effort has a smaller impact on their rewards) as N increases. Notice that the expressions for e_i and h_i follow from the Cournot assumption: a worker's decisions are not affected by the fact that they receive (1/N) of what his co-worker produces, since he believes that he does not influence worker j's effort choices. Shirking occurs, therefore, and the first best is not attained.

Table 2.1: Effort choices at equilibrium – basic model

	First-best	ES rule	IP rule	RP rule
Worker's effort choices	$e_i = (\alpha/\delta)^2$ $h_i = (\alpha/\delta)^2$	$e_i = (1/N^2)(\alpha/\delta)^2$ $h_i = (1/N^2)(\alpha/\delta)^2$	$e_i = (\alpha/\delta)^2$ $h_i = 0$	$e_i = (1/N^2)[\alpha/(\delta - \Delta)]^2 > (1/N^2)(\alpha/\delta)^{2}$ [1] $h_i = (1/N^2)[\alpha/(\delta + \Delta)]^2 < (1/N^2)(\alpha/\delta)^2$
Worker's total effort $t_i = e_i + h_i$	$t_i = 2(\alpha/\delta)^2$	$t_i = (2/N^2)(\alpha/\delta)^2$	$t_i = (\alpha/\delta)^2$	$t_i = (1/N^2)[\alpha/(\delta - \Delta)]^2 + (1/N^2)[\alpha/(\delta + \Delta)]^2$ $> (2/N^2)(\alpha/\delta)^2$
Worker's mix of effort $Mix = [e_i/(e_i + h_i)]$	Mix = ½	Mix = ½	Mix = 0	Mix between 0 and ½
Team performance $Q(\mathbf{e}, \mathbf{h})$	$Q = 4N\alpha^2/\delta$	$Q = 4\alpha^2/\delta$	$Q = 2N\alpha^2/\delta$	$Q = 2\alpha^2/(\delta - \Delta) + 2\alpha^2/(\delta + \Delta)$ $> 4\alpha^2/\delta$

[1] $\Delta = Q(\cdot)\sum_{z=1}^{N} P_e^z(\rho^z - p^N)$ with $P_e^z = -P_h^z$

[31] In my thesis, the bonus pool is a linear function of team output. This specification provides the most straightforward and concise way to study the effects of sharing rules and group cohesiveness on the free riding problem. I do not consider the discrete (standard-based) function of output presented by Holmstrom [1982]. Holmstrom [1982] shows that under certainty and when the workers' utility function is known, a standard-based contract can induce the first best solution (i.e. no free-riding). However, when these assumptions are relaxed (e.g. when there is uncertainty), the free-riding problems reappear and a standard based contract may no longer be optimal (or even superior to the linear specification).

2.1.3.2 Choices of effort under IP

Under the IP rule, worker i maximizes $W_i = Eq_i - C(e_i, h_i)$. In this case, increasing individual effort increases compensation by the full marginal product while helping effort increases only co-workers' compensation. Thus, the workers provide only individualistic effort, such that $e_i = (\alpha/\delta)^2$ and $h_i = 0$ (see appendix C). Comparing this solution to the first best, individualistic effort is efficient, i.e. $e_i = e_i^*$, but helping effort is inefficiently low. Note that due to the construction of the shares, the effort choices in the IP case are independent of N.

A first set of hypotheses results from the comparison of the ES and IP rules. It is clear from the above that individualistic effort is higher and helping effort is lower under the IP rule. In addition, we can compare the total effort (the sum of the individualistic and helping efforts of both workers) and total output under each rule (these values are derived in appendices B and C and summarised in table 2.1). The total effort is higher in the IP case. The intuition is as follows. For any level of individualistic effort, each worker's marginal benefit of individualistic effort is N times as high under the IP rule (although the marginal cost is the same under each scheme). Due to declining marginal productivity of effort, more than 2 times the individualistic effort must be provided before the marginal benefit equals the marginal cost δ. When $N = 2$ the increase in total effort just offsets the inefficient mix so that total output is the same under each rule, and when $n > 2$ performance is higher under IP.[32] This leads to the following hypotheses that compare effort levels and performance between the ES and IP rules:

H1a: Helping effort is greater under the ES rule than under the IP rule

H1b: Individual effort is greater under the IP rule than under the ES rule

H1c: Total effort is greater under the IP rule than under the ES rule

H1d: Mix of effort is greater under the ES rule than under the IP rule

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[32] Note however that team surplus may be lower under the IP rule due to the lower productivity associated with an inefficient mix of efforts.

H1e: When N > 2, performance is greater under the IP rule than under the ES rule

2.1.3.3 Choices of effort under RP

Under the RP rule, worker i maximizes $W_i = \sum_{z=1}^{N}[P(\cdot)^z \rho^z E\theta] - C(e_i, h_i)$ where $P(\cdot)^z = P(e, h)^z$ is the probability of attaining position z contingent on workers' efforts as described above. Let P_e^z and P_h^z denote the derivatives with respect to the first and second arguments, i.e. the change in worker i's probability of attaining position z due to a change in e_i and h_i, respectively, with $P_e^z>0$ and $P_h^z<0$. The first order conditions indicate that he chooses e_i and h_i such that $e_i = \{\Phi\alpha / (\delta-\Delta)\}^2$ and $h_i = \{\Phi\alpha / (\delta+\Delta)\}^2$, where $\Delta = Q(\cdot)\sum_{z=1}^{N} Pe^z(\rho^z - \rho^N)$ with $P_e^z = -P_h^z$, and $\Phi = \sum_{z=1}^{N}(P(\cdot)^z \rho^z)$. (The calculations for RP are presented in Appendix D.)

These expressions for e_i and h_i differ from the first best solution in two ways: the numerator is multiplied by Φ, and Δ is subtracted from or added to the denominator. Intuitively, the parameter Δ ($-\Delta$) captures the *bonus differential* (the difference between the bonus earned by different positions) times P_e (P_h), the increased (decreased) probability of getting this differential due to an additional e_i (h_i). An increased differential (due to an increased Q or/and ρ) increases a worker's motivation to attain an higher position. Since an additional e_i increases his probability of receiving a higher share while an additional h_i decreases it, an increase in the bonus differential increases individualistic effort but decreases helping effort.

The second parameter Φ ($0 \leq \Phi \leq 1$) captures worker i's expected bonus (i.e. his expected share of the value he is creating). As a worker's expected share of the bonus pool increases, both his individualistic and helping efforts increase. The intuition is that both types of effort contribute to the collective output and consequently to his own bonus. In short, differentiating bonuses have a positive impact on e_i but its impact on h_i is ambiguous. This is because an additional e_i increases both the bonus pool and the probability of attaining superior positions, while an additional h_i increases the bonus pool but reduces the probability of attaining those positions. In fact, the worker compares the potential benefit of increasing h_i (i.e. the increase in the expected income of himself and his co-workers) and the potential cost (the decrease in his probability of winning the bonus differential multiplied by this differential). If the potential benefit is greater than this cost plus his cost of effort δ, then an additional h is supplied.

My second set of hypotheses is derived from comparing the RP rule to the ES rule above. Since all workers are identical, any solution under the RP rule will have the feature that $P(\cdot)=(1/N)$.[33] That is, each worker will have a fair chance to obtain the first position and the actual winner will depend on ε. When $P(\cdot) = (1/N)$, the effort choices become $e_i = (1/N^2)(\alpha/(\delta - \Delta))^2$ and $h_i = (1/N^2)(\alpha/(\delta + \Delta))^2$. And since $\rho > (1/N)$ in a competitive context, $e_i > (1/N^2)(\alpha/\delta)^2$ and $h_i < (1/N^2)(\alpha/\delta)^2$. Compared to the ES, therefore, the RP induces more individualistic effort but less helping effort, which implies a sub-optimal mix of effort. Moreover, the increase in individualistic effort is greater than the decrease in helping effort, because $(\delta + \Delta) > (\delta - \Delta)$ (the proof is in appendix D(b)). This means the total level of effort provided under the RP rule is greater than that provided under the ES rule. In addition, the increase in total effort leads to an increase in output despite the sub-optimal mix of effort (the proof is in appendix D(c)). This leads to the following hypotheses that compare effort levels and performance between ES and RP rules:

H2a: Helping effort is greater under the ES rule than under the RP rule

H2b: Individual effort is greater under the RP rule than under the ES rule

H2c: Total effort is greater under the RP rule than under the ES rule

H2d: Mix of effort is greater under the ES rule than under the RP rule

H2e: Performance is greater under the RP rule than under the ES rule

2.2 The extended model

My basic model assumes that workers do not affect each other's choices of effort, since each worker believes his co-worker will not respond to his effort choices. However, the social psychology literature predicts that members of a cohesive group will affect each other's behaviour, through mutual influence or through peer pressure. That is, cohesiveness is associated with communication among group members (Moran [1966], Lott and Lott [1961]), the readiness of group members to be influenced by others in the group (Berkowitz [1954], Schachter [1951]), and the tendency to respond positively to the actions of other group members (French [1941]) and to behave in accordance with group expectations (Wyer [1966], Lott and Lott [1961]).

In this section, my model is extended to consider the possibility that workers respond positively to the actions of their co-members. Sub-section 2.2.1 incorporates a cohesion parameter into my basic model. Sub-section 2.2.2 develops hypotheses regarding the effect of cohesion on the level and mix of effort and its interaction with bonus-sharing rules.

2.2.1 Inclusion of a team cohesion parameter in the basic model

I incorporate cohesion in my model by allowing for non-zero "conjectural variations" over efforts.[34] A conjectural variation over effort is a guess about how your co-workers' effort will vary in response to your own. Agency models assume that each worker provides effort until the increase in his expected bonus equals the cost of supplying the additional effort. To determine the increased bonus, the worker must make a behavioural assumption concerning the impact of his decisions on his co-worker's behaviour (since the efforts jointly determine the outcome).

Specifically, conjectural variations over individualistic efforts are defined as the response in one worker's individual effort to changes in another's individualistic effort choices, i.e. $\partial e_i / \partial e_j = \partial e_j / \partial e_i = V_e$, with $0 \leq V_e \leq 1$. Similarly, conjectural variations over help are defined as $\partial h_i / \partial h_j = \partial h_j / \partial h_i = V_h$, with $0 \leq V_h \leq 1$. In the basic model, the behaviour of the workers was predicted assuming $V_e = V_h = 0$. That is, I assumed that the workers believe that a change in their effort level would provoke no change in their co-

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[33] Generally assumed with classic rank-order tournament (e.g. Lazear and Rosen [1981], Drago and Turnbull [1991]).
[34] This is common in game theory (e.g. in Von Stackelberg equilibrium). In Drago and Turnbull [1988, 1991], this was used to model bargaining of efforts between two workers.

workers' effort choices. In contrast, when V>0, an increase in worker i's effort is met with an increase in worker j's effort. The "perfect response" case is defined where the coefficients equal one, i.e. where $V_e = V_h = 1$, which implies perfect reciprocity in team workers' supply of effort.[35] I let $0 \leq \Omega \leq 1$ represent the degree of cohesion within a team, where $\Omega = 0$ expresses no cohesion and $\Omega = 1$ expresses "perfect" cohesion. The extended model assumes that cohesion increases the level of response within a team, such that $V_e = V_h = \Omega$. The basic model corresponds to the case of no cohesion, i.e. $\Omega = 0$.

These assumptions are consistent with Shaw's [1981] argument that there must be a minimum degree of cohesiveness among individuals in order to function as a group. To the extent that this minimum requirement is exceeded, one could expect that the degree of cohesiveness will be related to the other aspect of group processes, including mutual influence and peer pressure. In other words, when this minimum is exceeded, the responsiveness of team members is expected to increase with the level of cohesiveness. Consistently, Deutsch [1968] argues that cohesiveness is associated with communication among group members, the readiness of group members to be influenced by others in the group, and the tendency to respond positively to the actions of other group members.

2.2.2 Effect of cohesion on effort choices

The specific effects of the cohesion parameter on the effort choices depend on the particular bonus-sharing rule. Under the ES rule, worker i chooses e_i and h_i such that $e_i = (1/N^2)[\alpha(1 + (N-1)\Omega)/\delta]^2$

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[35] An alternative extension could be to modify the workers' welfare functions to include an altruistic component reflecting that the workers care about each others' welfare. For example, the welfare function of worker i could be written as $W_i = E[U(\theta_i) + U(W_j) - C(e_i, h_i)]$ where $U(W_j)$ is worker i's utility for worker j's welfare. Including this term would clearly decrease worker i's free-riding behaviour and improve the effort mix under any of the compensation schemes considered above. Similarly, the normative pressure exerted on group members that is widely discussed in the social psychology literature could be included by extending the workers' utility functions to include a cost of social pressure, e.g. $W_i = E[U(\theta_i) - C(e_i, h_i) - C(SP)]$ where C(SP) is the cost associated with social pressure (non-acceptance or rejection by other group members) (as in Kandel and Lazear [1992]). This again would decrease free-riding and improve the mix of effort.

and $h_i = (1/N^2)[\alpha(1+(N-1)\Omega)/\delta]^2$ (the derivations are presented in appendix E and all results are summarized in table 2.2). Under this rule, the first best mix is obtained for all levels of cohesion. This is because workers receive the same increase in bonus whether output is increased due to individualistic or helping effort. As the cohesion parameter increases, however, total effort (and output) increases. This is due to the positive effect of their increasing effort levels on their co-workers' efforts, which increases the bonus pool to be shared amongst the team members. In the perfect cohesion case ($\Omega = 1$), both the levels and mix of efforts reach their first best levels. These results lead to the following hypotheses describing the effect of cohesion on effort choices and performance under the ES rule:

H3a: Cohesion is positively related to helping effort under the ES rule

H3b: Cohesion is positively related to individual effort under the ES rule

H3c: Cohesion is positively related to total effort under the ES rule

H3d: Cohesion is not related to mix of effort under the ES rule

H3e: Cohesion is positively related to performance under the ES rule

Table 2.2: Effort choices at equilibrium – extended model

	Choices of e_i and h_i in equilibrium	Case when $\Omega = 0$	Case when $\Omega = 1$
ES rule	$e_i = (1/N^2)[\alpha(1+(N-1)\Omega)/\delta]^2$ $h_i = (1/N^2)[\alpha(1+(N-1)\Omega)/\delta]^2$	$E_i = (1/N^2)(\alpha/\delta)^2$ $H_i = (1/N^2)(\alpha/\delta)^2$	$e_i = (\alpha/\delta)^2$ $h_i = (\alpha/\delta)^2$
IP rule	$e_i = (\alpha/\delta)^2$ $h_i = (\alpha\Omega/\delta)^2$	$E_i = (\alpha/\delta)^2$ $H_i = 0$	$e_i = (\alpha/\delta)^2$ $h_i = (\alpha/\delta)^2$
RP rule	$e_i = (1/N^2)[\alpha(1+((N-1)\Omega))/(\delta-(\Delta(1-\Omega))]^2$ $h_i = (1/N^2)[\alpha(1+((N-1)\Omega))/(\delta+(\Delta(1-\Omega))]^2$	$E_i = (1/N^2)(\alpha/(\delta-\Delta)))^2$ $H_i = (1/N^2)(\alpha/(\delta+\Delta)))^2$	$e_i = (\alpha/\delta)^2$ $h_i = (\alpha/\delta)^2$

where $\Delta = Q(\cdot)\sum_{z=1}^{N} P_e^{z}(\rho^{z} - p^{N})$ with $P_e^z = -P_h^z$

Under the IP rule, worker i chooses e_i and h_i such that $e_i = (\alpha/\delta)^2$ and $h_i = (\alpha\Omega/\delta)^2$. The IP rule always induces the first best level of individualistic effort, since the worker receives his entire marginal product as a bonus. In this case, an increase in the cohesion parameter leads to an improvement in the mix of effort. This is because helping a co-worker has no direct effect on a worker's bonus (it increases only the co-worker's bonus). As the cohesion parameter increases, however, the worker believes that co-workers will provide more help in return. This increases the indirect effect on a worker's bonus and leads to more helping effort. The higher helping effort leads to an improved effort mix under the IP rule. In the perfect cohesion case ($\Omega = 1$), the first best levels and mix of efforts is again obtained (appendix F). These results lead to the following hypotheses describing the effect of cohesion on effort choices and performance under the IP rule:

H4a: Cohesion is positively related to helping effort under the IP rule

H4b: Cohesion is not related to individual effort under the IP rule

H4c: Cohesion is positively related to total effort under the IP rule

H4d: Cohesion is positively related to mix of effort under the IP rule

H4e: Cohesion is positively related to performance under the IP rule

Under the RP rule, worker i chooses e_i and h_i such that $e_i = (1/N^2)[\alpha (1+ ((N-1)\Omega))/(\delta - (\Delta (1 - \Omega))]^2$ and $h_i = (1/N^2)[\alpha (1+ ((N-1)\Omega))/(\delta + (\Delta (1 - \Omega))]^2$. Under this rule, both helping and individual efforts increase as the cohesion parameter increases. This reflects the positive effects of increasing effort levels on co-workers' effort levels, which increases the total bonus pool to be shared amongst the team members (similar to the ES case above). Under the RP rule, however, the cohesion parameter also affects the probability of obtaining a higher share of the bonus pool. In particular, the increase in the probability from individualistic effort is offset with cohesion, because co-workers increase their individualistic effort also. Similarly, the decrease in the probability when a worker provides help is relaxed with cohesion because co-workers increase their help in return. This implies that helping effort increases faster as cohesion increases, so that the effort mix is also improved under the RP rule (appendix G). These results lead to the following hypotheses describing the effect of cohesion on effort choices and performance under the RP rule:

H5a: Cohesion is positively related to helping effort under the RP rule

H5b: Cohesion is positively related to individual effort under the RP rule

H5c: Cohesion is positively related to total effort under the RP rule

H5d: Cohesion is positively related to mix of effort under the RP rule

H5e: Cohesion is positively related to performance under the RP rule

As discussed above, the effect of cohesion on effort choices and performance depends on rules. That is, team cohesion and bonus-sharing rule interact to effect choices of effort and performance. A last set of hypotheses describe the nature of such interaction. The H6 hypotheses compare the effect of cohesion on effort choices and performance between the ES rule and the IP rule:

H6a: There is a stronger positive relationship between cohesion and helping effort under the IP rule than under the ES rule

H6b: There is a stronger positive relationship between cohesion and individual effort under the ES rule than under the IP rule

H6c: There is a stronger positive relationship between cohesion and total effort under the ES rule than under the IP rule

H6d: There is a stronger positive relationship between cohesion and mix of effort under the IP rule than under the ES rule

H6e: There is a stronger positive relationship between cohesion and performance under the ES rule than under the IP rule

Finally, the H7 hypotheses compare the effect of cohesion on effort choices and performance between the ES rule and the RP rule:

H7a: There is a stronger positive relationship between cohesion and helping effort under the RP rule than under the ES rule

H7b: There is a stronger positive relationship between cohesion and individual effort under the ES rule than under the RP rule

H7c: There is a stronger positive relationship between cohesion and total effort under the ES rule than under the RP rule

H7d: There is a stronger positive relationship between cohesion and mix of effort under the RP rule than under the ES rule

H7e: There is a stronger positive relationship between cohesion and performance under the ES rule than under the RP rule

To conclude, two general statements about cohesion emerge from the model. First, as the cohesion parameter Ω increases, the total level of effort provided under all three bonus-sharing rules increases. So also does team performance under all three bonus-sharing rules. The reason is that as Ω increases, each worker believes that increasing his own effort will cause his co-workers to increase their effort also. Thus, the perceived marginal benefit of effort is higher and additional effort is provided. Overall, results from the model are consistent with the three meta-analyses of the relationship between cohesiveness and group performance (Evans and Dion [1991], Muller and Cooper [1994], and Gully et al. [1995]) that find a significant and positive relationship between the two concepts, as well as with results from recent field studies (e.g., Vinokur-Kaplan [1995]; George and Bettenhausen [1990]; Seers et al. [1995]).

Second, as Ω increases the differences between the three bonus-sharing rules are reduced. In fact, in the limit (as Ω approaches unity), all three bonus-sharing rules produce the first best solution (i.e. the first best effort levels and the first best mix). Thus, firms generating extremely strong cohesion should be less concerned with the choice of bonus-sharing rules while the choice of sharing rules is more important for firms with very low levels of cohesion. In the next chapter I describe how I experimentally examine this set of hypotheses.

Chapter 3 - Experimental Method

This chapter is organized as follows. Sections 3.1 to 3.3 include a description of the participants involved in the experiment, the experimental task, and the three experimental conditions. Section 3.4 describes the computer interface used during the experiment. Section 3.5 reviews the experimental procedures. Finally, section 3.6 describes variable measurement and overviews the hypotheses tests.

3.1 Participants

My experiment was conducted with the participation of undergraduate students enrolled in an introductory course in management accounting at a large public university.[36] Three extra marks were given to students for participating in this experiment or submitting an alternative assignment. In addition, a $100 prize was drawn for each group of 20 students that participated in my experiment.[37] As 566 students (162 teams) chose to participate, 29 draws were held (for a total of $2,900). All participants received the 3 extra marks. The number of tickets received throughout the experiment varied according to performance. Extra marks provided a basic motivation to participate (similar to a salary) and draw tickets served as bonuses (performance-based compensation).

This course presented an excellent opportunity to investigate natural teams since teamwork is a major component of the curriculum. In the course, teams are formed during the first week of class and teamwork is required on a weekly basis throughout the term.[38] Students had six weeks to develop group cohesion before starting the experiment. Previous experimental studies suggest that this time period is sufficient to develop a stable level of group cohesion (e.g., Mulvey and Klein [1998], Klein and Mulvey

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[36] Two sections of the course were offered and 602 students were enrolled in it at the time of the experiment. The same instructor taught both sections.

[37] This particular form of lottery was chosen based on the results of my pilot study. The draw provides an expected value of $5.[00] per participant. This is similar to the monetary incentives provided in other experimental studies on compensation schemes. For example, undergraduate students in Young, Fisher, and Lindquist [1993] received up to $16.[00] for taking part in three experimental sessions (i.e. $5.[33] per session).

[1995], and Grant et al. [1992]).[39] In addition, since students continue working with team members throughout the remainder of the term, the likelihood of peer pressure during the experiment increases.

The experiment was conducted in computer laboratories that accommodated 24 students. Thirty-three laboratory sessions (one hour) were offered over a three week period. Table 3.1 presents the lab session schedule. Twenty-seven sessions were filled by natural teams (teams from the class), and the remaining six sessions were filled by artificial teams (teams formed solely for the experiment). That is, teams composed of three or four people from the course were registered as natural teams. Teams composed of two people from the course, along with students whose cohort refused to participate, were randomly assigned to artificial teams.[40] 23 of the 162 teams (14%) encountered computer failure while performing the experimental task.[41] The sample contains the remaining 139 teams: 111 natural teams and 28 artificial teams. Respectively 45, 46, and 48 teams are included in the ES, IP, and RP conditions (see table 3.2). Group size and artificial teams are distinguished in the hypotheses tests.

321 participants are female and 166 participants are male. The majority of students enrolled in the course are in their first term / first year undergraduate studies. Ninety-six percent of the students included in

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[38] The instructor created the teams and the students had no participation in choosing their cohort.

[39] Grant et al. [1992] studied the development of groups and inter-group conflicts during a laboratory simulation (five 2-hour sessions). Cohesion was measured three times during the first session, which essentially consisted of group development activities. Cohesion was also measured before a negotiation period during sessions 3, 4, and 5. A short (5-item) measure of cohesion showed rapid and significant increases throughout the first session. As a more comprehensive (22-item) measure indicated, the increase continued but only up to the point of the negotiation (third session). This suggests that cohesion is developed over a few weeks. Consistently, Klein & Mulvey [1995] found reliable cohesion measures 10 days after the groups have been created (the 3rd week of classes) and 10 days before the project ended (the 7th week of class). The reliabilities obtained were .86 on the first questionnaire and .89 on the second, and the correlation between the two assessments was .72. Mulvey and Klein [1998] found a reliability of .86 measured five weeks after the groups were formed. In the two last papers, after five or six weeks, there was sufficient variance in the cohesion measures to allow statistical analysis.

[40] All artificial teams are composed of students that had not worked together prior to the experiment.

[41] Students encountering computer failure during the experimental task received the average number of tickets received by students in their experimental conditions. They were not included in the analysis.

my sample range from 18-20 years of age.[42] One hundred and seventy-one participants are registered in accounting – with an arts (98 students), science (25 students), or mathematics (48 students) major, 72 participants are registered in business studies minor, and the remaining participants are registered in applied arts studies (230 students) or science non accounting programs (14 students).

Table 3.1: Lab session schedule

Day	Time period 1	2	3	4	5	6
1				1 IP	2 RP	3 ES
2				4 ES	5 ES	6 RP
3				7 IP	8 RP	9 ES
4				10 RP	11 ES	12 IP
5		13 IP	14 RP	15 RP	16 IP	17 ES
6				18 IP	19 RP	20 ES
7			21 ES	22 IP	23 ES	24 RP
8						27 IP
9	28 RP	29 IP				
10					30 RP	31 IP
11				32 ES	33 ES	34 IP
12					26 RP	

: Lab session with natural teams   : Lab session with artificial teams

ES: Lab session assigned to the ES condition
IP: Lab session assigned to the IP condition
RP: Lab session assigned to the RP condition

Approximately half of the participants answered "yes" to the question: "In addition to being Canadian, is there a particular nationality or ethnic group you feel you belong to?" One hundred and eight students indicated belonging to the Chinese nationality. The remaining 131 students are distributed across more

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[42] In particular, the sample includes 3 seventeen year old students, 52 eighteen year old students, 383 nineteen year old students, 32 twenty year old students, 8 twenty-one year students, and 4 twenty-two year old students; the remaining 5 students range from twenty-three to thirty-one years of age.

than 50 particular nationalities or ethnic groups.[43] Even though I randomly assigned lab sessions to experimental conditions, I control for demographic data related to participants in the hypotheses tests.

Table 3.2: Sample size per experimental condition: distinction between natural and artificial team along with team sizes

	ES condition			IP condition			RP condition			Whole sample		
	4 p / t	3 p / t	Total	4 p / t	3 p / t	Total	4 p / t	3 p / t	Total	4 p / t	3 p / t	Total
Natural teams	21	15	36	19	18	37	20	18	38	60	51	111
Artificial teams	1	8	9	3	6	9	6	4	10	10	18	28
Total	22	23	45	22	24	46	26	22	48	70	69	139

3.2 Experimental task

As illustrated in the third column of Table 3.3, a participant's task is to answer mathematical questions taken from a list accessed through his / her computer screen.[44] A specified number of draw tickets are distributed for each correct answer (second column of Table 3.3). As the participant progresses through the list of questions, the number of tickets awarded for each correct answer decreases. Teams composed of three or four people took part in the experiment. Each member within a team has a color associated with him / her to ease the explanation and implementation of the experiment. Each participant has his / her own task to complete.

Participants must add three single-digit numbers to answer each question: two of the numbers are given, but the third must be traced from a matrix (see Table 3.3). This number matrix includes cells from A/a to Z/z, where A to Z is the vertical axis and a to z is the horizontal axis (their identification is case-sensitive). As shown in Figure 3.1, each team member is provided with the values for only one-quarter of the complete

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[43] After Chinese, the most mentioned nationalities are Indian (15 students), Irish (11 students), and Italian (11 students). There were less than ten students in all other mentioned nationalities.

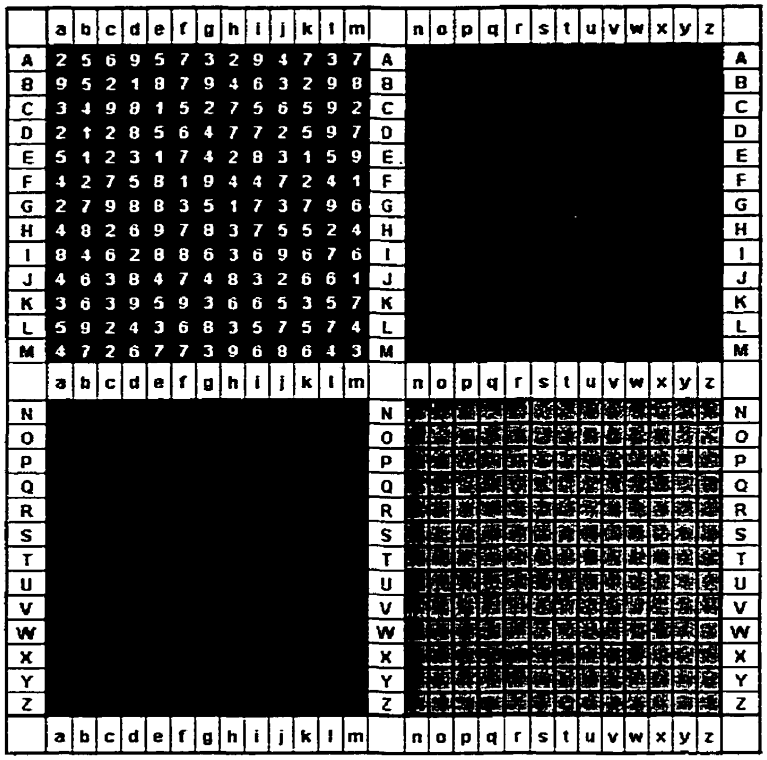
[44] There are so many questions that it is impossible for participants to exhaust them in the time period allotted by the experimenter, even if he / she only answers those for which he / she has the information. During the pilot-study, a specific experimental condition was set where subjects could only answered their own questions. The fastest student answered 100 questions in 12 minutes. In the main experiment, the 15-minute task included 200 questions.

matrix. More precisely, member red' s matrix includes cells from A/a to M/m, member blue's matrix includes cells from N/a to Z/m, member green's matrix includes cells from A/n to M/z, and member purple's matrix includes cells from N/n to Z/z (Note that member purple exists only in a team composed of four people). Each team member is provided with a unique list of questions. Questions are ordered in a way that allows participants to answer questions 1,3,5, etc. using their own matrix. Help from team members is necessary to answer the even numbered questions. Team members can choose to work individually, answering only the odd numbered questions, or cooperatively, answering any questions they choose.

Table 3.3: Experimental task (member red / 4 person team)

Question #	Tickets per correct answer	Question	Answer
1	100	7 + Ae + 4 =	
2	100	3 + 9 + Og =	
3	59.5	8 + Cg + 5 =	
4	59.5	Ft + 6 + 7 =	
5	43.9	Gi + 3 + 4 =	
6	43.9	2 + 9 + Ux =	
7	35.4	7 + Hb + 5 =	
8	35.4	Zm + 2 + 6 =	
...	...	...	
31	12.5	Ii + 4 + 2 =	
32	12.5	Sg + 6 + 5 =	
33	11.9	3 + 9 + Ll =	
34	11.9	7 + Ap + 1 =	
...	...	...	
55	8.2	Ia + 2 + 3 =	
56	8.2	7 + 2 + Wk =	
57	8	9 + Kg + 6 =	
58	8	2 + 5 + Lu =	
...	...	...	

Figure 3.1: Number matrix (member red)



A participant can choose to concentrate on the questions for which he has the information or to help other team members too. Considering that the number of tickets offered per question decreases as participants progress through the list, it is in the individual's interest, to a certain degree, to cooperate with the other team members. If there were no additional cost for communicating, the efficiency of a team would increase if questions were answered by the participants in the order in which they are presented. This implies an equal number of questions answered with and without help. In the experiment, however, there are additional costs for communicating i.e. the time required for requesting and sending information to team members. Considering this additional time, it remains efficient for a team if members collaborate, but less than half of the questions answered should be ones requiring cooperation.

The following analysis maps the experimental task to the model being tested. First, a participant can supply individual and helping effort. That is, he can answer his own questions and can also help other team members. Second, the cost of effort comes from the time and attention required by a participant to find numbers in their matrix. Third, the declining productivity of the technology is captured by the decreasing number of reward tickets offered per question as task progresses. Fourth, a participant remains free to help his team or to focus on the question for which he / she has the information. Finally, the risk neutrality of members is imposed by the use of lottery tickets.[45]

3.3 Experimental conditions

The three experimental conditions correspond to the three bonus sharing rules defined in the model. Under the ES condition, accumulation of tickets by participants is achieved through team effort and the ticket pool is shared equally among team members. Under the IP condition, each participant receives tickets based on his / her answers, regardless of whether they are a result of individual or helping effort. Under the RP condition, participants accumulate tickets through team effort and distribution of the ticket pool is based on individual performance of team members in rank order. In the four person teams, bonuses equal to 40%, 30%, 20%, or 10% of the team bonus pool are associated with the 1st, 2nd, 3rd, or 4th position in terms of individual performance. In the three person teams, bonuses equal to 50%, 33.3%, or 16.6% of the team bonus pool are associated with the 1st, 2nd, or 3rd position in terms of individual performance. The bonus values increase in equal percentages within teams, while maintaining a total of 100%.

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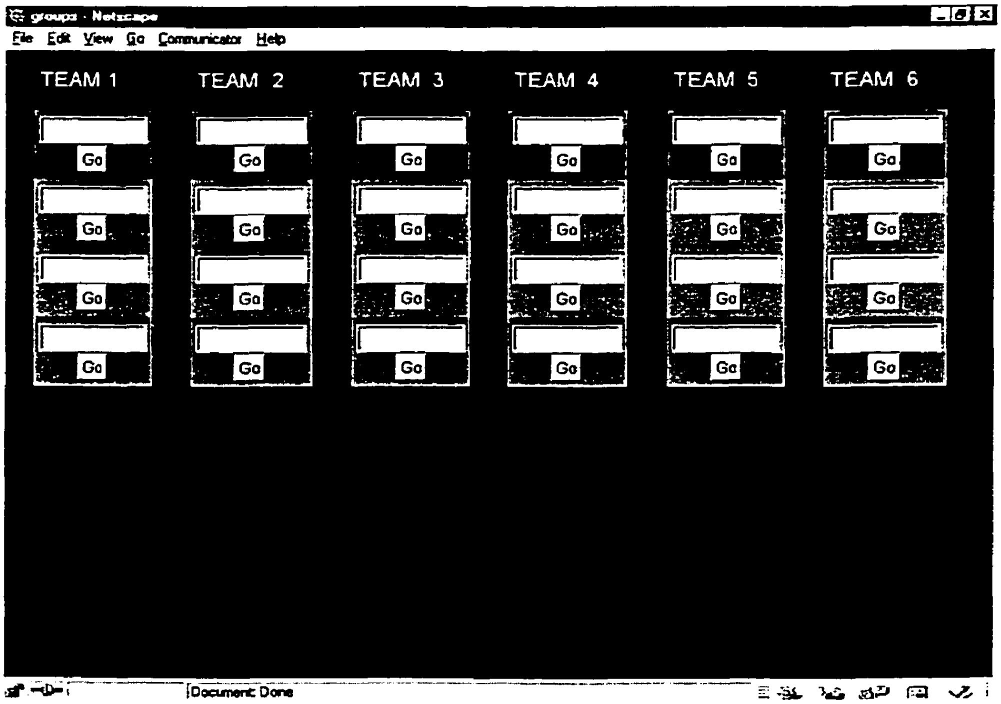
[45] My model assumes a risk-neutral agent which is induced in my experiment as follows: each question correctly answered is worth a certain number of lottery tickets. In a simple lottery, the expected utility of each participant is given by: [pU(Prize)] + [(1 – p)U(0)] where $0<p<1$ is the participant's probability of winning the prize (and therefore (1 – p) is his probability of winning nothing). A participant who increases his number of tickets increases his p, and consequently, has a "linear" increase in his expected utility. Using a lottery makes the participants risk-neutral in terms of lottery tickets (see Baiman and Lewis [1989]).

3.4 Computer interface

Each participant was given access to a computer screen. As students entered their lab session, they faced the "gateway screen" (see Figure 3.2). This first webpage requested personal identification. The students entered (i) their team number, (ii) their assigned color, and (iii) their first name.

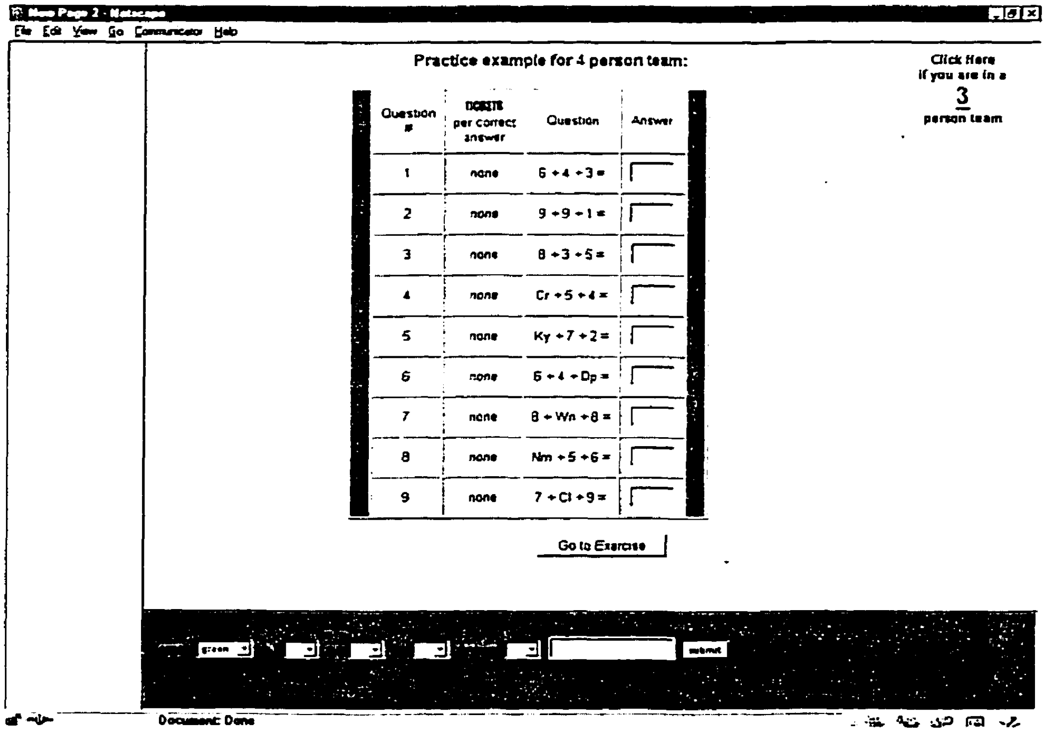
Figure 3.2: Gateway Screen



The main screen was divided into three areas (see Figures 3.3 and 3.4). The large shaded (yellow on the computer) area dominating the screen was used for two different purposes. First, it was used for a practice session (Figure 3.3), and subsequently it was used for the experimental task (Figure 3.4). In the practice session, students learned how to answer questions, use their number matrix, and communicate with the other team members. Students were asked to click on "Go to Exercise" once they answered all questions. This presented them with the experimental task section *only if* all questions were correctly answered. As discussed above, the experimental task was composed of a series of mathematical questions and each question had its own answer space. Participants could scroll back and fourth on the page to answer the questions in any order.

The second area at the bottom of the screen allowed students to communicate with other team members. A student could systematically request the number corresponding to a cell, provide a cell value to team members, or send them personal messages. This area contained six input spaces and a submit button. The first input space was used to identify the targeted member (the member one wanted to communicate with). The following four input spaces were used to ask for or to provide the number corresponding to a cell. Students could add comments in the sixth input. Finally, messages were sent by clicking on submit. The message sent to participants appears in the blank vertical area to the left of his screen. The messages were automatically written in the color of the member sending the information and then followed by his / her name.

Figure 3.3: Main Screen with Practice Session (member green / 4 person team)



3.5 Experimental procedures

3.5.1 Procedures prior to the lab sessions

In the second week of classes, I visited both sections of the course to present my project to the students. I described the nature of my experiment, the scheduling, and the compensation for participating. Following my presentation, students indicated on an informed consent letter (Appendix H) their intention to participate in my experiment or submit an alternative assignment. This provided me with an estimate of the number of participants for my experiment. I referred to this estimate to determine the number of lab sessions that would be offered. A few days later, available sessions were posted on the experiment's website and students were invited to register.

Twenty-nine sessions were offered and scheduled in a two week period (corresponding to the seventh and eight weeks of classes).[46] Among the 29 sessions available, 25 sessions were offered to the teams composed of three and four people from the course. These students were invited to register for a lab session with the other members of their team. The four other lab sessions welcomed teams composed of two people from the course, along with students whose cohort refused to participate.[47] The lab sessions were assigned on a "first come, first served" basis. The students emailed me their preferred time slots and I continually updated the schedule as people registered. Up to five or six (three or four person) teams were scheduled in each lab session.[48]

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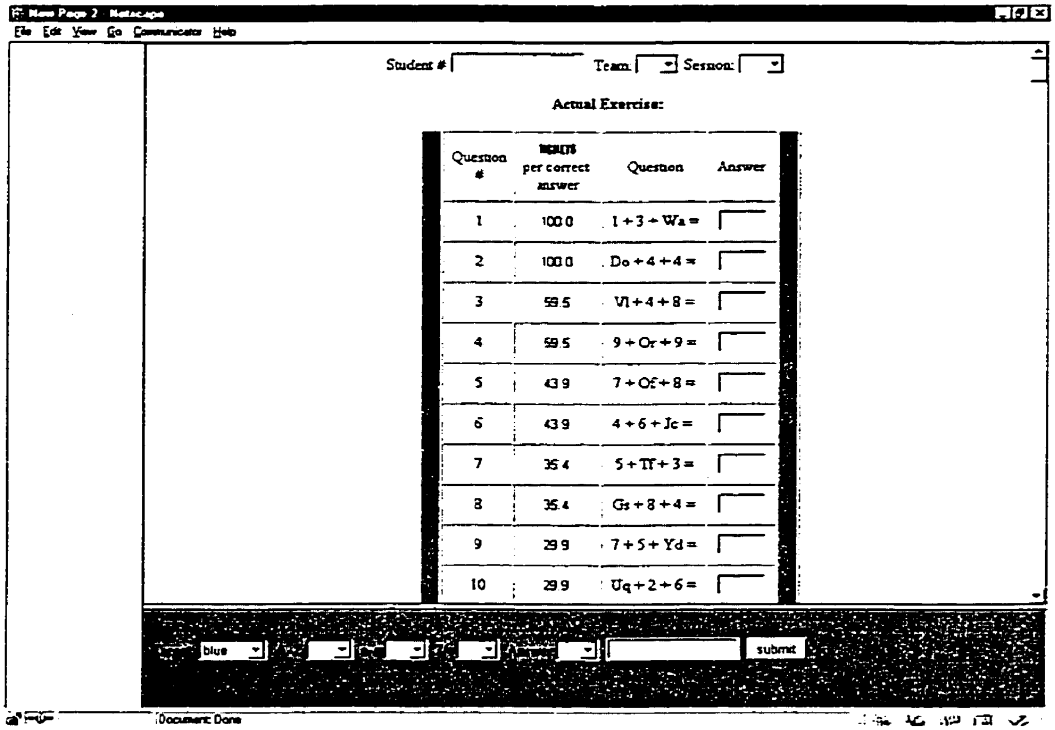
[46] Five time slots were reserved for the tenth week of classes to allow for rescheduling but there was no mention of it in the initial schedule.

[47] The instructor provided me with a list of the class teams. Combined with the students' informed consent letter, I was able to estimate the number of natural and artificial teams that would register.

[48] Before visiting the courses, I believed that each student would be part of a four-person team. This was the case during previous course offering and it was intended to have four-person teams again in 1999. My plan was to schedule 5 teams per session (20 participants) and hold one draw per session (as indicated in the Informed consent letter). Scheduling problems regarding classes, however, led to teams with two, three, or four members. My experimental task had already been adapted for three-person teams in order to cope with exceptional cases (if one team member did not attend his session). Thus I made the following decision and explained it clearly to the students. As the experiment *required* teams with three or four members, only class teams with three or four members could register as a team.

During the fifth week of classes, five new lab sessions were added to the initial schedule (three and two of these sessions were intended respectively for the natural and artificial teams). These sessions were scheduled in the ninth week of classes. The additional sessions were included to accommodate teams who needed to reschedule (because of exam conflicts or extraordinary events). As the lab sessions progressed, students that missed their time slots and students left out by the other members of their teams also registered in these additional sessions.

Figure 3.4: Main Screen with Experimental Task (member blue / 4 person team)



In the sixth week of classes, I visited both sections of the course to obtain the initial measure of cohesion. I asked participants to indicate their agreement with 5 statements using a 7-point Likert scale (see Appendix I). Examples of statements are "I look forward to being with the members of my team" and "I

Artificial three or four person teams would be created with the other students. In any case, no volunteering students would be excluded from the experiment and everybody would receive the same incentive, i.e. a $100 draw for each group of 20 students who participated. This was necessary since it was no longer possible to schedule exactly 20 have confidence and trust in my team". This cohesion index (adapted from Seashore [1954]) is used in Klein and Mulvey [1995] and Mulvey and Klein [1998]. I chose this index because it performed well in settings similar to the setting in my experiment. In particular, Klein and Mulvey (1995, 1998) found the index to be positively related to group performance in experimental studies conducted with the participation of undergraduate students in naturally occurring groups (with 3 to 6 members). In each previous study, the index had a high level of reliability (approximately .88).

I randomly assigned each lab session to one of the three bonus-sharing conditions. The sessions with natural and artificial teams were assigned separately to insure an equal number of both types of team across experimental conditions.

3.5.2 Procedures during each lab session

I telephoned each participant the day before the experiment to reduce absenteeism. Before each session, I prepared a plan of the room with a specific place for each participant. Members of a team were assigned to non adjacent areas to reduce chances of oral communication. Members of a color were similarly assigned to reduce chances of copying answers. Before the arrival of the participants, personal computers were set to the experiment webpage. A matrix for practicing and 5X7 and 8½X11 envelopes were distributed to each station seat. The matrices for practicing were leaning against the computer screens, face down. On the other side were printed the team number and the color of the member seated there. The actual matrices (to be used during the 15-minute exercise) were stored in the 5X7 envelopes on the top of the computer screen (with "do not open" written on them). The 8½ X11 envelopes were put beside the keyboards. They contained the four documents: (i) Instructions, (ii) Exercise and incentives, (iii) Index of cohesion, and (iv) Follow-up questions. Each document was printed in a specific color to facilitate its identification.

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students per lab session (the sessions now being composed of up to five or six teams with three or four members). As a consequence, the number of students per lab session varies from 11 to 22 participants.

As participants arrived, I seated them according to the plan. I welcomed them and reminded them of their compensation for participating in the experiment. They were first assured that each participant would receive 3 extra marks in the course. They were then reminded that a prize of $100.00 would be drawn for each group of 20 participants in the experiment. They would be given the opportunity to accumulate tickets for the draw during a fifteen-minute exercise later on during the hour. I briefly explained how we proceed with the envelope and asked them to take the document entitled "Instructions" (see Appendix J) from the envelope.

I read the instructions orally. This document covers (i) the personal identification process and (ii) the practice session and it leads into (iii) the main exercise. During the personal identification process, students learned their team number and assigned color. In the sessions with artificial teams, they were also introduced to their team members.[49] Students entered personal identification (in the gateway screen) and were introduced to the main screen.

During each practice session, I used the same script to teach students to use the computer program and number matrix. The session was organized around 9 practice questions. With questions 1, 2, and 3, students familiarized themselves with the computer program. Each question simply required the students to add three single digit numbers. Students learned how to enter their answers and how to move from one question to the next. Questions 4, 5, and 6 introduced the question format used during the experimental task (questions with a missing number) and verified that students could retrieve numbers from their matrix. Questions 7, 8, and 9 required participants to obtain information from each of their team members. These questions verified that students could communicate with each other. Students were able to move on to the experimental task only when all 9 questions are correctly answered.[50]

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[49] As I called their team number, students stood up, gave their name and assigned color. It was not the first time students saw each other as they were part of the same course.

[50] The effectiveness of this practice session was tested during the pilot study. The results indicated that all participants understood how to (i) enter their answers to the arithmetic questions, (ii) retrieve numbers from their matrix, and (iii) interact with the other members of their team. In addition, on a scale from 0 to 10, where 0 is as bad as it can be and

Once students started the main exercise, they entered their student ID number. When all participants were ready to perform the experimental task, I asked them to remove, from their envelope, the document "Exercise and Incentives" that describes the exercise and its incentive scheme (see Appendix K). I read this document to them. The description of the exercise contains two main points. First, students are free to answer the questions they wish. It is clearly stated that students do not have to answer all the questions, they do not have to answer them in the order presented, and they do not have to help their team members by answering their requests. They may choose to help others but they are not forced to. Students are also informed that they can answer every other question from their list using their own matrix but they need the help of their teammates to answer the rest. The incentives are described using numerical examples with hypothetical teams. The examples emphasize (i) how the tickets are accumulated by members during the exercise and (ii) how the tickets are allocated to members by applying the incentive scheme. In the example, teammates accumulate different numbers of tickets to help clarify how effort can affect personal rewards.

Once the document "Exercise and Incentives" was reviewed, I asked the participants to be ready to extract their matrix from the 5X7 envelope and gave the signal to start the exercise. After 15 minutes, I ended the exercise.[51] Participants were then asked to scroll down the list of questions and select the button entitled "Send your answers". Students were finally asked to take the documents entitled "Index of cohesion" and "Follow-up questions" from the envelope (see Appendices I and L). The follow-up questions included (i) demographic questions (gender, age, programs, and nationality or ethic group), and (ii) manipulation checks regarding the incentive schemes. These questions verified that students understood

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10 is as good as it can be, they gave average scores of 8.87 and 8.95, respectively, when evaluating the instructions and the practice example.

[51] I chose 15 minutes for the following reasons. Free-riding problems occur because effort is costly. Repeating the simple task may become quite boring i.e. costly. Free-riding problems could indicate students doing the least work required as opposed to being eager to succeed. Other experimental studies on incentive plans also used a15-minute experimental task (e.g. Young, Fisher, Lindquist [1993]).

how their actions (individual and cooperative work) affected the outcomes for their team, themselves, and the other team members.

3.5.3 Procedures after the lab sessions

The draws were held electronically during the 11th week of classes. A few days later, I visited both sections of the course. First, I asked participants to answer the following two questions using a scale from 0 to 10, where 0 is as bad as it can be and 10 is as good as it can be: (i) "How would you evaluate your ability to add numbers quickly?" and (ii) "How would you evaluate your computer skills?". These questions were designed to capture differences in abilities across participants. Because these questions were asked at least two weeks after the experiment but before announcing the winners, the likelihood that the students' evaluations were biased toward their performance during the experiment was reduced. After receiving the questionnaire, I gave a short presentation on my study. I spoke of my research questions and hypotheses, provided an overview of the experimental design, and discussed the role of the students as participants. My experiment was proposed to the students as a first-hand learning opportunity on research. This presentation was to ensure that the experience was an educational one for the students. Finally, I distributed prizes to the 29 winners.

3.6 Measurement of variables

Table 3.4 presents the definition and measurement of the variables used in the statistical analysis. The five dependent variables - HELP, IND, TOTAL, MIX and PERFORM – measure levels of effort and performance in teams. Two of the independent (tested) variables are dummies (IP and RP) representing the three bonus-sharing conditions. The third tested variable measures the teams' cohesion levels (CO). This experiment controls for participants' age (AGE) and gender (GENDER) as well as for the fact that people were part of natural or artificial teams (ARTIFICIAL) composed of three or four people (SIZE).

For the sake of simplicity, the model assumes that people have identical preferences and abilities. Regarding preferences, the assumption is that people are indifferent to whether they perform individual or collective work (which implies that choices of effort depend on marginal productivity only). This experiment controls for individual and social preferences. Individual preference (INDPR) is self-reported and social preference score (SOCPR) is attributed based on ethnic background.[52] Ethnic background is considered as it is suggested in the literature that some cultures are more collective while others are more individualistic.[53]

The model also assumes uniform ability, which implies that differences in effort and performance levels depend on monetary incentive only. In this experiment, participants' ability to add numbers quickly and to a smaller extent their familiarity with computers could affect the number of questions they answer in a fifteen-minute period. Four control variables are considered as alternative measures of ability. Two of them are self-reported measures of mathematical and computer skills (MATH and COMP) and the others represent registration in accounting (ACC) and science / math (SCIENCE) programs. These programs were considered as they might attract students with higher grades and / or students comfortable working with numbers.

Table 3.6 presents descriptive statistics for the variables and tables 3.7 and 3.8 present the correlation matrices using, respectively, Spearman and Pearson measures. The dichotomous variables,

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[52] Social preference is measured using Hofstede's [1980] index of individualism versus collectivism in different cultures. Based on extensive cultural surveys and subsequent statistical analysis, Hofstede outlines four dimensions of common social preference that can be used to measure the base values of societies (Salter and Niswander [1994]). The dimension considered in this thesis concerns individual versus collectivism cultures. Participants were asked if, in addition to being Canadian, they belong to an additional nationality or ethnic group. Subjects that did not belong to any other nationality or ethnic group received the Hofstede score for Canadian. Participants that indicated belonging to an additional nationality or ethnic group received the average score for Canadian and the other nationality mentioned.

[53] For example, Chow et al. [1991] compared the performance of a group of American students with the performance of a group of Japanese students, under different incentive schemes (competitive versus collective schemes). The hypotheses was that the American students would perform better under the competitive schemes while the Japanese would do better under a collective scheme. Their experimental results indicate that the Japanese students outperformed the American under all schemes; a possible explanation being that the two groups were not comparable in terms of abilities.

SIZE and ARTIFICIAL, are absent when using the Pearson coefficient. The results for the remaining variables are generally consistent between both matrices. The main results from these statistics are described next.

At any time during the experiment, team members had a choice between answering more of their own questions (IND) and helping a co-member answering her / his questions (HELP). Given the time required to exchange information among team members (i.e. time required to ask for and provide information as well as the time required to view responses), a question that required an exchange of information took much longer to complete than a question that could be answered individually. The negative correlation between IND and HELP reflects this trade-off between effort types. The effort trade-off also explains the negative correlation between TOTAL and MIX since providing additional helping replies prevented people from answering more than one of their own questions. It is consistent with the observed value for MIX (mean of .33) which indicates that people answered three of their own questions for each time that they helped a co-member. For questions worth an equal amount of tickets, it was more beneficial for a team to answer questions that did not require an exchange of information. Some level of helping effort was still beneficial since the number of tickets per question decreased as people progressed down the list of questions, so that it was more beneficial to answer a question that required help higher on the list than a question of their own lower on the list (see table 3.3). As performance is measured by the number of lottery tickets earned by a team, there is a strong positive correlation between PERFORM and each of the variables that captures effort levels (i.e. IND, TOTAL, and to a smaller extend HELP). As discussed above, past a certain point, increasing mix was detrimental to performance as suggested by the negative correlation between MIX and PERFORM.

There was little variation in the average number of helping replies across teams, which implies a low probability of finding any statistical results in terms of the HELP variable. In contrast, the number of questions answered individually varied considerably across teams. As a result, variations in TOTAL are due almost entirely to variations in IND which explains the strong correlation and similar distribution between both variables.

Four proxies (ACC, SCIENCE, MATH and COMP) could be used to measure the concept of ability. The ACC and SCIENCE variables are the most strongly related with levels of effort (IND and TOTAL) and performance (PERFORM). This is consistent with the argument that students in the accounting and science / math programs were particularly good at the experimental task. Both program variables are similarly related to peoples' self-reported ability to add numbers quickly (MATH).[54] The participants' self-reported computer skills (COMP) are not related to ACC, SCIENCE, or the dependent variables.

The strong correlation between ACC and SCIENCE is explained by the fact that 85% of participants registered in science / math programs are accounting students while only 25% of participants registered in arts are accounting students. In terms of the average high school scores of individual students (not reported), the profile of accounting students is quite similar between arts and science / math programs.[55] The 1st, 2nd and 3rd quartiles are, respectively, 87%, 90%, and 93% in the arts programs and, respectively, 88%, 90%, and 93% in the science / math programs. In comparison, 1st, 2nd, and 3rd quartiles of non-accounting students registered in this experiment were, respectively, 80%, 83%, and 86%. Therefore, ACC is used in the main regression analysis and sensitivity analyses are performed using the three alternative measures of ability.

Cohesion was measured using the Klein and Mulvey [1995; 1998] index during the sixth week of classes (before the experiment) and immediately after their experimental session. To calculate the index, participants are asked to agree or disagree with five statements implying high cohesion level, using a 7-point Likert scale. Few experimental teams scored 6 in their cohesion index and none scored 0. The mean team

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[54] Twenty-one observations are missing for the MATH and COMP variables since not all of the participants were in class when the mathematical and computer skills questionnaire was distributed.

[55] Due to the fact that the majority of participants were in their first semester, average high school scores were the broadest and most recent measures of ability available. High school scores were only available for 420 of the participants.

score is 4.45 (s.d. = .77) for their cohesion index, which is about half way between "somewhat agree" and "generally agree" with the given statements. Note that a score of 3 means that participants "neither agree nor disagree" with the cohesion statements, which could be interpreted as an absence of cohesion (this is what would be expected from people who do not know each other). A score of 0 means that participants "completely disagree" with the statements.

The reliability coefficients (cronbach's alpha) for the index of cohesion are .90 (N = 444 participants) and .92 (N = 487 participants), respectively, for the pre-experimental and the post-experimental measurement.[56] There are no significant differences in *change in cohesion* (which is defined as post-experimental minus pre-experimental cohesion scores) across experimental conditions. This result suggests that cohesion was not affected by the experiment allowing the use of post-experimental cohesion scores for the tests of hypotheses. Within-group interrater reliability (r_{WG}) tests have been performed to insure consistency in cohesion assessment among team members (James [1984]).[57] The mean interrater reliability coefficient is .82 (the 1st, 2nd, and 3rd quartiles being, respectively, .80, .91, and .97). The reliability coefficient for the aggregated measure of cohesion CO is .92.

As expected, the variables CO and ARTIFICIAL are negatively correlated. People in natural teams had worked together for at least six weeks prior to their experimental session, which allowed them to build some cohesion levels. In contrast, people in artificial teams had never worked together prior to the experiment. Interestingly, CO is positively correlated to INDPR, which suggests that individuals who prefer collective work build greater cohesion levels. Finally, results of ANOVA tests showed that true

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[56] Four hundred and forty-four participants were in class when the first cohesion index was distributed.

[57] Within-group interrater reliability coefficient (r_{WG}) is an estimate of the consistency of judgements of a single target by one set of judges (James, 1984). The coefficient $r_{WG} = J[1 - (s_{x_j}^2/\sigma_{EU}^2)] / J[1 - (s_{x_j}^2/\sigma_{EU}^2)] + (s_{x_j}^2/\sigma_{EU}^2)$ where r_{WG} is the within-group interrater reliability for judges' mean scores based on J essentially parallel items, $s_{x_j}^2$ is the mean of the observed variances on the J items, and σ_{EU}^2 is the variance on a single item X_j that would be expected if all judgements were due exclusively to random measurement error. In particular, $\sigma_{EU}^2 = (A^2 - 1)/12$ where A corresponds to the number of alternatives in the response scale for X_j, which is presumed to vary from 1 to A (Mood, Graybill, and Boes, 1974).

randomization occurred. For all control variables, there are no differences among the three bonus sharing conditions.

3.7 Test of hypotheses

The hypotheses were tested using OLS regression analyses. The cohesion scores (CO) were centered (COCENT) to reduce the multicolinearity problems resulting from the use of interactive terms (Cronbach, 1987).[58] Centering CO is calculated as: COCENT = CO_{raw} – Mean (CO). The variables IND and TOTAL were transformed to correct for the nonnormality of their regression residuals. Since their regression residuals had negative skewed distributions, the dependent variables were transformed as follow: TIND = -1/IND and TTOTAL = -1/TOTAL. Each dependent variable was regressed on IP, RP, COCENT, the interaction of IP and COCENT (IP*COCENT), the interaction of RP and COCENT (RP*COCENT), and the control variables, as follows (equation number in bracket):

$$\text{HELP} = a + b_1\text{IP} + b_2\text{RP} + b_3\text{COCENT} + b_4\text{IP*COCENT} + b_5\text{RP*COCENT} + b_6\text{SIZE} + b_7\text{AGE} + b_8\text{GENDER} + b_9\text{ACC} + b_{10}\text{INDPR} + b_{11}\text{SOCPR} + b_{12}\text{ARTIFICIAL} + e; \quad \text{(E1)}$$

$$\text{TIND} = a + b_1\text{IP} + b_2\text{RP} + b_3\text{COCENT} + b_4\text{IP*COCENT} + b_5\text{RP*COCENT} + b_6\text{SIZE} + b_7\text{AGE} + b_8\text{GENDER} + b_9\text{ACC} + b_{10}\text{INDPR} + b_{11}\text{SOCPR} + b_{12}\text{ARTIFICIAL} + e; \quad \text{(E2)}$$

$$\text{TTOTAL} = a + b_1\text{IP} + b_2\text{RP} + b_3\text{COCENT} + b_4\text{IP*COCENT} + b_5\text{RP*COCENT} + b_6\text{SIZE} + b_7\text{AGE} + b_8\text{GENDER} + b_9\text{ACC} + b_{10}\text{INDPR} + b_{11}\text{SOCPR} + b_{12}\text{ARTIFICIAL} + e; \quad \text{(E3)}$$

$$\text{MIX} = a + b_1\text{IP} + b_2\text{RP} + b_3\text{COCENT} + b_4\text{IP*COCENT} + b_5\text{RP*COCENT} + b_6\text{SIZE} + b_7\text{AGE} + b_8\text{GENDER} + b_9\text{ACC} + b_{10}\text{INDPR} + b_{11}\text{SOCPR} + b_{12}\text{ARTIFICIAL} + e; \quad \text{(E4)}$$

$$\text{PERFORM} = a + b_1\text{IP} + b_2\text{RP} + b_3\text{COCENT} + b_4\text{IP*COCENT} + b_5\text{RP*COCENT} + b_6\text{SIZE} + b_7\text{AGE} + b_8\text{GENDER} + b_9\text{ACC} + b_{10}\text{INDPR} + b_{11}\text{SOCPR} + b_{12}\text{ARTIFICIAL} + e; \quad \text{(E5)}$$

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[58] Centering the variables prior to forming the multiplicative term tend to yield low correlations between the product term and the component parts of the term.

The tests of hypotheses are summarized in table 3.9. Most of the hypothesis tests are simple t-test on regression coefficients. The H4 and H5 hypotheses are tests of the simple slope of the independent variables on COCENT for, respectively, the IP and RP conditions.

TABLE 3.4
Variable definition and measurement

Dependent variables

HELP	Helping effort, measured using the average (per person) number of helping replies (correct or incorrect) in a team (i.e. the total number of helping replies in a team divided by the number of team members).[1]
IND	Individual effort, measured using the average (per person) number of questions answered individually (correct or incorrect) in a team (i.e. the total number of questions answered individually in a team divided by the number of team members).[1]
TOTAL	Total effort, being the sum of helping and individual effort (i.e. TOTAL = HELP + IND).
MIX	Mix of effort, being the ratio of helping effort to total effort (i.e. MIX = HELP / TOTAL).
PERFORM	Performance, measured using the average (per person) number of lottery tickets earned by a team (i.e. the total number of tickets earned by a team divided by the number of team members).

Independent variables

IP	Dummy variable coded as 1 if IP condition and 0 otherwise.
RP	Dummy variable coded as 1 if RP condition and 0 otherwise.
CO	Team cohesion, measured using the average cohesion score in Klein and Mulvey [1995, 1998] cohesion index, ranging from 0 in a team without cohesion to 6 in a team with maximum cohesion.

Control variables

AGE	Average age of members in a team.
GENDER	Average score for gender in a team, ranging from 0 in a team with females only to 1 in a team with males only.
ACC	Average accounting program score in a team, ranging from 0 in a team without accounting students to 1 in a team with accounting students only.
SCIENCE	Average science or mathematics program score in a team, ranging from 0 in a team without science or mathematics students to 1 in a team with science or mathematics students only.
MATH	Average score for mathematical skills in a team. Mathematical skill is measured using a participant's answer to the following question, on a scale from a low of 0 to a high of 10: How would you evaluate your ability to add numbers quickly?
COMP	Average score for computer skills in a team. Computer skill is measured using a participant's answer to the following question on a scale from a low of 0 to a high of 10: How would you evaluate your computer skills?
INDPR	Average score for members' individual preferences in a team. Individual preference is measured using participants' answers to the following question, on a scale from a low of 0 to a high of 6: How do you feel about working in a group relative to individually?

SOCPR	Average score for social preferences in a team. Members' social preferences are measured using the Hofstede (1980) cultural index of individualism versus collectivism. The scores ranged from 0 for a highly collectivist society to 100 for a highly individualistic society. Participants not listing a nationality other than Canadian were given a score of 80; participants who also listed Chinese, Indian, Irish, or Italian received a scores of, 47, 64, 75, and 78 respectively.
SIZE	Dummy variable coded as 1 if four-person team and 0 if three-person team.
ARTIFICIAL	Dummy variable coded as 1 if artificial teams and 0 if natural teams.

[1] The frequency of incorrect answers was not significantly different across sharing rules.

TABLE 3.5
Descriptive Statistics

Panels A: Descriptive statistics for the complete sample (N = 139)

Variable		*Mean*	*Std. dev.*	*Minimum*	*Maximum*	*1 quartile*	*2 quartile*	*3 quartile*
Dependent Variables								
HELP		9.30	2.64	0.00	15.17	7.67	9.55	10.97
IND		21.05	11.07	11.21	77.50	14.50	17.76	23.10
TOTAL		30.35	9.66	18.67	78.25	25.00	28.00	33.00
MIX		0.33	0.11	0.00	0.46	0.27	0.35	0.41
PERFORM		807.92	70.89	599.90	968.10	763.53	808.58	854.87
Independent variable								
CO		4.45	0.77	1.47	6.00	3.90	4.50	5.05
Control variables								
AGE		19.09	0.57	18.00	22.30	18.80	19.00	19.30
GENDER		0.34	0.27	0.00	1.00	0.00	0.33	0.50
ACC		0.34	0.36	0.00	1.00	0.00	0.25	0.67
SCIENCE		0.18	0.28	0.00	1.00	0.00	0.00	0.33
MATH [1]		7.76	0.87	5.00	9.17	7.25	8.00	8.50
COMP [1]		7.38	0.94	4.33	9.25	6.75	7.50	8.00
INDPR		4.10	0.80	1.25	5.50	3.50	4.00	4.75
SOCPR		68.74	7.63	48.00	83.00	64.20	69.50	73.80
Dichotomous control variables								
SIZE	Three-person team coded as 0	69 (49.6 %)						
	Four-person team coded as 1	70 (50.4 %)						
ARTIFICIAL	Natural team coded as 0	111 (79.9 %)						
	Artificial team coded as 1	28 (20.1 %)						

Panels B: Descriptive statistics by experimental condition

Variable		*ES condition (N = 45)*		*IP condition (N = 46)*		*RP condition (N = 48)*	
Dependent variables		*Mean*	*Std. dev.*	*Mean*	*Std. dev.*	*Mean*	*Std. dev.*
HELP		9.47	2.48	8.98	3.11	9.45	2.29
IND		20.68	11.35	21.66	14.17	20.80	6.83
TOTAL		30.15	10.01	30.64	12.19	30.26	6.13
MIX		0.34	0.11	0.33	0.12	0.33	0.09
PERFORM		811.88	65.32	798.38	81.17	815.28	65.20
Independent variable							
CO		4.38	0.69	4.61	0.68	4.38	0.89
Control variables							
AGE		19.12	0.60	19.18	0.73	18.99	0.32
GENDER		0.38	0.25	0.32	0.27	0.32	0.28
ACC		0.41	0.36	0.31	0.36	0.31	0.34
SCIENCE		0.21	0.31	0.16	0.24	0.17	0.28
MATH [1]		7.86	0.82	7.72	0.87	7.70	0.92
COMP [1]		7.43	1.07	7.33	0.90	7.37	0.87
INDPR		3.99	0.83	4.26	0.75	4.05	0.81
SOCPR		67.92	7.77	69.53	8.07	68.76	7.14
Dichotomous control variables							
SIZE	Three-person team coded as 0	23 (51.1 %)		24 (52.2 %)		22 (45.8 %)	
	Four-person team coded as 1	22 (48.9 %)		22 (47.8 %)		26 (54.2 %)	
ARTIFICIAL	Natural team coded as 0	36 (80.0 %)		37 (80.4 %)		38 (79.2 %)	
	Artificial team coded as 1	9 (20.0 %)		9 (19.6 %)		10 (20.8 %)	

TABLE 3.5 ***(Continuing)***
Descriptive Statistics

[1] The MATH and COMP variables have twenty-one observations missing. For these two variables, N = 118 in the complete sample, N = 41 in the ES condition, N = 38 in the IP condition, and N = 39 in the RP condition.

HELP: helping effort
IND: individual effort
TOTAL: total effort
MIX: mix of effort
PERFORM: performance
CO: team cohesion – range from 0 to 6
AGE: age
GENDER: gender – range from 0 (team with females only) to 1 (team with males only)
ACC: accounting programs – range from 0 (team without accounting students) to 1 (team with accounting students only)
SCIENCE: science / math programs – range from 0 (team without science / math students) to 1 (team with science / math students only)
MATH: mathematics skill – range from 0 to 10
COMP: computer skill – range from 0 to 10
INDPR: individual preference – range from 0 to 6
SOCPR: social preference – range from 0 to 100
SIZE: team size – 0 if three-person team, 1 if four-person team
ARTIFICIAL: artificial team – 0 if natural team, 1 if artificial team

TABLE 3.6
Correlation Matrix – Spearman coefficients

	HELP	IND	TOTAL	MIX	PERFORM	CO	AGE	GENDER	ACC	SCIENCE	MATH	COMP	INDPR	SOCPR	SIZE
IND	-.294** .000														
TOTAL	-.036 .674	.945** .000													
MIX	.702** .000	-.846** .000	-.647** .000												
PERFORM	.410** .000	.599** .000	.762** .000	-.197* .020											
CO	.259** .002	-.176* .039	-.109 .201	.231** .006	.006 .946										
AGE	.002 .985	-.079 .354	-.085 .318	.050 .557	-.088 .302	.186* .029									
GENDER	-.044 .607	.206* .015	.221** .009	-.168* .047	.157 .064	-.089 .298	.180* .034								
ACC	.149 .080	.215* .011	.267** .001	-.087 .307	.310** .000	.051 .554	-.163 .055	.055 .523							
SCIENCE	.223** .008	.166 .051	.237** .005	-.016 .853	.293** .000	.008 .926	.046 .595	.067 .432	.541** .000						
MATH	.041 .657	.208* .024	.200* .030	-.169 .068	.216* .019	-.118 .203	-.115 .214	.177 .056	.314** .001	.330** .000					
COMP	.055 .557	.110 .237	.095 .308	-.088 .345	.021 .817	-.075 .422	.051 .581	.253** .006	.111 .232	.096 .303	.482** .000				
INDPR	.041 .635	-.084 .328	-.060 .483	.114 .181	.052 .545	.481** .000	-.053 .535	-.093 .278	-.017 .842	-.045 .603	-.046 .619	-.190* .039			
SOCPR	-006 .947	-.132 .121	-.125 .143	.081 .345	-.087 .308	.094 .271	.109 .200	.140 .101	-.192* .024	-.181* .033	-.157 .090	.000 .999	.002 .984		
SIZE	-.019 .823	.127 .136	.127 .137	-.094 .272	.064 .455	.143 .092	.157 .065	.038 .654	.187* .028	-.044 .610	-.028 .760	.116 .212	.050 .556	-.003 .977	
ARTIFICIAL	.007 .938	-.016 .849	-.012 .892	.017 .840	-.029 .734	-.218** .010	-.009 .917	.085 .321	-.085 .318	-.076 .376	.108 .246	.122 .188	-.130 .127	-.008 .929	-.147 .084

** Correlation is significant at the 0.01 level (2 tailed)   * Correlation is significant at the 0.05 level (2 tailed)

The variables are defined in table 3.5.

TABLE 3.7
Correlation Matrix – Pearson coefficients

	HELP	IND	TOTAL	MIX	PERFORM	CO	AGE	GENDER	ACC	SCIENCE	MATH	COMP	INDPR
IND	-.621**												
	.000												
TOTAL	-.439**	.977**											
	.000	.000											
MIX	.806**	-.862**	-.768**										
	.000	.000	.000										
PERFORM	.387**	.359**	.517**	-.137									
	.000	.000	.000	.109									
CO	.243**	-.175*	-.135	.251**	.003								
	.004	.039	.114	.003	.969								
AGE	-.025	-.110	-.133	.096	-.210*	.179*							
	.774	.197	.119	.263	.013	.035							
GENDER	-.076	.210*	.220**	-.205*	.145	-.138	.128						
	.372	.013	.009	.016	.088	.105	.134						
ACC	.101	.210*	.268**	-.099	.304**	.054	-.065	.086					
	.239	.013	.001	.246	.000	.525	.449	.312					
SCIENCE	.187*	.154	.227**	-.019	.305**	.002	.039	.039	.619**				
	.028	.071	.007	.825	.000	.978	.651	.647	.000				
MATH	.010	.121	.142	-.095	.172	-.153	-.073	.162	.294**	.351**			
	.917	.192	.125	.307	.062	.099	.433	.080	.001	.000			
COMP	-.016	.071	.078	-.060	.052	-.074	-.038	.258**	.083	.112	.449**		
	.862	.443	.401	.518	.574	.424	.683	.005	.373	.227	.000		
INDPR	.083	-.046	-.030	.101	.060	.502**	-.014	-.136	-.010	-.020	-.099	-.169	
	.331	.589	.723	.236	.482	.000	.866	.112	.907	.816	.285	.067	
SOCPR	-.011	-.062	-.074	.081	-.117	.080	.050	.137	-.209*	-.186*	-.195*	-.018	.022
	.895	.470	.387	.341	.171	.346	.556	.107	.014	.028	.034	.850	.799

** Correlation is significant at the 0.01 level (2 tailed) * Correlation is significant at the 0.05 level (2 tailed)

The variables are defined in table 3.5.

TABLE 3.8
Tests of hypotheses

Hypotheses	*Tests of hypotheses*
Effects of Bonus-Sharing Rules	
H1a: HELP is greater under ES than under IP	t-test on b_1 in E1
H1b: IND is greater under IP than under ES	t-test on b_1 in E2
H1c: TOTAL is greater under IP than under ES	t-test on b_1 in E3
H1d: MIX is greater under ES than under IP	t-test on b_1 in E4
H1e: PERFORM is greater under IP than under ES	t-test on b_1 in E5
H2a: HELP is greater under ES than under RP	t-test on b_2 in E1
H2b: IND is greater under RP than under ES	t-test on b_2 in E2
H2c: TOTAL is greater under RP than under ES	t-test on b_2 in E3
H2d: MIX is greater under ES than under RP	t-test on b_2 in E4
H2e: PERFORM is greater under RP than under ES	t-test on b_2 in E5
Effects of Group Cohesion	
H3a: CO is positively related to HELP under ES	t-test on b_3 in E1
H3b: CO is positively related to IND under ES	t-test on b_3 in E2
H3c: CO is positively related to TOTAL under ES	t-test on b_3 in E3
H3d: CO is not related to MIX under ES	t-test on b_3 in E4
H3e: CO is positively related to PERFORM under ES	t-test on b_3 in E5
H4a: CO is positively related to HELP under IP	t-test on $(b_3 + b_4)$ in E1 [1]
H4b: CO is not related to IND under IP	t-test on $(b_3 + b_4)$ in E2
H4c: CO is positively related to TOTAL under IP	t-test on $(b_3 + b_4)$ in E3
H4d: CO is positively related to MIX under IP	t-test on $(b_3 + b_4)$ in E4
H4e: CO is positively related to PERF under IP	t-test on $(b_3 + b_4)$ in E5
H5a: CO is positively related to HELP under RP	t-test on $(b_3 + b_5)$ in E1
H5b: CO is positively related to IND under RP	t-test on $(b_3 + b_5)$ in E2
H5c: CO is positively related to TOTAL under RP	t-test on $(b_3 + b_5)$ in E3
H5d: CO is positively related to MIX under RP	t-test on $(b_3 + b_5)$ in E4
H5e: CO is positively related to PERF under RP	t-test on $(b_3 + b_5)$ in E5
H6a: There is a stronger positive relationship between CO and HELP under IP than under ES	t-test on b_4 in E1
H6b: There is a stronger positive relationship between CO and IND under ES than under IP	t-test on b_4 in E2
H6c: There is a stronger positive relationship between CO and TOTAL under ES than under IP	t-test on b_4 in E3
H6d: There is a stronger positive relationship between CO and MIX under IP than under ES	t-test on b_4 in E4
H6e: There is a stronger positive relationship between CO and PERFORM under ES than under IP	t-test on b_4 in E5
H7a: There is a stronger positive relationship between CO and HELP under RP than under ES	t-test on b_5 in E1
H7b: There is a stronger positive relationship between CO and IND under ES than under RP	t-test on b_5 in E2
H7c: There is a stronger positive relationship between CO and TOTAL under ES than under RP	t-test on b_5 in E3
H7d: There is a stronger positive relationship between CO and MIX under RP than under ES	t-test on b_5 in E4
H7e: There is a stronger positive relationship between CO and PERFORM under ES than under RP	t-test on b_5 in E5

[1] From equation (1), one may compute the regression coefficient of CO in the IP condition i.e., (b_3+b_4). The test of the regression coefficient for (b_3+b_4) takes the form of a t test, such that $t = [(b_3+b_4) / s(b_3+b_4)]$ where $s(b_3+b_4) = [(var(b_3) + var(b_4) + 2\ cov(b_3, b_4)]^{.5}$. The value of $[(b_3+b_4) / s(b_3+b_{54})]$ is approximately distributed as t with N-k-1 degrees of freedom, where k is the number of predictor terms in equation (1) (see Jaccard et al. [1990], p.28).1

Chapter 4 – Experimental Results

Chapter four is organized as follows. Sections 4.1 describes the results on the experimental manipulations. Section 4.2 reports the tests of hypotheses and Section 4.3 reports the sensitivity analysis.

4.1 Experimental manipulation check

Subjects were asked post-experimental questions to verify the success of the experimental manipulation. The two main questions tested the subjects' perceptions of the effect of individual and helping effort on individual payoff. More precisely, subjects are questioned on the effect of (i) answering one of the questions from their list and (ii) helping one of their team members on the number of tickets they received. Manipulation of bonus-sharing rules is such that answering your own questions increases the number of tickets one received across all three experimental conditions.

In contrast, the effect of helping a team member differed across conditions as follows. In the ES condition, helping always increases the number of tickets received without regard to reciprocal behaviour. In the IP condition, helping increases the number of tickets upon the assumption that team members would reciprocate help; otherwise, helping had no effect on the number of tickets received.[59] In the RP condition, helping would be particularly beneficial if team members reciprocated help; otherwise, helping has an uncertain effect on the number of tickets received. That is, helping increases the number received because it increases the team's ticket pool, but helping decreases the expected number received since it decreases the chance of becoming the team's highest performing member.

Results are the following. In the ES, IP, and RP conditions, respectively 89, 84, and 85 percent of subjects indicate that answering a question from their list *increases* the number of tickets received. The remaining subjects indicate that answering their own questions decreases or does not affect the number of

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[59] Several subjects mention this assumption when answering this post-experimental question.

ticket received, providing evidence on the success of bonus-sharing rule manipulation.[60] There is no significant difference across experimental conditions in subjects' answers to this question ($\chi^2 = 1.664$, $p = .435$).

In the ES condition, 64 percent of subjects indicate that helping a team member *increases* the amount of tickets received compared to 13 and 17 percent in, respectively, the IP and RP conditions. In the IP condition, 49 percent of subjects indicate that helping *has no effect* on the amount of tickets received compared to 8 and 18 percent in, respectively, the ES and RP conditions. In the RP conditions, 44 percent of subjects indicate that helping *has an uncertain effect* on the amount of tickets received compared to 23 percent in both the ES and IP conditions. Finally, in the ES, IP, and RP conditions, respectively 5, 15, and 21 percent of subjects indicate that helping a team member *decreases* the amount of tickets received. Differences found in answers across experimental conditions are significant ($\chi^2 = 60.746$, $p = .000$) and in the direction expected, providing evidence on the success of the sharing rule manipulation.

4.2 Regression results

Tables 4.1 to 4.5 report the results from the HELP, TIND, TTOTAL, MIX, and PERFORM OLS regressions (respectively, equations 1 to 5). DFFITS statistics were smaller than 1.2 in all regression analyses, indicating no outliers.[61] An analysis of the variance inflation factors did not suggest the presence of any multicollinearity problems i.e. all variable-specific variance inflation factors are found to be smaller

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[60] In the ES, IP, and RP conditions, respectively 1 (10), 6 (11), and 6 (9) percent of the subjects indicate that answering one of the question from their list *decreases* (*had no effect on*) the number of tickets received. The *no effect* answer can be explained by the use of a lottery (some students thought that payoff is related to performance). The answer *decreased* may indicate that the subject was distracted while answering post-experimental questions or while performing the experimental task or did not understand the post-experimental questions or ticket system.

[61] DFFITS = $(Y_i - Y_{i(i)})/(MSE_{(i)} h_{ii})^{.5}$ where Y_i is the fitted value for the ith case when all n cases are used in fitting the regression function, $Y_{i(i)}$ is the predicted value for the ith case obtained when the ith case is omitted in fitting the regression function, $MSE_{(i)}$ is the mean square error when the ith case is omitted in fitting the regression function, and h_{ii} is the ith element on the main diagonal of the hat matrix (Neter, Wasserman, and Kutner [1989]).

than 4.8.[62] Three of the regressions (TIND, TTOTAL and PERFORM) are significant ($p < .001$) and explain between 14.3% and 17.1% of the overall variance.[63] The MIX regression is marginally significant ($F = 1.723$, $p < .10$; table 4.4) explaining 6% of the overall variance and the HELP regression is not significant ($F = 1.144$, $p > .33$; table 4.1). Consequently, results regarding HELP are not discussed further.

The remainder of this section is organised as follows. Sub-section 4.2.1 presents tests of hypotheses (the H1 and H2 hypotheses) describing the effect of bonus-sharing rules on effort choices and performance. Sub-section 4.2.2 presents tests of hypotheses describing the effect of team cohesion on effort choices and performance under each bonus-sharing rule (the H3, H4 and H5 hypotheses) and the interaction effect between cohesion and rules (the H6 and H7 hypotheses). Finally, sub-section 4.2.3 presents a sensitivity analysis of the results using alternative proxies for ability and controlling for teams' interrater reliability scores.

4.2.1 Effect of bonus-sharing rule

Two sets of hypotheses – the H1 and H2 hypotheses - compares effort levels and performance between ES and the two other rules. The H1 hypotheses compare effort levels and performance between the ES and IP rules. It is hypothesized that helping effort (H1a) and mix of effort (H1d) are greater under the ES rule than under the IP rule while individual effort (H1b) , total effort (H1c), and performance (H1e) are greater under the IP rule that under the ES rule. The regression results indicate no significant differences in any of the dependent variables (TIND, TTOTAL, MIX and PERFORM) between the ES and IP conditions, providing no support for the H1 hypotheses. That is, IP is not a significant predictor for TIND ($t = 1.092$,

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[62] The variance inflation factor (VIF) for X_j is $1/1 - RSQ_j$, RSQ_j being the R-squared value from the regression of X_j on the remaining $k - 1$ predictors. If X_j is highly correlated with the remaining predictors, its VIF is very large.

[63] That is, the TIND regression explains 15.2 % of overall variance ($F = 3.054$, $p < .001$; table 4.2); the TTOTAL regression explains 17.1% of overall variance ($F = 3.372$, $p < .001$; table 4.3); and the PERFORM regression explains 14.3% of the overall variance ($F = 2.923$, $p < .001$; table 4.5).

one-tailed $p > .13$; table 4.2), TTOTAL ($t = 0.625$, one-tailed $p > .26$; table 4.3), MIX ($t = -1.243$, one-tailed $p > .10$; table 4.4), or PERFORM ($t = -0.424$, two-tailed $p > .67$; table 4.5).

The H2 hypotheses compare effort levels and performance between the ES and RP rules. It is hypothesized that helping effort (H2a) and mix of effort (H2d) are greater under ES rule than under RP rule while individual effort (H2b) , total effort (H2c), and performance (H2e) are greater under RP rule than under ES rule. The regression results indicate that TIND ($t = 1.918$, one-tailed $p < .05$; table 4.2) and TTOTAL ($t = 1.763$, one-tailed $p < .05$; table 4.3) are significantly greater in the RP condition than in the ES condition, providing evidence for H2b and H2c. There are, however, no significant differences in the remaining variables (MIX and PERFORM) between the ES and RP conditions. That is, there are no significant differences in MIX ($t = -1.187$, one-tailed $p > .11$; table 4.4), or PERFORM ($t = 0.964$, one-tailed $p > .16$; table 4.5) between the ES and RP conditions.

In the tests discussed above, IP (RP) captures the difference in the dependent variables between the ES and IP (RP) conditions when COCENT equals 0, i.e. when cohesion is centered (CO = 4.45).[64] Given that the interaction term RP*COCENT is significant in the TTOTAL and PERFORM regression equations, differences in total effort and performance between the ES and RP rules might not be constant across cohesion levels. Table 4.6 presents additional testing of such differences for low and high cohesion levels. Following Cohen and Cohen's (1983) convention, low cohesion (COLOW) is defined as the mean cohesion level minus one standard deviation (i.e. 4.45 – 0.77 = 3.68) while high cohesion (COHIGH) is defined as the mean cohesion level plus one standard deviation (i.e. 4.45 + 0.77 = 5.22). The regressions' coefficients were estimated and tested with CO re-scaled so that it value was 0 at COLOW and COHIGH (i.e. $COLOW = CO_{raw} - 3.68$ and $COHIGH = CO_{raw} - 5.22$).

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[64] Regression coefficients in models involving interactions are *conditional effects*. Conditional effects refer to effects that hold *only* at specific values of other predictors in the equation. First-order effects are interpreted when all other continuous variables are coded 0 (West, Aiken, and Krull, 1996, page 14).

The differences in total effort levels between the ES and RP conditions remain significant at high cohesion level. That is, the regression results indicate that TTOTAL ($t = 2.415$, one-tailed $p < .05$; table 4.16, panel C) is significantly greater in the RP condition than in the ES condition, providing additional evidence for H2c. However, the differences become insignificant when cohesion is low. The regression results also indicate that, when cohesion is high, PERFORM ($t = 2.347$, one-tailed $p < .05$; table 4.16, panel E) is significantly greater in the RP condition than in the ES condition, providing some evidence for H2e.

Overall, these results suggest that in teams with average or high cohesion levels, the RP rule leads to higher levels of total effort in teams than the ES rule; the RP rule also leads to higher performance than the ES rule but only when cohesion is high. The effect of team cohesion on effort choices and performance is reported next.

4.2.2 Effect of team cohesion

Three sets of hypotheses – the H3, H4, and H5 hypotheses - describe the effect of team cohesion under each bonus-sharing rule.[65] The H3 hypotheses describe the effect of team cohesion on effort choices and performance under the ES rule. It is hypothesized that, under this rule, cohesion is positively related to both helping (H3a) and individual (H3b) effort. As a consequence, a positive relationship between cohesion and both total effort (H3c) and performance (H3e) are also predicted. Finally it is hypothesized that the mix of effort would remain constant across cohesion levels (H3d), as cohesion is expected to have the same effect on both effort types. None of the H3 hypotheses are supported by the regression results. That is, COCENT is not a significant predictor for PERFORM ($t = -1.609$, two-tailed $p > .11$; table 4.5), providing no evidence for H3e. The positive effect of COCENT on MIX is marginally significant ($t = 1.922$, two-tailed $p < .10$; table 4.4), which is inconsistent with H3d predicting an absence of relationship between both variables.

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[65] These tests estimate the simple slopes of the independent variables on COCENT for each experimental group and the associated *t* tests assess whether these values are significantly different from 0.

Finally, the effect of COCENT on TIND ($t = -2.005$, two-tailed $p < .05$; table 4.2) and TTOTAL ($t = -1.802$, two-tailed $p < .10$; table 4.3) is in the direction opposite to that predicted in H3b and H3c.

The H4 hypotheses describe the effect of team cohesion on effort choices and performance under the IP rule. It is hypothesized that cohesion is positively related to helping effort (H4a) but has no relationship with individual effort (H4b). Consequently, team cohesion is positively related to total effort (H4c), mix of effort (H4d) and performance (H4e). The regression results indicate that the positive effect of COCENT+ IP*COCENT on MIX ($t = 1.660$, one-tailed $p < .10$; table 4.3) is marginally significant, providing some support for H4d. COCENT+ IP*COCENT is not a significant predictor for TIND ($t = 1.186$, two-tailed $p > .47$; table 4.2), TTOTAL ($t = -0.972$, two-tailed $p > .66$; table 4.3) or PERFORM ($t = -0.566$, two-tailed $p > .78$; table 4.5). These results are consistent with H4d predicting an absence of relationship between cohesion and individual effort, but they provide no support for H4c or H4e.

The H5 hypotheses describe the effect of team cohesion on effort choices and performance under RP rule. It is hypothesized that, under this rule, cohesion is positively related to helping effort (H5a), individual effort (H5b), total effort (H5c), mix of effort (H5d), and performance (H5e). The regression results indicate that the positive effect of COCENT+ RP*COCENT on PERFORM ($t = 1.762$, one-tailed $p < .10$; table 4.5) is marginally significant, providing some support for H5e. COCENT+ RP*COCENT is not a significant predictor for TIND ($t = -0.287$, two-tailed $p > .98$; table 4.2), TTOTAL ($t = 0.379$, one-tailed $p > .70$; table 4.2), or MIX ($t = 1.571$, one-tailed $p > .11$; table 4.4), providing no evidence for H5b, H5c, and H5d.

Finally, two sets of hypotheses - the H6 and H7 hypotheses - compare the effect of cohesion between the ES rule and the two other rules. The H6 hypotheses compare the effect of cohesion on effort choices and performance between ES and IP rules. It is hypothesized that there is a stronger positive relationship between team cohesion and both helping effort (H6a) and mix of effort (H6d) under IP rule than under ES rule. In contrast, a stronger positive relationship is hypothesized between team cohesion and the remaining dependent variables - individual effort (H6b), total effort (H6c) and performance (H6e) - under ES rule than under IP rule. The regression results indicate that IP*COCENT is not a significant predictor for any of the dependent variables, providing no support for the H6 hypotheses. That is, IP*COCENT is not a significant predictor for TIND ($t = 0.545$, two-tailed $p > .58$; table 4.2), TTOTAL ($t = 0.563$, one-tailed $p > .28$; table 4.3), MIX ($t = -0.117$, two-tailed $p > .90$; table 4.4), or PERFORM ($t = 0.736$, two-tailed $p > .46$; table 4.5).

Finally, the H7 hypotheses compare the effect of cohesion on effort choices and performance between ES and RP rules. It is hypothesized that there is a stronger positive relationship between team cohesion and both helping effort (H7a) and mix of effort (H7d) under RP rule than under ES rule. In contrast, a stronger positive relationship is hypothesized between team cohesion and the remaining dependent variables - individual effort (H7b), total effort (H7c) and performance (H7e) - under ES rule than under RP rule. The regression results indicate that RP*COCENT has a significant effect on PERFORM ($t = 2.532$, two-tailed $p < .05$; table 4.5) and a marginally significant effect on TTOTAL ($t = 1.837$, two-tailed $p < .10$; table 4.3) in the direction opposite to that predicted. Finally, the regression results indicate that RP*COCENT is not a significant predictor for TIND ($t = 1.600$, two-tailed $p > .11$; table 4.2) or MIX ($t = -0.724$, one-tailed $p > .47$; table 4.4), providing no evidence for H7b or H7d.

Overall, the regression results suggest that team cohesion has the following effect on effort and performance levels in teams, under the three bonus-sharing rules investigated. As predicted, results suggest that cohesion is positively related to the mix of effort (H4d) under the IP rule. Under the RP rule, cohesion is also positively related to team performance (H5e). Under the ES rule, results suggest that cohesion is negatively related to individual and total effort, which goes against the modelled predictions.

The results also suggest some differences in the way cohesion affects effort and performance levels between the ES and RP rules. As predicted, results suggest a stronger positive relationship between cohesion and helping effort (H7a) under the RP rule than under the ES rule. Contrary to expectations, results suggest a stronger positive relationship between cohesion and both total effort and performance under the RP rule than under the ES rule.

4.2.3 Sensitivity analysis

I consider alternative proxies for ability. Tables 4.7 to 4.10 present results, respectively, from the TIND, TTOTAL, MIX and PERFORM regressions, using each of the alternative proxies(ACC, SCIENCE, MATH and COMP) for ability. Overall, the regression results are fairly robust across proxies. In the TIND regression, RP*COCENT becomes marginally significant ($t = 1.760$, two-tailed $p < .10$; table 4.7) when using MATH as a proxy for ability, but in the direction opposite to that predicted. In the TTOTAL regression, RP passes from being significant to being marginally significant when SCIENCE ($t = 1.489$, one-tailed $p < .10$; table 4.8) or COMP ($t = 1.616$, one-tailed $p < .10$; table 4.8) are used while COCENT passes from being marginally significant to being significant when MATH ($t = -2.033$, two-tailed $p < .05$) is used. The former result would reduce the support for H2c while the later would increase the support for H5d. In the MIX regression, IP becomes marginally significant when MATH ($t = -1.371$, one-tailed $p < .10$) or COMP ($t = -1.388$, one-tailed $p < .10$) are used, providing some support for H1d. Finally, in the PERFORM regression COCENT and IP*COCENT becomes significant when MATH (respectively $t = -2.169$, two-tailed $p < .05$; $t = 1.998$, two-tailed $p < .05$) and COMP ($t = -1.984$, two-tailed $p < .05$; $t = 1.701$, two-tailed $p < .10$) are used, but in the direction opposite to that predicted. Finally, statistical analysis was performed excluding teams with low interrater reliability scores, but the regression results remain unchanged.[66]

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[66] In this experiment, the variance on X_j that would be expected if all judgements were due exclusively to random measurement error is 4 i.e. $\sigma_{EU}^2 = (7^2 - 1)/12 = 4$. Therefore, a team's r_{WG} equals 0 if the mean of the observed variances on the J items (s_{Xj}^2) is equal to (or greater) than 4. In my experiment, nine out of 139 teams had an interrater reliability score equals to 0, which is the result we would expect if team members were rating cohesion randomly. Withdrawing these nine teams from the sample did not change my results.

Overall, the experimental results provide a rather modest support for the modeled hypotheses. Results from the model and experimental results are discussed in the conclusion. The conclusion also discusses the difficulties of testing a mathematical model with a laboratory experiment.

TABLE 4.1
Results of HELP regression

$$HELP = a + b_1 IP + b_2 RP + b_3 COCENT + b_4 IP{*}COCENT + b_5 RP{*}COCENT + b_6 AGE + b_7 GENDER + b_8 ACC + b_9 INDPR + b_{10} SOCPR + b_{11} SIZE + b_{12} ARTIFICIAL + e$$

Independent Variable	*Expected Sign*	*Coefficient*	*Std. Error*	*t-value*	*P-value* [1]	*Hypothesis*
Panel A: Regression coefficients						
Intercept		15.089	8.378	1.801	.074	
IP	-	-0.625	0.591	-1.057	.146	H1a
RP	-	-0.006	0.547	-0.011	.496	H2a
COCENT	+	0.758	0.637	1.190	.118	H3a
IP*COCENT	+	0.432	0.872	0.496	.311	H6a
RP*COCENT	+	0.377	0.718	0.525	.300	H7a
AGE		-0.264	0.409	-0.644	.521	
GENDER		-0.403	0.879	-0.459	.647	
ACC		0.737	0.677	1.089	.278	
INDPR		-0.142	0.331	-0.430	.668	
SOCPR		0.001	0.031	0.034	.973	
SIZE		-0.469	0.468	-1.001	.319	
ARTIFICIAL		0.248	0.587	0.422	.674	
N = 139				*F-statistic*		
R^2		.098		1.144	.331	
Adjusted R^2		.012				

[1] One-tailed if directional prediction and if in the right direction, two-tailed otherwise.

HELP: Helping effort
IP: 1 if IP condition, 0 otherwise
RP: 1 if RP condition, 0 otherwise
COCENT: CO_{raw} – Mean (CO) where CO is the team cohesion
IP*COCENT: interaction between IP and COCENT
RP*COCENT: interaction between RP and COCENT
AGE: Average age of members in a team.age
GENDER: gender – range from 0 (team with females only) to 1 (team with males only)
ACC: accounting programs – range from 0 (team without accounting students) to 1 (team with accounting students only)
INDPR: individual preference – range from 0 to 6
SOCPR: social preference – range from 0 to 100
SIZE: team size – 0 if three-person team, 1 if four-person team
ARTIFICIAL: artificial team – 0 if natural team, 1 if artificial team

TABLE 4.2
Results of TIND regression

$$TIND = a + b_1 IP + b_2 RP + b_3 COCENT + b_4 IP^*COCENT + b_5 RP^*COCENT + b_6 AGE + b_7 GENDER + b_8 ACC + b_9 INDPR + b_{10} SOCPR + b_{11} SIZE + b_{12} ARTIFICIAL + e$$

Independent Variable	*Expected Sign*	*Coefficient*	*Std. Error*	*t-value*	*P-value* [1]	***Hypothesis***
Panel A: Regression coefficients						
Intercept		0.0357	0.051	0.697	.487	
IP	+	0.0039	0.004	1.092	.139	H1b
RP	+	0.0064	0.003	1.918	.028	H2b
COCENT	+	-0.0078	0.004	-2.005	.047	H3b
IP*COCENT	-	0.0029	0.005	0.545	.587	H6b
RP*COCENT	-	0.0070	0.004	1.600	.112	H7b
AGE		-0.0047	0.002	-1.897	.060	
GENDER		0.0176	0.005	3.273	.001	
ACC		0.0092	0.004	2.224	.028	
INDPR		0.0009	0.002	0.425	.671	
SOCPR		-0.0003	0.000	-1.394	.166	
SIZE		0.0036	0.003	1.262	.209	
ARTIFICIAL		-0.0016	0.004	-0.469	.640	
N = 139				*F-statistic*		
R^2		.225		3.054	.001	
Adjusted R^2		.152				
Panel B: Additional coefficients[2]						
COCENT + IP*COCENT		-0.0049	0.0041	-1.186	.476	H4b
COCENT + RP*COCENT	+	-0.0008	0.0028	-0.287	.988	H5b

[1] One-tailed if directional prediction and if in the right direction, two-tailed otherwise.
[2] The alpha levels are adjusted for multiple comparisons (Bonferroni adjustment).

TIND: -1/IND where IND is individual effort
IP: 1 if IP condition, 0 otherwise
RP: 1 if RP condition, 0 otherwise
COCENT: CO_{raw} – Mean (CO) where CO is the team cohesion
IP*COCENT: interaction between IP and COCENT
RP*COCENT: interaction between RP and COCENT
AGE: Average age of members in a team.age
GENDER: gender – range from 0 (team with females only) to 1 (team with males only)
ACC: accounting programs – range from 0 (team without accounting students) to 1 (team with accounting students only)
INDPR: individual preference – range from 0 to 6
SOCPR: social preference – range from 0 to 100
SIZE: team size – 0 if three-person team, 1 if four-person team
ARTIFICIAL: artificial team – 0 if natural team, 1 if artificial team

TABLE 4.3
Results of TTOTAL regression

$$TTOTAL = a + b_1 IP + b_2 RP + b_3 COCENT + b_4 IP{*}COCENT + b_5 RP{*}COCENT + b_6 AGE + b_7 GENDER + b_8 ACC + b_9 INDPR + b_{10} SOCPR + b_{11} SIZE + b_{12} ARTIFICIAL + e$$

Independent Variable	*Expected Sign*	*Coefficient*	*Std. Error*	*t-value*	*P-value* [1]	*Hypothesis*
Panel A: Regression coefficients						
Intercept		0.0096	0.023	0.412	.681	
IP	+	0.0010	0.002	0.625	.267	H1c
RP	+	0.0027	0.002	1.763	.040	H2c
COCENT	+	-0.0032	0.002	-1.802	.074	H3c
IP*COCENT	+	.0.0014	0.002	0.563	.288	H6c
RP*COCENT	-	0.0037	0.002	1.837	.068	H7c
AGE		-0.0025	0.001	-2.154	.033	
GENDER		0.0082	0.002	3.369	.001	
ACC		0.0055	0.002	2.900	.004	
INDPR		0.0005	0.001	0.533	.595	
SOCPR		-0.0001	0.000	-1.137	.258	
SIZE		0.0016	0.001	1.209	.229	
ARTIFICIAL		-0.0005	0.002	-0.288	.774	
N = 139				*F-statistic*		
R^2		.243		3.372	.000	
Adjusted R^2		.171				
Panel B: Additional coefficients[2]						
COCENT + IP*COCENT	+	-0.0018	0.0019	-0.972	.666	H4c
COCENT + RP*COCENT	+	0.0005	0.0013	0.379	.705	H5c

[1] One-tailed if directional prediction and if in the right direction, two-tailed otherwise.
[2] The alpha levels are adjusted for multiple comparisons (Bonferroni adjustment).

TTOTAL: -1/TOTAL where TOTAL is total effort
IP: 1 if IP condition, 0 otherwise
RP: 1 if RP condition, 0 otherwise
COCENT: CO_{raw} – Mean (CO) where CO is the team cohesion
IP*COCENT: interaction between IP and COCENT
RP*COCENT: interaction between RP and COCENT
AGE: Average age of members in a team.age
GENDER: gender – range from 0 (team with females only) to 1 (team with males only)
ACC: accounting programs – range from 0 (team without accounting students) to 1 (team with accounting students only)
INDPR: individual preference – range from 0 to 6
SOCPR: social preference – range from 0 to 100
SIZE: team size – 0 if three-person team, 1 if four-person team
ARTIFICIAL: artificial team – 0 if natural team, 1 if artificial team

TABLE 4.4
Results of MIX regression

$$MIX = a + b_1 IP + b_2 RP + b_3 COCENT + b_4 IP*COCENT + b_5 RP*COCENT + b_6 AGE + b_7 GENDER + b_8 ACC + b_9 INDPR + b_{10} SOCPR + b_{11} SIZE + b_{12} ARTIFICIAL + e$$

Independent Variable	*Expected Sign*	*Coefficient*	*Std. Error*	*t-value*	*P-value* [1]	***Hypothesis***
Panel A: Regression coefficients						
Intercept		0.1200	0.330	0.362	.718	
IP	-	-0.0290	0.023	-1.243	.108	H1d
RP	-	-0.0256	0.022	-1.187	.119	H2d
COCENT		0.0483	0.025	1.922	.057	H3d
IP*COCENT	+	-0.0040	0.034	-0.117	.907	H6d
RP*COCENT	+	-0.0205	0.028	-0.724	.470	H7d
AGE		0.0115	0.016	0.714	.476	
GENDER		-0.0789	0.035	-2.280	.024	
ACC		-0.0203	0.027	-0.761	.448	
INDPR		-0.0060	0.013	-0.458	.647	
SOCPR		0.0011	0.001	0.923	.358	
SIZE		-0.0203	0.018	-1.097	.275	
ARTIFICIAL		0.0115	0.023	0.497.	.620	
N = 139				*F-statistic*		
R^2		.141		1.723	.069	
Adjusted R^2		.059				
Panel B: Additional coefficients[2]						
COCENT + IP*COCENT	+	0.0443	0.0266	1.660	.099	H4d
COCENT + RP*COCENT	+	0.0278	0.0177	1.571	.119	H5d

[1] One-tailed if directional prediction and if in the right direction, two-tailed otherwise.
[2] The alpha levels are adjusted for multiple comparisons (Bonferroni adjustment).

MIX: mix of effort
IP: 1 if IP condition, 0 otherwise
RP: 1 if RP condition, 0 otherwise
COCENT: CO_{raw} – Mean (CO) where CO is the team cohesion
IP*COCENT: interaction between IP and COCENT
RP*COCENT: interaction between RP and COCENT
AGE: Average age of members in a team.age
GENDER: gender – range from 0 (team with females only) to 1 (team with males only)
ACC: accounting programs – range from 0 (team without accounting students) to 1 (team with accounting students only)
INDPR: individual preference – range from 0 to 6
SOCPR: social preference – range from 0 to 100
SIZE: team size – 0 if three-person team, 1 if four-person team
ARTIFICIAL: artificial team – 0 if natural team, 1 if artificial team

TABLE 4.5
Results of PERFORM regression

$$PERFORM = a + b_1 IP + b_2 RP + b_3 COCENT + b_4 IP*COCENT + b_5 RP*COCENT + b_6 AGE + b_7 GENDER + b_8 ACC + b_9 INDPR + b_{10} SOCPR + b_{11} SIZE + b_{12} ARTIFICIAL + e$$

Independent Variable	*Expected Sign*	*Coefficient*	*Std. Error*	*t-value*	*P-value* [1]	*Hypothesis*
Panel A: Regression coefficients						
Intercept		1234.449	209.857	5.882	.000	
IP	+	-6.285	14.805	-0.424	.672	H1e
RP	+	13.224	13.713	0.964	.169	H2e
COCENT	+	-25.676	15.957	-1.609	.110	H3e
IP*COCENT	-	16.083	21.841	0.736	.463	H6c
RP*COCENT	-	45.514	17.977	2.532	.013	H7c
AGE		-24.071	10.245	-2.350	.020	
GENDER		50.320	22.010	2.286	.024	
ACC		52.463	16.954	3.094	.002	
INDPR		10.362	8.288	1.250	.213	
SOCPR		-0.681	0.767	-0.887	.377	
SIZE		1.021	11.728	0.087	.931	
ARTIFICIAL		14.710	14.710	-0.164	.870	
N = 139				*F-statistic*		
R^2		.218		2.923	.001	
Adjusted R^2		.143				
Panel B: Additional coefficients[2]						
COCENT + IP*COCENT	+	-9.593	16.939	-0.566	.786	H4e
COCENT + RP*COCENT	+	19.838	11.261	1.762	.081	H5e

[1] One-tailed if directional prediction and if in the right direction, two-tailed otherwise.
[2] The alpha levels are adjusted for multiple comparisons (Bonferroni adjustment).

PERFORM: performance
IP: 1 if IP condition, 0 otherwise
RP: 1 if RP condition, 0 otherwise
COCENT: CO_{raw} – Mean (CO) where CO is the team cohesion
IP*COCENT: interaction between IP and COCENT
RP*COCENT: interaction between RP and COCENT
AGE: Average age of members in a team.age
GENDER: gender – range from 0 (team with females only) to 1 (team with males only)
ACC: accounting programs – range from 0 (team without accounting students) to 1 (team with accounting students only)
INDPR: individual preference – range from 0 to 6
SOCPR: social preference – range from 0 to 100
SIZE: team size – 0 if three-person team, 1 if four-person team
ARTIFICIAL: artificial team – 0 if natural team, 1 if artificial team

TABLE 4.6
Regression results for high, centered, and low cohesion levels

Independent Variable	Expected Sign	Low cohesion [5] (COLOW) [1] Coefficient	P-value [4]	Centered cohesion (COLOW) [1] Coefficient	P-value [4]	High cohesion [5] (COHIGH) [3] Coefficient	P-value [4]	Hypotheses
Panel A: Results for TTOTAL regression (table 4.3)								
IP	+	-0.0000	.995	0.0010	.267	0.0021	.186	H1c
RP	+	-0.0001	.951	0.0027	.040	0.0055	.009	H2c
Panel B: Results for PERFORM regression (table 4.5)								
IP	+	-18.602	.436	-6.285	.672	6.032	.386	H1e
RP	+	-21.630	.240	13.224	.169	48.079	.010	H2e

[1] COLOW = CO_{raw} – [Mean(CO) + s.d.(CO)]
[2] COCENT = CO_{raw} – Mean(CO) i.e. identical to main results in tables 4.1 to 4.5
[3] COHIGH = CO_{raw} – [Mean(CO) - s.d.(CO)]

[4] One-tailed if directional prediction and if in the right direction, two-tailed otherwise.
[5] The alpha levels are adjusted for multiple comparisons (Bonferroni adjustment).

HELP: Helping effort
TIND: -1/IND where IND is individual effort
TTOTAL: -1/TOTAL where TOTAL is total effort
MIX: mix of effort
PERFORM: performance
IP: 1 if IP condition, 0 otherwise
RP: 1 if RP condition, 0 otherwise

TABLE 4.7
Results of TIND regression using alternative proxies for ability

$$TIND = a + b_1 IP + b_2 RP + b_3 COCENT + b_4 IP^{*}COCENT + b_5 RP^{*}COCENT + b_6 AGE + b_7 GENDER + b_8 \textit{Ability} + b_9 INDPR + b_{10} SOCPR + b_{11} SIZE + b_{12} ARTIFICIAL + e$$

		Ability measured by ACC		*Ability measured by* SCIENCE		*Ability measured by* MATH		*Ability measured by* COMP	
Independent Variable	*Expected sign*	*Coefficient*	*P-value* [1]	*Coefficient*	*P-value* [1]	*Coefficient*	*P-value* [1]	*Coefficient*	*P-value* [1]
Intercept		0.0357	.487	0.0533	.294	0.0037	.953	0.0271	.665
IP	+	0.0039	.139	0.0038	.147	0.0044	.138	0.0045	.134
RP	+	0.0064	.028	0.0057	.046	0.0067	.035	0.0065	.039
COCENT		-0.0078	.047	-0.0078	.047	-0.0092	.036	-0.0087	.047
IP*COCENT	+	0.0029	.587	0.0039	.465	0.0072	.216	0.0062	.289
RP*COCENT	-	0.0070	.112	0.0072	.103	0.0085	.081	0.0078	.107
AGE	-	-0.0047	.060	-0.0055	.029	-0.0039	.183	-0.0042	.157
GENDER		0.0176	.001	0.0183	.001	0.0184	.003	0.0196	.002
Ability		0.0092	.028	0.0010	.043	0.0020	.289	0.0001	.957
INDPR		0.0009	.671	0.0007	.719	0.0016	.526	0.0015	.553
SOCPR		-0.0003	.166	-0.0003	.129	-0.0003	.200	-0.0003	.123
SIZE		0.0036	.209	0.0051	.073	0.0046	.146	0.0046	.156
ARTIFICIAL		-0.0016	.640	-0.0013	.717	-0.0002	.964	0.0003	.942
N		139		139		118		118	
R^2		.225	.001	.221	.001	.196	.020	.188	.029
Adjusted R^2		.152		.147		.105		.095	

[1] One-tailed if directional prediction and if in the right direction, two-tailed otherwise.

TIND: -1/IND where IND is individual effort
IP: 1 if IP condition, 0 otherwise
RP: 1 if RP condition, 0 otherwise
COCENT: CO_{raw} – Mean (CO) where CO is the team cohesion
IP*COCENT: interaction between IP and COCENT
RP*COCENT: interaction between RP and COCENT
AGE: age
GENDER: gender – range from 0 (team with females only) to 1 (team with males only)
ACC: accounting programs – range from 0 (team without accounting students) to 1 (team with accounting students only)
INDPR: individual preference
SOCPR: social preference
SIZE: team size – 0 if three-person team, 1 if four-person team
ARTIFICIAL: artificial team – 0 if natural team, 1 if artificial team

TABLE 4.8
Results of TTOTAL regression using alternative proxies for ability

$$\text{TTOTAL} = a + b_1\,\text{IP} + b_2\,\text{RP} + b_3\,\text{COCENT} + b_4\,\text{IP*COCENT} + b_5\,\text{RP*COCENT} + b_6\,\text{AGE} + b_7\,\text{GENDER} + b_8\,\textit{Ability} + b_9\,\text{INDPR} + b_{10}\,\text{SOCPR} + b_{11}\,\text{SIZE} + b_{12}\,\text{ARTIFICIAL} + e$$

		Ability measured by ACC		*Ability measured by* SCIENCE		*Ability measured by* MATH		*Ability measured by* COMP	
Independent Variable	*Expected sign*	*Coefficient*	*P-value* [1]	*Coefficient*	*P-value* [1]	*Coefficient*	*P-value* [1]	*Coefficient*	*P-value* [1]
Intercept		0.0096	.681	0.0199	.387	-0.0002	.995	0.0106	.712
IP	+	0.0010	.267	0.0010	.274	0.0010	.290	0.0011	.283
RP	+	0.0027	.040	0.0022	.069	0.0028	.048	0.0027	.055
COCENT		-0.0032	.074	-0.0032	.073	-0.0040	.045	-0.0038	.058
IP*COCENT	+	0.0014	.288	0.0019	.215	0.0040	.066	0.0036	.092
RP*COCENT	+	0.0037	.068	0.0038	.060	0.0041	.065	0.0038	.088
AGE	-	-0.0025	.033	-0.0029	.011	-0.0024	.074	-0.0026	.062
GENDER		0.0082	.001	0.0086	.001	0.0086	.002	0.0092	.002
Ability		0.0055	.004	0.0069	.004	0.0010	.260	0.0001	.905
INDPR		0.0005	.595	0.0004	.650	0.0010	.365	0.0010	.385
SOCPR		-0.0001	.258	-0.0001	.210	-0.0001	.370	-0.0001	.245
SIZE		0.0016	.229	0.0025	.054	0.0020	.174	0.0020	.188
ARTIFICIAL		-0.0005	.774	-0.0002	.907	0.0005	.790	0.0007	.707
N		139		139		118		118	
R^2		.243	.000	.245	.000	.197	.020	.187	.030
Adjusted R^2		.171		.173		.105		.094	

[1] One-tailed if directional prediction and if in the right direction, two-tailed otherwise.

TTOTAL: -1/TOTAL where TOTAL is total effort
IP: 1 if IP condition, 0 otherwise
RP: 1 if RP condition, 0 otherwise
COCENT: CO_{raw} – Mean (CO) where CO is the team cohesion
IP*COCENT: interaction between IP and COCENT
RP*COCENT: interaction between RP and COCENT
AGE: age
GENDER: gender – range from 0 (team with females only) to 1 (team with males only)
ACC: accounting programs – range from 0 (team without accounting students) to 1 (team with accounting students only)
INDPR: individual preference
SOCPR: social preference
SIZE: team size – 0 if three-person team, 1 if four-person team
ARTIFICIAL: artificial team – 0 if natural team, 1 if artificial team

TABLE 4.9
Results of MIX regression using alternative proxies for ability

$$MIX = a + b_1 IP + b_2 RP + b_3 COCENT + b_4 IP{*}COCENT + b_5 RP{*}COCENT + b_6 AGE + b_7 GENDER + b_8 \mathit{Ability} + b_9 INDPR + b_{10} SOCPR + b_{11} SIZE + b_{12} ARTIFICIAL + e$$

		Ability measured by ACC		*Ability measured by* SCIENCE		*Ability measured by* MATH		*Ability measured by* COMP	
Independent Variable	*Expected sign*	*Coefficient*	*P-value* [1]	*Coefficient*	*P-value* [1]	*Coefficient*	*P-value* [1]	*Coefficient*	*P-value* [1]
Intercept		0.1200	.718	0.0757	.817	0.2820	.486	0.2120	.596
IP	-	-0.0290	.108	-0.0276	.119	-0.0354	.087	-0.0358	.084
RP	-	-0.0256	.119	-0.0235	.138	-0.0261	.134	-0.0259	.136
COCENT		0.0483	.057	0.0488	.055	0.0515	.066	0.0499	.076
IP*COCENT		-0.0040	.907	-0.0076	.825	-0.0067	.857	-0.0037	.921
RP*COCENT	+	-0.0205	.470	-0.0215	.450	-0.0235	.449	-0.0220	.474
AGE	+	0.0115	.476	0.0127	.431	0.0039	.836	0.0048	.799
GENDER		-0.0789	.024	-0.0818	.019	-0.0801	.040	-0.0847	.034
Ability		-0.0203	.448	-0.0018	.957	-0.0034	.781	0.0023	.837
INDPR		-0.0060	.647	-0.0056	.669	-0.0080	.612	-0.0072	.652
SOCPR		0.0011	.358	0.0013	.275	0.0014	.303	0.0015	.256
SIZE		-0.0203	.275	-0.0228	.213	-0.0249	.223	-0.0257	.216
ARTIFICIAL		0.0115	.620	0.0127	.587	0.0097	.714	0.0078	.770
N		139		139		118		118	
R^2		.141	.069	.137	.082	.137	.185	.136	.186
Adjusted R^2		.059		.055		.038		.038	

[1] One-tailed if directional prediction and if in the right direction, two-tailed otherwise.

MIX: mix of effort
IP: 1 if IP condition, 0 otherwise
RP: 1 if RP condition, 0 otherwise
COCENT: CO_{raw} – Mean (CO) where CO is the team cohesion
IP*COCENT: interaction between IP and COCENT
RP*COCENT: interaction between RP and COCENT
AGE: age
GENDER: gender – range from 0 (team with females only) to 1 (team with males only)
ACC: accounting programs – range from 0 (team without accounting students) to 1 (team with accounting students only)
INDPR: individual preference
SOCPR: social preference
SIZE: team size – 0 if three-person team, 1 if four-person team
ARTIFICIAL: artificial team – 0 if natural team, 1 if artificial team

TABLE 4.10
Results of PERFORM regression using alternative proxies for ability

$$PERFORM = a + b_1 IP + b_2 RP + b_3 COCENT + b_4 IP{*}COCENT + b_5 RP{*}COCENT + b_6 AGE + b_7 GENDER + b_8 \mathit{Ability} + b_9 INDPR + b_{10} SOCPR + b_{11} SIZE + b_{12} ARTIFICIAL + e$$

		Ability measured by ACC		*Ability measured by* SCIENCE		*Ability measured by* MATH		*Ability measured by* COMP	
Independent Variable	*Expected sigh*	*Coefficient*	*P-value* [1]	*Coefficient*	*P-value* [1]	*Coefficient*	*P-value* [1]	*Coefficient*	*P-value* [1]
Intercept		1234.449	.000	1331.057	.000	1099.888	.000	1245.974	.000
IP	+	-6.285	.672	-6.173	.673	-12.306	.445	-11.726	.474
RP	+	13.224	.169	9.190	.247	17.469	.117	16.191	.138
COCENT		-25.676	.110	-25.541	.107	-37.348	.032	-34.882	.050
IP*COCENT	+	16.083	.463	20.641	.336	46.082	.048	39.784	.092
RP*COCENT	-	45.514	.013	46.292	.010	50.678	.010	46.231	.019
AGE	-	-24.071	.020	-28.956	.005	-25.068	.035	-26.743	.027
GENDER		50.320	.024	53.141	.015	46.537	.055	53.559	.034
Ability		52.463	.002	75.989	.000	13.897	.068	2.002	.782
INDPR		10.362	.213	9.707	.237	19.671	.046	19.561	.054
SOCPR		-0.681	.377	-0.702	.351	-0.327	.695	-0.656	.428
SIZE		1.021	.931	10.179	.373	2.024	.873	1.506	.908
ARTIFICIAL		14.710	.870	1.197	.9350	1.497	.927	4.348	.796
N		139		139		118		118	
R^2		.218	.001	.240	.000	.198	.019	.173	.053
Adjusted R^2		.143		.168		.107		.078	

[1] One-tailed if directional prediction and if in the right direction, two-tailed otherwise.

PERFORM: performance
IP: 1 if IP condition, 0 otherwise
RP: 1 if RP condition, 0 otherwise
COCENT: CO_{raw} – Mean (CO) where CO is the team cohesion
IP*COCENT: interaction between IP and COCENT
RP*COCENT: interaction between RP and COCENT
AGE: age
GENDER: gender – range from 0 (team with females only) to 1 (team with males only)
ACC: accounting programs – range from 0 (team without accounting students) to 1 (team with accounting students only)
INDPR: individual preference
SOCPR: social preference
SIZE: team size – 0 if three-person team, 1 if four-person team
ARTIFICIAL: artificial team – 0 if natural team, 1 if artificial team

Conclusion

Experimental research on incentives in teams has mainly focussed on "pure" forms of technologies, that is, a technology where each subject works alone on an individual task and a technology where subjects work together on a common task. Results strongly suggest that group rewards are more productive with collective production (e.g., Rosenbaum et al. [1980]; French et al. [1977]) while competitive rewards appear weakly superior with individual production (e.g., Scott and Cherrington [1974]; Weinsteen and Holzbach [1972]). However, few insights are provided on the best reward for a "hybrid" technology i.e. a technology requiring both collective and individual action (Wageman [1995]).

My thesis compares alternative methods of sharing a bonus pool in a technology where each member is accountable for a particular task and where help is mutually productive. Following Drago and Turnbull [1988; 1991], I developed a mathematical economic model on teams where help increases production and improves efficiency. The model highlights the fact that group incentives promote helping effort but reduce overall motivation i.e. the free-riding problems (Holmstrom [1982]).[67] Sharing based on individual or relative performance alleviates the free-riding problems. Attempts to differentiate the contributions of various team members have been discouraged in the literature because it can undermine collective effort (e.g., Hackman [1990]; Shea and Guzzo [1987]). In my model, however, the reduction in helping effort is counterbalanced by the increase in total effort, causing the IP and RP rules to outperform the ES rule.

Based on behavioural research (e.g., Shaw [1981]; Deutsch [1968]), a cohesion parameter is incorporated in the model. The basic assumption is that cohesion increases the level of effort response among team members. The model shows that, as cohesion increases, the total level of effort and the team performance increases under all three sharing rules, which is consistent with the resources invested by

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[67] Consistent with the modelled results, experimental results suggest collective behaviour to be greater under group incentives than under individual (e.g., Mitchell and Silver [1990]) or competitive incentives (e.g., Ravenscroft and Haka [1996]); and free riding problems were found in Nalbantian and Schotler [1997] and Weldon and Mustari [1988].

firms to stimulate team spirit.[68] Cohesion increases effort levels and/or improves the effort mix depending on the sharing-rules considered (interaction effect). The nature of the interaction is such that, as cohesion increases, the differences between the three bonus-sharing rules are reduced. As cohesion reaches its limit, all three sharing rules produce the optimal level and mix of effort. These modelling results suggest that firms generating extremely strong cohesion should be less concerned with the choice of bonus-sharing rules while the choice of sharing rules is more important for firms with very low levels of cohesion.

Unlike other research that generates alternative hypotheses (e.g., Frederickson [1992]) from economic theories versus behavioural theories, this thesis includes insights from social psychology in a mathematical economic model. A model's conclusions are essentially driven by the assumptions that are made about human behaviour. Although there are some common assumptions in economics (e.g., utility for money, cost of effort, or risk aversion), other sensible assumptions can also be included in a mathematical model. In my model, the Cournot assumption is relaxed, as people are part of cohesive groups. In all cases, models are enriched using the knowledge emerging from different but often complementary disciplines.

This model is used to develop hypotheses to be tested in a laboratory experiment. Testing an economic model in a laboratory experiment poses some difficulties. There is always a trade-off between a model's clarity, which implies that simplifying assumptions are made, and its relationship to reality. For the sake of clarity, my model assumes that people have identical abilities. Although I have used a simple experimental task (i.e. adding three numbers) and trained the participants to use the computer program, the data suggests great differences in ability. In my statistical analysis, the control variable for ability is measured by whether the participants are accounting students. Despite its imprecision, this control variable is highly significant. In addition, experimental settings might not be ideal environments to detect free-riding problems. For a free-riding problem to occur, working has to be costly; it must be strenuous or

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[68] The modelled results are also consistent with three recent meta-analyses of the relationship between cohesiveness and group performance (e.g., Evans and Dion [1991]; Muller and Cooper [1994]; and Gully et al. [1995]).

uninteresting or it must preclude more enjoyable activities. Laboratory experiments last for a short period of time, present unusual activity, and leave subjects with nothing better to do then the experimental task. My experimental task was to answer a list of arithmetic questions. I was expecting this task to be strenuous enough that students would slow down after a few minutes, but students made enthusiastic comments about their experience. This could mean that performing the experimental task was not very costly. In addition, the presence of an experimenter might have a monitoring effect. Free-riding problems are supported in Nalbantian and Schotler (1997), but in their experiment, subjects were presented with a written work scenario and chose their level of effort. Their subjects did not experience the cost of working but rather "walked in the shoes" of an individual faced with work to be done under specific incentives. Frederickson [1992] had a similar experimental setting.[69]

Testing monetary incentives during a lab experiment also poses a problem. Monetary incentives are quite small in an experiment setting compared with what they can be in reality. These experiments try to replicate the kind of financial incentives offered to business people, which in some cases can be very high. Given that students have different economic backgrounds, an identical amount of money can also represent a radically different financial incentives.

Finally, performing laboratory experiments that require the participation of teams rather than individuals raises both practical and statistical problems. Keeping a large sample size is jeopardised by the problems involved with scheduling all members of a team for an experimental session, and ensuring they will arrive. Even with a complete team present, 14% of my data was lost due to the failure of the software or hardware of one team member. Statistically, incorporating personal control information is difficult at the group level. In my experiment, demographic data about participants' gender, age, program, and preferences were averaged at the team level. This results in a leveling of variables that makes systematic differences more difficult to capture. Even aggregated, some of these personal characteristics are

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[69] The difficulty to detect free-riding problems during laboratory experiments can explain that in previous experimental studies, group incentives often outperformed individual incentives. The relationship between group incentive and team

significant. Finally, the reliability of self-reported group characteristics should be taken into account in order to use the data.

In the near future, I will re-examine my experimental results using individual member as the level of analysis. Predictions from my model are the same regardless of the level of analysis. When averaged, teams' results are identical to members' results. For statistical tests, the group level is less powerful than the individual level because the sample size goes from 139 (teams) t o 487 (members). Cohesion is also better controlled at the individual level of analysis. In addition, incorporating demographic data related to members (and which appear highly significant in the regression analysis) will be improved at the individual level of analysis.

The experimental support for the hypotheses is rather modest. The regression of helping effort is not significant while the regression of the mix of effort is only marginally significant. The regressions of individual effort, total effort, and performance are significant but they explain only between 14% and 17% of the overall variance. As discussed above, my model predicts that individual effort, total effort, and performance are greater under the IP and RP rules than under the ES rule. As predicted, the results suggest that individual effort, total effort, and performance are greater under the RP rule than under the ES rule (supporting H2b, H2c, and H2e). However, the results suggest no differences in the levels of effort or performance between the ES and IP rules. In terms of helping effort, my model predicts that the mix of effort (proportion of helping effort) is greater under the ES rule than under the IP or RP rules. My results suggest no differences in the mix of effort across the three sharing rules.

Overall, my model predicts that cohesion has a positive effect on effort under the three sharing rules, with two exceptions. First, the mix of effort is independent of cohesion under the ES rule and second, individual effort is independent of cohesion under the IP rule. Nevertheless, cohesion has a positive effect on the mix of effort and / or the total level of effort, both of which should lead to greater performance. None of the hypotheses are supported under the ES rule. Under the IP rule, the results suggest that individual

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performance remains unclear in field results, where free-riding problems potentially occur.

effort remains stable across cohesion levels (consistent with H4d) and that the mix of effort is positively related to cohesion (supporting H4b). Under the RP rule, performance is positively related to cohesion (supporting H5e). The experimental results also suggest that, in some cases, cohesion does interact with sharing rules, but in the direction opposite to that predicted. The positive effects of cohesion on total effort and performance were greater under the RP rule than under the ES rule. These results do not support the model's suggestion that differences across rules are reduced as cohesion increases. On the contrary, the experiment shows that the competitive rule outperforms both other rules when cohesion is high.

Some patterns in the data might imply problems with my modelled assumptions and experimental design. One of my model's assumptions is that cohesion increases the level of response of both helping and individual effort. In my experiment, cohesion is positively related to mix of effort but has no relationship with total effort. These results raise concerns about my experimental setting. It is possible that cohesion increases the level of response among team members, but only for actions observable by the group. Peer monitoring requires members to be able to gather information about mutual contributions to the pool (Milgrom and Roberts [1992]). In my experiments, team members were not seated together. Subjects could evaluate helping effort of their peers by their availability to answer questions. In contrast, individual work was not as easily evaluated. To test this possibility, multiple-period experiments in which subjects can assess each others' individual contribution would be needed.

Another possibility is that my model is incorrect. It might be that cohesion simply changes people's preferences - their utility function - so that members prefer work that involves social interactions, especially as they are part of cohesive teams. This implies that people receive utility for both monetary incentives and social interactions in cohesive groups. This would be consistent with behavioural research that found cohesion to be particularly productive in tasks requiring a high level of interaction (Mullen and Cooper, 1994; Karayaman and Nath, 1984).

Another modeled assumption is that some level of help improves efficiency. After reaching a certain point, helping effort is detrimental to performance because it prevents members from performing individual work with greater marginal productivity. In my experiment, the mix of effort was negatively related to performance, which means that some members have given too much help. In other words, they helped others in spite of the decrease in their performance. A possible explanation could be that collective behaviour has a cost of communicating which is difficult to assess in my experiment. Another explanation is that in the real world individuals could be financially and socially rewarded for cooperating.

Future research should continue investigating the effect of incentives on team interactions. Ravenscroft and Haka [1996] find that members under group incentives share more information than members under competitive incentives. In their experiment, thus, the subjects who understood the task best had no reason to share their knowledge when competing. They had nothing to win by sharing out of pure altruism. In my experiment, each team member had exclusive pieces of knowledge (i.e. numbers from some part of the matrix) that were of great value to their team members. Helping behaviour was reciprocal since everybody needed everybody else. Team members exchanged information not out of altruism but out of opportunism.

In conclusion, the experimental results provide few insights in understanding the effects of incentives in a technology where help is productive. Consistent with Wageman [1995], no differences in performance were found between group and individual incentive schemes. Note that Wageman [1995] did not consider competitive incentives, which are the only type of incentives that outperform the other incentives in my experiment. My results suggest that individual effort, total effort, and performance are greater under the RP rule than under the ES rule. The superiority of the RP rule is consistent with Frederickson [1992] and Nalbantian and Schotler [1997] in finding effort levels to be higher under competitive incentives than under individual incentives. My results extend previous findings in considering a technology where both helping and individual effort are provided. Future research should investigate the possibility of creating discrepancies amongst team members' bonuses.

As predicted, my experimental results also suggest a positive relationship between cohesion and performance under the RP rule. The question is, however, whether people working with competitive incentives over a long period of time would remain cohesive. During the experiment, changes in cohesion under the RP were not different than changes under the other rules, but the experimental task took only 15 minutes. Future research should investigate the development of cohesion under different schemes over a longer period of time.

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Appendix A
First-best solution

The solution that maximizes the team's total surplus, the first-best solution, occurs when each worker receives his marginal contribution to the team output.

The team's total surplus is given by: $S = EQ(\mathbf{e}, \mathbf{h}) - C(\mathbf{e}, \mathbf{h})$ where $EQ = 2\alpha \sum_{i=1}^{N}[e_i^{.5} + (\sum_{j\neq i}^{N} h_{ji})^{.5}]$.

$$S = 2\alpha\{[e_1^{.5} + (\sum_{j\neq 1}^{N} h_{j1})^{.5}] + [e_2^{.5} + (\sum_{j\neq 2}^{N} h_{j2})^{.5}] + \ldots + [e_N^{.5} + (\sum_{j\neq N}^{N} h_{jN})^{.5}]\} - [\delta(e_1+e_2+\ldots+e_N) + \delta(h_1+h_2+\ldots+h_N)]$$

$$S = 2\alpha\{[e_1^{.5} + (h_{21}+h_{31}+\ldots+h_{N1})^{.5}] + [e_2^{.5} + (h_{12}+h_{32}+\ldots+h_{N2})^{.5}] + \ldots + [e_N^{.5} + (h_{1N}+h_{2N}+\ldots+h_{(N-1)N})^{.5}]\}$$
$$- [\delta(e_1+e_2+\ldots+e_N) + \delta(h_1+h_2+\ldots+h_N)]$$

$\partial S/\partial e_1$:

$\alpha/e_1^{.5} - \delta = 0$ — Worker 1 supplies e_1 until the marginal product of e_1 $[\alpha/e_1^{.5}]$ equals

$\alpha/e_1^{.5} = \delta$ — the marginal cost of e_1 $[\delta]$; e_1^{**} is the efficient level of individual work.

$\delta e_1^{.5} = \alpha$

$e_1^{.5} = \alpha/\delta$

$e_1^{**} = (\alpha/\delta)^2$ — (double stars indicates first best solution)

Consider the choice of h_{12}, i.e. the help from 1 to 2, and more broadly, the choice of $h_1 = \sum_{j\neq 1}^{N} h_{1j}$.

$\partial S/\partial h_{12} = \partial S/\partial(\sum_{j\neq 2}^{N} h_{j2}) \cdot \partial(\sum_{j\neq 2}^{N} h_{j2})/\partial h_{12}$ — Worker 1 supplies h_{12} until the marginal product of h_{12}

$[\alpha/(\sum_{j\neq 2}^{N} h_{j2})^{.5} - \delta] \cdot 1 = 0$ — $[\alpha/((\sum_{j\neq 2}^{N} h_{j2}))^{.5}]$ equals marginal cost of h_{12} $[\delta]$;

$\alpha/(\sum_{j\neq 2}^{N} h_{j2})^{.5} = \delta$ — h_{12}^{**} is the efficient level of help.

$(\sum_{j\neq 2}^{N} h_{j2})^{.5} = \alpha/\delta$

$\sum_{j\neq 2}^{N} h_{j2} = (\alpha/\delta)^2$

$(h_{12}+h_{32}+\ldots+h_{N2}) = (\alpha/\delta)^2$

$h_{12} = (\alpha/\delta)^2 - (h_{32}+h_{42}+\ldots+h_{N2})$

In equilibrium, $h_{12} = (\alpha/\delta)^2 - (N-2)h_{12}$ since all workers are identical and act symmetrically (i.e. $h_{ik} = h_{jk}$).

$h_{12} + (N-2)h_{12} = (\alpha/\delta)^2$

$(N-1)h_{12} = (\alpha/\delta)^2$

$h_{12} = (\alpha/\delta)^2/(N-1)$

$h_1^{*} = (\alpha/\delta)^2$ since all workers are identical and act symmetrically (i.e. $h_i = (N-1)\sum_{j\neq i}^{N} h_{ij}$).

At equilibrium, $e_1 = h_1 = (\alpha/\delta)^2$ with total effort $t_1 = 2(\alpha/\delta)^2$. The mix of effort $[e_1/(e_1+h_1)]$ is efficient at ½.

The outputs are:

$Eq_1 = 2\{\{\alpha[(\alpha/\delta)^2]^{.5}\} + \{\alpha[(\alpha/\delta)^2]^{.5}\}\}$

$Eq_1 = 2\{\{\alpha(\alpha/\delta)\} + \{\alpha(\alpha/\delta)\}\}$

$Eq_1 = 4\alpha^2/\delta$.

So that the team performance is $Q = 4N\alpha^2/\delta$.

Appendix B

Solution under ES / Basic model

Under ES, $\theta_1 = \theta/N = EQ/N$ where $EQ = 2\alpha \sum_{i=1}^{N}[e_i^{.5} + (\sum_{j\neq i}^{N} h_{ij})^{.5}]$.

Worker 1 maximises: $W_1(\mathbf{e}, \mathbf{h}) = EQ(\mathbf{e}, \mathbf{h})/N - C(e_1, h_1)$

$$W_1=(2/N)\ \alpha\{[e_1^{.5}+(\textstyle\sum_{j\neq 1}^{N}h_{j1})^{.5}]+[e_2^{.5}+(\sum_{j\neq 2}^{N}h_{j2})^{.5}]+\ldots+[e_N^{.5}+(\sum_{j\neq N}^{N}h_{jN})^{.5}]\}-(\delta e_1+\delta h_1)$$

$$W_1=(2/N)\ \alpha\{[e_1^{.5}+(h_{21}+h_{31}+\ldots+h_{N1})^{.5}]+[e_2^{.5}+(h_{12}+h_{32}+\ldots+h_{N2})^{.5}]+\ldots+[e_N^{.5}+(h_{1N}+h_{2N}+\ldots+h_{(N-1)N})^{.5}]\}-(\delta e_1+\delta h_1)$$

$\partial W_1/\partial e_1 =$

$$(1/N)\alpha/e_1^{.5} - \delta = 0$$
$$(1/N)\alpha/e_1^{.5} = \delta$$
$$\delta e_1^{.5} = (1/N)\alpha$$
$$e_1^{.5} = (1/N)(\alpha/\delta)$$
$$e_1^{*} = (1/N^2)(\alpha/\delta)^2.$$

Some individual work; free-riding i.e. $e_1^{*} < e_1^{**}$. Individual work is inversely related with N, the size of the team. Consider the choice of h_{12}, i.e. the help from 1 to 2, and more broadly, the choice of $h_1 = \sum_{j\neq 1}^{N} h_{1j}$.

$\partial W_1/\partial h_{12} =$

$$\partial W_1/\partial(\textstyle\sum_{j\neq 2}^{N}h_{j2}) \cdot \partial(\sum_{j\neq 2}^{N}h_{j2})/\partial h_{12}$$
$$[(1/N)\alpha/(\textstyle\sum_{j\neq 2}^{N}h_{j2})^{.5} - \delta]\cdot 1 = 0$$
$$(1/N)\alpha/(\textstyle\sum_{j\neq 2}^{N}h_{j2})^{.5} = \delta$$
$$\delta(\textstyle\sum_{j\neq 2}^{N}h_{j2})^{.5} = (1/N)\alpha$$
$$(\textstyle\sum_{j\neq 2}^{N}h_{j2})^{.5} = (1/N)(\alpha/\delta)$$
$$\textstyle\sum_{j\neq 2}^{N}h_{j2} = (1/N^2)(\alpha/\delta)^2$$
$$(h_{12}+h_{32}+\ldots+h_{N2}) = (1/N^2)(\alpha/\delta)^2$$
$$h_{12} = (1/N^2)(\alpha/\delta)^2 - (h_{32}+h_{42}+\ldots+h_{N2})$$

In equilibrium, $h_{12} = (1/N^2)(\alpha/\delta)^2 - (N-2)h_{12}$ since all workers are identical and act symmetrically. (i.e. $h_{ik} = h_{jk}$).

$$h_{12}+(N-2)h_{12} = (1/N^2)(\alpha/\delta)^2$$
$$(N-1)h_{12} = (1/N^2)(\alpha/\delta)^2$$
$$h_{12} = (1/N^2)(\alpha/\delta)^2/(N-1)$$

$h_1^{*} = (1/N^2)(\alpha/\delta)^2$ since all workers are identical and act symmetrically (i.e. $h_i = (N-1)\sum_{j\neq i}^{N} h_{ij}$).

Some help; free-riding, i.e. $h_1^{*} < h_1^{**}$. Help is inversely related with N, the size of the team.

At equilibrium, $e_1 = h_1 = (1/N^2)(\alpha/\delta)^2$ with total effort $t_1 = (2/N^2)(\alpha/\delta)^2$. The mix of individual work and help is efficient (i.e. the level of individual effort "relative" to help remains at its first best) because a worker is indifferent between supplying both types of effort).[1] The mix of individual work and help is independent of N.

The outputs are:

$$Eq_1 = 2\{\{\alpha[(1/N^2)(\alpha/\delta)^2]^{.5}\} + \{\alpha[(1/N^2)(\alpha/\delta)^2]^{.5}\}\}$$
$$Eq_1 = [2\alpha(1/N)(\alpha/\delta)] + [2\alpha(1/N)(\alpha/\delta)]$$

[1] The second order conditions are satisfied since $\partial^2 W_1/\partial e_1^2 < 0$, $\partial^2 W_1/\partial h_1^2 < 0$ and $(\partial^2 W_1/\partial e_1^2)(\partial^2 W_1/\partial h_1^2) - (\partial^2 W_1/\partial e_1/\partial h_1)^2 = (\partial^2 W_1/\partial e_1^2)(\partial^2 W_1/\partial e_1^2) > 0$.

$$Eq_1 = [(2/N)(\alpha^2/\delta)] + [(2/N)(\alpha^2/\delta)]$$
$$Eq_1 = (4/N)(\alpha^2/\delta).$$

So that the team performance is $Q = 4\alpha^2/\delta$.

Appendix C

Solution under IP / Basic model

- Under IP, $\theta_1 = \theta\,[q_1 / \sum_{i\neq1}^{N} q_i] = q_1 \sum_{i\neq1}^{N} q_i / \sum_{i=1}^{N} q_i = q_1$ (θ_1 independent of N).

Worker 1 maximises:

$$W_1 = Eq_1 - C(e_1, h_1) \quad \text{s.t.} \quad h_1 \geq 0$$
$$= Eq_1 - C(e_1, h_1) + \lambda h_1 \quad \text{where } \lambda \text{ is the Lagrangian multiplier}$$
$$= 2\forall[e_1^{.5} + (h_{21}+h_{31}+\ldots+h_{N1})^{.5}] - (\delta e_k + \delta h_k) + \lambda\, h_k$$

$\partial W_1/\partial e_1 =$

$\alpha/e_1^{.5} - \delta = 0$
$\alpha/e_1^{.5} = \delta$
$\delta e_1^{.5} = \alpha$
$e_1^{.5} = \alpha/\delta$
$e_1^{*} = (\alpha/\delta)^2$. Efficient individual work, i.e. $e_1^{*} = e_1^{**}$.

$\partial W_1/\partial h_1 =$

$-\delta + \lambda = 0$
$\lambda = \delta$. Since the marginal cost of effort is greater than 0 (i.e. $\delta>0$), then $\lambda>0$. A positive Lagrangian multiplier implies that the constraint is binding, so that $h_1 = 0$, and the worker's welfare would increase by $\lambda>0$ if h_1 could be reduced by one unit.

$\partial W_1/\partial\lambda =$ $h_1 = 0$. No help. The mix of individual work and help is inefficient at 0.

In equilibrium, $e_1^{*} = (\alpha/\delta)^2$, $h_1^{*} = 0$, and total effort $t_1 = (\alpha/\delta)^2$.

The outputs are:

$Eq_1 = 2\{\alpha\,[(\alpha/\delta)^2]^{.5}\}$
$Eq_1 = 2\{\alpha\,(\alpha/\delta)\}$
$Eq_1 = 2\alpha^2/\delta$.

So that the team performance is $Q = 2N(\alpha^2 / \delta)$.

Appendix D

Solution under RP / Basic model

Under RP, $W_1 = \sum_{z=1}^{N}[P^z(\cdot)\rho^z Q(\cdot)] - C(e_1, h_1)$,

where $Q(\cdot)=(2/N)\ \alpha\{[e_1^{.5} + (h_{21}+h_{31}+\ldots+h_{N1})^{.5}]+[e_2^{.5} + (h_{12}+h_{32}+\ldots+h_{N2})^{.5}]+\ldots+[e_N^{.5} + (h_{1N}+h_{2N}+\ldots+h_{(N-1)N})^{.5}]\}$

Worker 1 maximises:

$\partial W_1/\partial e_1 =$

$$\sum_{z=1}^{N}[P^z(\cdot)\rho^z(\partial Q(\cdot)/\partial e_i)+(\partial P^z(\cdot)/\partial e_1)\rho^z Q(\cdot)]] - \delta = 0$$
$$\sum_{z=1}^{N}[P^z(\cdot)\rho^z(\partial Q(\cdot)/\partial e_i)+(\partial P^z(\cdot)/\partial e_1)\rho^z Q(\cdot)]] = \delta$$
$$\sum_{z=1}^{N}[P^z(\cdot)\rho^z(\alpha/e_1^{.5})+(P_{e_1}{}^z\rho^z Q(\cdot)] = \delta$$
$$\sum_{z=1}^{N}[P^z(\cdot)\rho^z(\alpha/e_1^{.5})] = \delta - \sum_{z=1}^{N}[P_{e_1}{}^z\rho^z Q(\cdot)]$$
$$(\alpha/e_1^{.5})\sum_{z=1}^{N}[P^z(\cdot)\rho^z] = \delta - \sum_{z=1}^{N}[P_{e_1}{}^z\rho^z Q(\cdot)]$$
$$e_1^{.5}[\delta - \sum_{z=1}^{N}[P_{e_1}{}^z\rho^z Q(\cdot)] = \alpha\sum_{z=1}^{N}[P^z(\cdot)\rho^z]$$
$$e_1^{.5} = \alpha\sum_{z=1}^{N}[P^z(\cdot)\rho^z]/[\delta - \sum_{z=1}^{N}[P_{e_1}{}^z\rho^z Q(\cdot)]$$
$$e_1 = [\alpha\sum_{z=1}^{N}[P^z(\cdot)\rho^z]/[\delta - \sum_{z=1}^{N}[P_{e_1}{}^z\rho^z Q(\cdot)]]^2$$
$$e_1 = [\Phi\alpha/(\delta-\Delta)]^2 \quad \text{where } \Phi = \sum_{z=1}^{N}[P^z(\cdot)\rho^z] \text{ and } \Delta = \sum_{z=1}^{N}[P_{e_1}{}^z\rho^z Q(\cdot)]$$

$\partial W_1/\partial h_{12} =$

$$\sum_{z=1}^{N}[P^z(\cdot)\rho^z[(\partial Q(\cdot)/\partial(\textstyle\sum_{j\neq 2}^{N}h_{j2})(\partial(\sum_{j\neq 2}^{N}h_{j2})/\partial h_{12})]+(\partial P^z(\cdot)/\partial h_{12})\rho^z Q(\cdot)] - \delta = 0$$
$$\sum_{z=1}^{N}[P^z(\cdot)\rho^z\alpha/(\textstyle\sum_{j\neq 2}^{N}h_{j2})^{.5}(1)+P_{h_{12}}{}^z\rho^z Q(\cdot)] = \delta$$
$$\alpha/(\textstyle\sum_{j\neq 2}^{N}h_{j2})^{.5}\ \sum_{z=1}^{N}[P^z(\cdot)\rho^z] = \delta - \sum_{z=1}^{N}[P_{h_{12}}{}^z\rho^z Q(\cdot)]$$
$$(\textstyle\sum_{j\neq 2}^{N}h_{j2})^{.5}\ [\delta - \sum_{z=1}^{N}[P_{h_{12}}{}^z\rho^z Q(\cdot)] = \forall\sum_{z=1}^{N}[P^z(\cdot)\rho^z]$$
$$(\textstyle\sum_{j\neq 2}^{N}h_{j2})^{.5} = \alpha\sum_{z=1}^{N}[P^z(\cdot)\rho^z]/\delta - \sum_{z=1}^{N}[P_{h_{12}}{}^z\rho^z Q(\cdot)]$$
$$(\textstyle\sum_{j\neq 2}^{N}h_{j2}) = [\alpha\sum_{z=1}^{N}[P^z(\cdot)\rho^z]/\delta - \sum_{z=1}^{N}[P_{h_{12}}{}^z\rho^z Q(\cdot)]^2$$
$$(\textstyle\sum_{j\neq 2}^{N}h_{j2}) = [\alpha\Phi/(\delta+))]^2 \quad \text{where } \Phi = \sum_{z=1}^{N}[P^z(\cdot)\rho^z] \text{ and } \Delta = \sum_{z=1}^{N}[P_{e_1}{}^z\rho^z Q(\cdot)]$$
$$(h_{12}+h_{13}+\ldots+h_{1N}) = [\alpha\Phi/(\delta+))]^2$$
$$h_{12} = [\alpha\Phi/(\delta+))]^2 - (h_{13}+\ldots+h_{1N})$$

In equilibrium,

$$h_{12} = [\alpha\Phi/(\delta+))]^2 - ((N-1)h_{12})]$$
$$(N-1)h_{12} = [\alpha\Phi/(\delta+))]^2$$
$$h_{12} = [\alpha\Phi/(\delta+))]^2/(N-1)$$
$$h_1 = (N-1)\ [\alpha\Phi/(\delta+))]^2/(N-1)$$
$$h_1 = [\alpha\Phi/(\delta+))]^2$$

(a) Demonstration that at the equilibrium $e_1 > (1/N^2)(\alpha/\delta)^2$ and $h_1 < (1/N^2)(\alpha/\delta)^2$:

As demonstrated in Appendix D, under RP:

$$e_1 = \{\Phi\alpha/(\delta-\Delta)\}^2 \text{ where } \Phi = \sum_{z=1}^{N}(P(\cdot)^z\rho^z) \text{ and } \Delta = Q(\cdot)\sum_{z=1}^{N}Pe^z(\rho^z - p^N).$$

In any equilibrium, $P(\cdot)^z = (1/N)$ (since all workers supply same effort and faced same technology). Then

$$e_1 = [(1/N)\alpha/(\delta-\Delta)]^2.$$

If $\rho = (1/N)$ (i.e. there is no competition), then $\Delta = 0$ and $e_1 = (1/N^2)(\alpha/\delta)^2$ as in ES. If $(1/N) < \rho \leq 1$ (there is competition), then Δ is positive and since $P_e^z > 0$, $e_1 > (1/N^2)(\alpha/\delta)^2$. As ρ increases, e_1 increases also.

A similar argument holds for the help. As demonstrated in Appendix D, under CS

$$h_1 = \{\Phi\alpha / (\delta + \Delta)\}^2 \text{ where } \Phi = \textstyle\sum_{z=1}^{N} (P(\cdot)^z \rho^z) \text{ and } \Delta = Q(\cdot)\sum_{z=1}^{N} Pe^z(\rho^z - p^N)$$

With $P(\cdot) = (1/N)$, help becomes

$$h_1 = [(1/N)\alpha / (\delta + \Delta)]^2.$$

If $\rho = (1/N)$, then $\Delta = 0$ and $h_1 = (1/N^2)(\alpha/\delta)^2$ as in ES. If $(1/N) < \rho \leq 1$, then Δ is positive and $h_1 < (1/N^2)(\alpha/\delta)^2$ since $P_h < 0$. As ρ increases, h_1 decreases.

(b) Demonstration that at the equilibrium $t_1 > (2/N^2)(\alpha/\delta)^2$:

It was demonstrated above [Appendix D(a)] that under the RP, $e_1 > (1/N^2)(\alpha/\delta)^2$ while $h_1 < (1/N^2)(\alpha/\delta)^2$. It may well be that the increase in e_1 compensates for the decrease in h_1, so that total effort $t_1 = e_1 + h_1$ may be greater or less than $(2/N^2)(\alpha/\delta)^2$ as in the ES case. I will demonstrate that the increase in e_1 exceeds the decrease in h_1, so that $t_1 > (2/N^2)(\alpha/\delta)^2$.

$$e_1 = [(1/N)\alpha / (\delta - \Delta)]^2 \quad \text{and} \quad h_1 = [(1/N)\alpha / (\delta + \Delta)]^2.$$

I want to show that $[e_1^{RP} - e_1^{ES}] > [h_1^{ES} - h_1^{RP}]$

$$(1/N^2)(\alpha/(\delta - \Delta))^2 - (1/N^2)(\alpha/\delta)^2 > (1/N^2)(\alpha/\delta)^2 - (1/N^2)(\alpha/(\delta + \Delta)^2$$
$$(1/N^2)(\alpha/(\delta - \Delta))^2 + (1/N^2)(\alpha/(\delta + \Delta))^2 > (2/N^2)(\alpha/\delta)^2$$
$$(1/N^2)\alpha^2(\delta - \Delta)^{-2} + (1/N^2)\alpha^2(\delta + \Delta)^{-2} > (2/N^2)(\alpha/\delta)^2$$

If $\Delta = 0$, than LHS = RHS
However in my model $\Delta > 0$. Let us see how LHS is affected by an increase in Δ.

$\partial LHS/\partial\Delta$	=	$[(2/N^2)\alpha^2(\delta - \Delta)^{-3}] + [-(2/N^2)\alpha^2(\delta + \Delta)^{-3}]$
	=	$(2/N^2)\alpha^2 \{ [1 / (\delta - \Delta)^3] - [1 / (\delta + \Delta)^3] \}$
Since		$(\delta + \Delta) > (\delta - \Delta) > 0$ and $(\delta - \Delta)^3 < (\delta + \Delta)^3$
then		$[1 / (\delta - \Delta)^3] > [1 / (\delta + \Delta)^3]$
Thus,		$\partial LHS/\partial\Delta = (2/N^2)\alpha^2 \{ [1 / (\delta - \Delta)^3] - [1 / (\delta + \Delta)^3] \} > 0$,
and since		$\partial RHS/\partial\Delta = 0$, LHS > RHS when $\Delta > 0$. QED

(c) Demonstration that at the equilibrium $Q > 4\alpha^2/\delta$:

$$Eq_1 = 2\alpha\, [e_1^{.5} + (\textstyle\sum_{j\neq 1}^{N} h_{j1})^{.5}\,] = 2\alpha\, [e_1^{.5} + (h_{21} + h_{31} + \ldots + h_{N1})^{.5}]$$

Under RP, $e_1 = [(1/N)\alpha / (\delta - \Delta)]^2$ and $h_1 = [(1/N)\alpha / (\delta + \Delta)]^2$ so that:

$$Eq_1 = \{ 2\alpha \{ [(1/N)\alpha / (\delta - \Delta)]^2 \}^{.5}\} + \{ 2\alpha \{[(1/N)\alpha / (\delta + \Delta)]^2 \}^{.5} \}$$
$$Eq_1 = \{ 2\alpha\, (1/N)(\alpha/(\delta - \Delta))\} + \{ 2\alpha\, (1/N)(\alpha/(\delta + \Delta)) \}$$
$$Eq_1 = \{ (2\alpha^2/N)(1/(\delta - \Delta))\} + \{ (2\alpha^2/N)(1/(\delta + \Delta)) \}$$

As demonstrated in Appendix B, under ES, $Eq_1 = (4/N)(\alpha^2/\delta)$

I want to show that $[q_1^{RP} > q_1^{ES}]$

$$\{(2\alpha^2/N)(1/(\delta - \Delta))\} + \{ (2\alpha^2/N)(1/(\delta + \Delta)) \} > (4/N)(\alpha^2/\delta)$$
$$\{(2\alpha^2/N)(\delta - \Delta)^{-1}\} + \{(2\alpha^2/N)(\delta + \Delta)^{-1}\} > (4/N)(\alpha^2/\delta)$$

If $\Delta = 0$, than LHS = RHS. Also,

$$\partial LHS/\partial\Delta = \{(2\alpha^2/N)(\delta - \Delta)^{-2}\} + \{-(2\alpha^2/N)(\delta + \Delta)^{-2}\}$$
$$= (2\alpha^2/N)\,[(1/(\delta - \Delta)^2) - (1/(\delta + \Delta)^2)]$$

Given that $(\delta - \Delta)^2 < (\delta + \Delta)^2]$

$[1 / (\delta - \Delta)^2] > [1 / (\delta + \Delta)^2]$

and $\alpha^2 \{ [1 / (\delta - \Delta)^2] - [1 / (\delta + \Delta)^2] \} > 0$

Thus, $\partial LHS/\partial\Delta > 0$ and $\partial RHS/\partial\Delta = 0$ so LHS > RHS when $\Delta > 0$. QED

Appendix E

Solution under ES / Extended model

Under ES, $\theta_1 = \theta/N = EQ/N$ where $EQ = 2\alpha \sum_{i=1}^{N}[e_i^{.5} + (\sum_{j\neq i}^{N} h_{ji})^{.5}]$.

Worker 1 maximises: $W_1 = EQ/N - C(e_1, h_1)$

$$W_1=(2/N)\,\alpha\{[e_1^{.5}+(\textstyle\sum_{j\neq 1}^{N} h_{j1})^{.5}]+[e_2^{.5}+(\sum_{j\neq 2}^{N} h_{j2})^{.5}]+[e_3^{.5}+(\sum_{j\neq 3}^{N} h_{j3})^{.5}]+\ldots+[e_N^{.5}+(\sum_{j\neq N}^{N} h_{jN})^{.5}]\} - (\delta e_1 + \delta h_1)$$

$$\begin{aligned}
W_1=(2/N)\,\alpha\{&[e_1(e_2+e_3+\ldots+e_N)^{.5}+(h_{21}(h_{12}+h_{13}+\ldots+h_{1N}+h_{31}+h_{32}+\ldots+h_{3N}+\ldots+h_{N1}+h_{N2}+\ldots+h_{N(N-1)})\\
&\quad + h_{31}(h_{12}+h_{13}+\ldots+h_{1N}+h_{21}+h_{23}+\ldots+h_{2N}+\ldots+h_{N1}+h_{N2}+\ldots+h_{N(N-1)})\\
&\quad +\ldots\\
&\quad + h_{N1}(h_{12}+h_{13}+\ldots+h_{1N}+h_{21}+h_{22}+\ldots+h_{2N}+\ldots+h_{(N-1)1}+h_{(N-1)2}+\ldots+h_{(N-1)N}))^{.5}]\\
&+[e_2(e_1+e_3+\ldots+e_N)^{.5}+(h_{12}(h_{21}+h_{23}+\ldots+h_{2N}+h_{31}+h_{32}+\ldots+h_{3N}+\ldots+h_{N1}+h_{N2}+\ldots+h_{N(N-1)})\\
&\quad + h_{32}(h_{12}+h_{13}+\ldots+h_{1N}+h_{21}+h_{23}+\ldots+h_{2N}+\ldots+h_{N1}+h_{N2}+\ldots+h_{N(N-1)})\\
&\quad +\ldots\\
&\quad + h_{N2}(h_{12}+h_{13}+\ldots+h_{1N}+h_{21}+h_{23}+\ldots+h_{2N}+\ldots+h_{(N-1)1}+h_{(N-1)2}+\ldots+h_{(N-1)N}))^{.5}]\\
&+[e_3(e_1+e_2+\ldots+e_N)^{.5}+(h_{13}(h_{21}+h_{23}+\ldots+h_{2N}+h_{31}+h_{32}+\ldots+h_{3N}+\ldots+h_{N1}+h_{N2}+\ldots+h_{N(N-1)})\\
&\quad + h_{23}(h_{12}+h_{13}+\ldots+h_{1N}+h_{31}+h_{32}+\ldots+h_{3N}+\ldots+h_{N1}+h_{N2}+\ldots+h_{N(N-1)})\\
&\quad +\ldots\\
&\quad + h_{N3}(h_{12}+h_{13}+\ldots+h_{1N}+h_{21}+h_{23}+\ldots+h_{2N}+\ldots+h_{(N-1)1}+h_{(N-1)2}+\ldots+h_{(N-1)N}))^{.5}]\\
&+\ldots\\
&+[e_N(e_1+e_2+\ldots+e_N)^{.5}+(h_{1N}(h_{21}+h_{23}+\ldots+h_{2N}+h_{31}+h_{32}+\ldots+h_{3N}+\ldots+h_{N1}+h_{N2}+\ldots+h_{N(N-1)})\\
&\quad + h_{2N}(h_{12}+h_{13}+\ldots+h_{1N}+h_{31}+h_{33}+\ldots+h_{3N}+\ldots+h_{N1}+h_{N2}+\ldots+h_{N(N-1)})\\
&\quad +\ldots\\
&\quad + h_{(N-1)N}(h_{12}+h_{13}+\ldots+h_{1N}+h_{21}+h_{23}+\ldots+h_{2N}+\ldots+h_{N1}+h_{N2}+\ldots+h_{N(N-1)}))^{.5}]\}\\
&-(\delta e_1+\delta h_1).
\end{aligned}$$

$$\begin{aligned}
\partial W_1/\partial e_1 = \quad & (\partial W_1/\partial e_1)+(\partial W_1/\partial e_2\cdot \partial e_2/\partial e_1)+(\partial W_1/\partial e_3\cdot \partial e_3/\partial e_1)+\ldots+(\partial W_1/\partial e_N\cdot \partial e_N/\partial e_1)\\
& [(1/N)(\alpha/e_1^{.5})-\delta]+[(1/N)(\alpha/e_2^{.5})v]+[(1/N)(\alpha/e_3^{.5})v]+\ldots+[(1/N)(\alpha/e_N^{.5})v]=0\\
& (1/N)\alpha/e_1^{.5} = \delta - [(1/N)\alpha v((1/e_2^{.5})+(1/e_3^{.5})+\ldots+(1/e_N^{.5})]\\
& e_1^{.5}\{\delta - [(1/N)\alpha v((1/e_2^{.5})+(1/e_3^{.5})+\ldots+(1/e_N^{.5}))]\} = (1/N)\alpha \qquad (1)\\
& e_1^{.5} = (1/N)\alpha/[\delta - (1/N)\alpha v((1/e_2^{.5})+(1/e_3^{.5})+\ldots+(1/e_N^{.5}))]\\
& e_1 = (1/N^2)\alpha^2/[\delta - (1/N)\alpha v((1/e_2^{.5})+(1/e_3^{.5})+\ldots+(1/e_N^{.5}))]^2
\end{aligned}$$

In equilibrium,

$$\begin{aligned}
& e_1^{.5}[\delta - ((1/N)\alpha v(N-1)(1/e_1^{.5}))] = (1/N)\alpha \quad \text{from (1)}\\
& e_1^{.5}\delta - ((1/N)\alpha v(N-1)) = (1/N)\alpha\\
& e_1^{.5}\delta = (1/N)\alpha(1+(N-1)v)\\
& e_1^{.5} = (1/N)\alpha(1+(N-1)v)/\delta\\
& e_1^{*} = (1/N^2)[\alpha(1+(N-1)v)/\delta]^2
\end{aligned}$$

$$\partial W_1/\partial h_{12} = (\partial W_1/\partial(\sum_{j\neq 1}^{N} h_{j1}) \cdot \partial(\sum_{j\neq 1}^{N} h_{j1})/\partial h_{12})$$
$$+ (\partial W_1/\partial(\sum_{j\neq 2}^{N} h_{j2}) \cdot \partial(\sum_{j\neq 2}^{N} h_{j2})/\partial h_{12})$$
$$+ (\partial W_1/\partial(\sum_{j\neq 3}^{N} h_{j3}) \cdot \partial(\sum_{j\neq 3}^{N} h_{j3})/\partial h_{12})$$
$$+ \ldots + (\partial W_1/\partial(\sum_{j\neq N}^{N} h_{jN}) \cdot \partial(\sum_{j\neq N}^{N} h_{jN})/\partial h_{12}) \qquad \text{where } (\sum_{j\neq 1}^{N} h_{j1}) = \partial h_{21}/\partial h_{12}+\partial h_{31}/\partial h_{12}+\ldots+\partial h_{N1}/\partial h_{12}$$

$$\partial W_1/\partial h_{12} = [(1/N)\alpha/(\sum_{j\neq 1}^{N} h_{j1})^{.5} \cdot (N-1)(v/(N-1))]$$
$$+ [(1/N)\alpha/(\sum_{j\neq 2}^{N} h_{j2})^{.5} \cdot 1+[(N-2)(v/(N-1))]]$$
$$+ [(1/N)\alpha/(\sum_{j\neq 3}^{N} h_{j3})^{.5} \cdot (N-2)(v/(N-1))]$$
$$+ \ldots + [(1/N)\alpha/(\sum_{j\neq N}^{N} h_{jN})^{.5} \cdot (N-2)(v/(N-1))] - \delta = 0.$$

$$[1+[(N-2)(v/(N-1))]](1/N)\alpha/(\sum_{j\neq 2}^{N} h_{j2})^{.5} + [(1/N)\alpha(v/(N-1))((N-1)/(\sum_{j\neq 1}^{N} h_{j1})^{.5}$$
$$+ (N-2)/(\sum_{j\neq 3}^{N} h_{j3})^{.5} + \ldots + (N-2)/(\sum_{j\neq N}^{N} h_{jN})^{.5})] = \delta.$$

$$[1+[(N-2)(v/(N-1))]](1/N)\alpha/(\sum_{j\neq 2}^{N} h_{j2})^{.5} = \delta - [\ldots]$$
$$(\sum_{j\neq 2}^{N} h_{j2})^{.5} \{\delta - [\ldots]\} = [1+[(N-2)(v/(N-1))]](1/N)\alpha$$
$$(\sum_{j\neq 2}^{N} h_{j2})^{.5} = [1+[(N-2)(v/(N-1))]](1/N)\alpha/[\delta - [\ldots]]$$
$$(\sum_{j\neq 2}^{N} h_{j2}) = [1+[(N-2)(v/(N-1))]]^2(1/N^2)[\alpha/[\delta - [\ldots]]]^2$$
$$(h_{12}+h_{32}+\ldots+h_{N2}) = [1+[(N-2)(v/(N-1))]]^2(1/N^2)[\alpha/[\delta - [\ldots]]]^2$$
$$h_{12} = [1+[(N-2)(v/(N-1))]]^2(1/N^2)[\alpha/[\delta - [\ldots]]]^2 - (h_{32}+\ldots+h_{N2}).$$

In equilibrium,

$$h_{12} = [1+[(N-2)(v/(N-1))]]^2(1/N^2)[\alpha/[\delta - [\ldots]]]^2 - ((N-2)h_{12}).$$
$$h_{12} = [1+[(N-2)(v/(N-1))]]^2(1/N^2)[\alpha/[\delta - [(1/N)\alpha(v/(N-1))(N^2-3N+3)/((N-1)h_{12})^{.5}]]]^2 - ((N-2)h_{12}).$$
$$(N-1)h_{12} = [1+[(N-2)(v/(N-1))]]^2(1/N^2)[\alpha/[\delta - [(1/N)\alpha(v/(N-1))(N^2-3N+3)/((N-1)h_{12})^{.5}]]]^2$$
$$((N-1)h_{12})^{.5} = [1+[(N-2)(v/(N-1))]](1/N)\alpha/[\delta - [(1/N)\alpha(v/(N-1))(N^2-3N+3)/((N-1)h_{12})^{.5}]]$$
$$((N-1)h_{12})^{.5}[\delta - [(1/N)\alpha(v/(N-1))(N^2-3N+3)/((N-1)h_{12})^{.5}]] = [1+[(N-2)(v/(N-1))]](1/N)\alpha$$
$$((N-1)h_{12})^{.5}\delta - [(1/N)\alpha(v/(N-1))(N^2-3N+3)] = [1+[(N-2)(v/(N-1))]](1/N)\alpha$$
$$((N-1)h_{12})^{.5}\delta = [1+[(N-2)(v/(N-1))]](1/N)\alpha + [(1/N)\alpha(v/(N-1))(N^2-3N+3)]$$
$$((N-1)h_{12})^{.5}\delta = [(1/N)\alpha] + [(N-2)(v/(N-1))(1/N)\alpha] + [(N^2-3N+3)(v/(N-1))(1/N)\alpha]$$
$$((N-1)h_{12})^{.5}\delta = (1/N)\alpha\,[\,1 + (N-2)(v/(N-1)) + (N^2-3N+3)(v/(N-1))]$$
$$((N-1)h_{12})^{.5}\delta = (1/N)\alpha\,[\,1 + (v/(N-1))(N-2+N^2-3N+3)]$$
$$((N-1)h_{12})^{.5}\delta = (1/N)\alpha\,[\,1 + (v/(N-1))(N-1)^2]$$
$$((N-1)h_{12})^{.5}\delta = (1/N)\alpha\,[\,1 + ((N-1)v)]$$
$$((N-1)h_{12})^{.5} = (1/N)\alpha[1 + (N-1)v]/\delta$$
$$(N-1)h_{12} = (1/N^2)[\alpha[1 + (N-1)v]/\delta]^2$$
$$h_{12} = (1/N^2)[\alpha[1 + (N-1)v]/\delta]^2/(N-1)$$

$$h_1 = (N-1)(1/N^2)[\alpha[1 + (N-1)v]/\delta]^2/(N-1)$$
$$h_1^* = (1/N^2)[\alpha[1 + (N-1)v]/\delta]^2$$

So that worker k's choices of effort are $e_1^* = (1/N^2)[\alpha(1 + (N-1)v)/\delta]^2$ and $h_1^* = (1/N^2)[\alpha(1 + (N-1)v)/\delta]^2$, with his total effort $t_1 = (2/N^2)[\alpha(1 + (N-1)v)/\delta]^2$. The mix of individual work and help is efficient (i.e. the level of individual effort relative to help remains at its first best) because a worker is indifferent between supplying both types of effort).[2]

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[2] The second order conditions are satisfied since $\partial^2 W_1/\partial e_1^2 < 0$, $\partial^2 W_1/\partial h_1^2 < 0$ and$(\partial^2 W_1/\partial e_1^2)(\partial^2 W_1/\partial h_1^2) - (\partial^2 W_1/\partial e_1\partial h_1)^2 = (\partial^2 W_1/\partial e_1^2)(\partial^2 W_1/\partial e_1^2) > 0$.

The outputs are: $Eq_1 = 2[\alpha\ [(1/N^2)[\alpha(1 + (N-1)v)/\delta]^2]^{.5} + [\alpha\ (1/N^2)[\alpha(1 + (N-1)v)/\delta]^2]^{.5}]$

$Eq_1 = 2[[(1/N)\alpha^2(1 + (N-1)v)/\delta] + [(1/N)\alpha^2(1 + (N-1)v)/\delta]]$

$Eq_1 = 2[(2/N)\alpha^2(1 + (N-1)v)/\delta]]$

$Eq_1 = (4/N)(\alpha^2(1 + (N-1)v)/\delta)$

So that the team performance is $Q = 4(\alpha^2(1 + ((N-1)v))/\delta)$

Appendix F

Solution under IP / Extended model

Under IP, $\theta_1 = \theta\,[q_1 / \sum_{i\neq 1}^{N} q_i] = q_1 \sum_{i\neq 1}^{N} q_i / \sum_{i=1}^{N} q_i = q_1$ (θ_1 independent of N).

Worker 1 maximises:

$W_1 = Eq_1 - C(e_1, h_1)$
$\quad = Eq_1 - C(e_1, h_1)$
$\quad = 2\alpha[e_1(e_2+e_3+\ldots+e_N)^{.5} + (h_{21}(h_{12}+h_{13}+\ldots+h_{1N}+h_{31}+h_{32}+\ldots+h_{3N}+\ldots+h_{N1}+h_{N2}+\ldots+h_{N(N-1)})$
$\quad + h_{31}(h_{12}+h_{13}+\ldots+h_{1N}+h_{21}+h_{23}+\ldots+h_{2N}+\ldots+h_{N1}+h_{N2}+\ldots+h_{N(N-1)})$
$\quad +\ldots$
$\quad + h_{N1}(h_{12}+h_{13}+\ldots+h_{1N}+h_{21}+h_{22}+\ldots+h_{2N}+\ldots+h_{(N-1)1}+h_{(N-1)2}+\ldots+h_{(N-1)N}))^{.5}] - (\delta e_1 + \delta h_1)$

$\partial W_1/\partial e_1 =$
$\alpha/e_1^{.5} - \delta = 0$
$\alpha/e_1^{.5} = \delta$
$\delta e_1^{.5} = \alpha$
$e_1^{.5} = \alpha/\delta$
$e_1^* = (\alpha/\delta)^2$. Efficient individual work, i.e. $e_1^* = e_1^{**}$.

$\partial W_1/\partial h_{12} = (\partial W_1/\partial(\sum_{j\neq 1}^{N} h_{j1}) \cdot \partial(\sum_{j\neq 1}^{N} h_{j1})/\partial h_{12})$ where $(\sum_{j\neq 1}^{N} h_{j1}) = \partial h_{21}/\partial h_{12}+\partial h_{31}/\partial h_{12}+\ldots+\partial h_{N1}/\partial h_{12}$

$\partial W_1/\partial h_{12} = \alpha/(\sum_{j\neq 1}^{N} h_{j1})^{.5} \cdot (N-1)(v/(N-1)) - \delta = 0.$
$v\alpha/(\sum_{j\neq 1}^{N} h_{j1})^{.5} = \delta$
$(\sum_{j\neq 1}^{N} h_{j1})^{.5}\,\delta = v\alpha$
$(\sum_{j\neq 1}^{N} h_{j1})^{.5} = v\alpha/\delta$
$(\sum_{j\neq 1}^{N} h_{j1}) = (v\alpha/\delta)^2$
$(h_{21}+h_{31}+\ldots+h_{N1}) = (v\alpha/\delta)^2$
$h_{21} = (v\alpha/\delta)^2 - (h_{31}+\ldots+h_{N1})$

In equilibrium,
$h_{21} = (v\alpha/\delta)^2 - ((N-2)h_{21})$
$(N-1)h_{21} = (v\alpha/\delta)^2$
$h_{21} = (v\alpha/\delta)^2/(N-1)$
$h_2 = (N-1)(v\alpha/\delta)^2/(N-1)$
$h_2 = (v\alpha/\delta)^2$

So that worker 1's choices of effort are $e_1^* = (\alpha/\delta)^2$ and $h_1^* = (\alpha v/\delta)^2$, with his total effort $t_1 = (1+v^2)(\alpha/\delta)^2$.

The outputs are:
$Eq_1 = 2\{[\alpha(\alpha/\delta)] + [\alpha(v\alpha/\delta)]\}$
$Eq_1 = 2(\alpha^2/\delta) + 2(v\alpha^2/\delta)$
$Eq_1 = 2(1+v)\alpha^2/\delta$

So that the team performance is $Q = 2N(1+v)\alpha^2/\delta$.

Appendix G

Solution under RP / Extended model

Under ES, $W_1 = \sum_{z=1}^{N}[P^z(\cdot)\rho^z Q(\cdot)] - C(e_1, h_1)$,

where
$$Q(\cdot)=2\alpha\{[e_1(e_2+e_3+\ldots+e_N)^{.5}+(h_{21}(h_{12}+h_{13}+\ldots+h_{1N}+h_{31}+h_{32}+\ldots+h_{3N}+\ldots+h_{N1}+h_{N2}+\ldots+h_{N(N-1)})$$
$$+ h_{31}(h_{12}+h_{13}+\ldots+h_{1N}+h_{21}+h_{23}+\ldots+h_{2N}+\ldots+h_{N1}+h_{N2}+\ldots+h_{N(N-1)})$$
$$+\ldots$$
$$+ h_{N1}(h_{12}+h_{13}+\ldots+h_{1N}+h_{21}+h_{22}+\ldots+h_{2N}+\ldots+h_{(N-1)1}+h_{(N-1)2}+\ldots+h_{(N-1)N}))^{.5}]$$

$$+[e_2(e_1+e_3+\ldots+e_N)^{.5}+(h_{12}(h_{21}+h_{23}+\ldots+h_{2N}+h_{31}+h_{32}+\ldots+h_{3N}+\ldots+h_{N1}+h_{N2}+\ldots+h_{N(N-1)})$$
$$+ h_{32}(h_{12}+h_{13}+\ldots+h_{1N}+h_{21}+h_{23}+\ldots+h_{2N}+\ldots+h_{N1}+h_{N2}+\ldots+h_{N(N-1)})$$
$$+\ldots$$
$$+ h_{N2}(h_{12}+h_{13}+\ldots+h_{1N}+h_{21}+h_{23}+\ldots+h_{2N}+\ldots+h_{(N-1)1}+h_{(N-1)2}+\ldots+h_{(N-1)N}))^{.5}]$$

$$+[e_3(e_1+e_2+\ldots+e_N)^{.5}+(h_{13}(h_{21}+h_{23}+\ldots+h_{2N}+h_{31}+h_{32}+\ldots+h_{3N}+\ldots+h_{N1}+h_{N2}+\ldots+h_{N(N-1)})$$
$$+ h_{23}(h_{12}+h_{13}+\ldots+h_{1N}+h_{31}+h_{32}+\ldots+h_{3N}+\ldots+h_{N1}+h_{N2}+\ldots+h_{N(N-1)})$$
$$+\ldots$$
$$+ h_{N3}(h_{12}+h_{13}+\ldots+h_{1N}+h_{21}+h_{23}+\ldots+h_{2N}+\ldots+h_{(N-1)1}+h_{(N-1)2}+\ldots+h_{(N-1)N}))^{.5}]$$

$$+\ldots\ +[e_N(e_1+e_2+\ldots+e_N)^{.5}+(h_{1N}(h_{21}+h_{23}+\ldots+h_{2N}+h_{31}+h_{32}+\ldots+h_{3N}+\ldots+h_{N1}+h_{N2}+\ldots+h_{N(N-1)})$$
$$+ h_{2N}(h_{12}+h_{13}+\ldots+h_{1N}+h_{31}+h_{33}+\ldots+h_{3N}+\ldots+h_{N1}+h_{N2}+\ldots+h_{N(N-1)})$$
$$+\ldots$$
$$+ h_{(N-1)N}(h_{12}+h_{13}+\ldots+h_{1N}+h_{21}+h_{23}+\ldots+h_{2N}+\ldots+h_{N1}+h_{N2}+\ldots+h_{N(N-1)}))^{.5}]\}$$

Worker 1 maximizes:

$$\partial W_1/\partial e_1 = \sum_{z=1}^{N} \begin{matrix}[P^z(\cdot)\rho^z[(\partial Q(\cdot)/\partial e_1)+(\partial Q(\cdot)/\partial e_2\cdot\partial e_2/\partial e_1)+\ldots+(\partial Q(\cdot)/\partial e_N\cdot\partial e_N/\partial e_1)] \\ +[(\partial P^z(\cdot)/\partial e_1)+(\partial P^z(\cdot)/\partial e_2\cdot\partial e_2/\partial e_1)+\ldots+(\partial P^z(\cdot)/\partial e_N\cdot\partial e_N/\partial e_1)](\rho^z Q(\cdot))]\end{matrix} - \delta = 0$$

$$\sum_{z=1}^{N}[P^z(\cdot)\rho^z[(\alpha/e_1^{.5})+(\alpha\nu(1/e_2^{.5}+1/e_3^{.5}+\ldots+1/e_N^{.5}))]+[(P_{e_1}^z+(\nu(P_{e_2}^z+P_{e_3}^z+\ldots+P_{e_N}^z)))\rho^z Q(\cdot)]-\delta=0$$

$$\sum_{z=1}^{N}P^z(\cdot)\rho^z(\alpha/e_1^{.5})+\sum_{z=1}^{N}P^z(\cdot)\rho^z\alpha\nu(1/e_2^{.5}+1/e_3^{.5}+\ldots+1/e_N^{.5})+\sum_{z=1}^{N}P_{e_1}^z\rho^z Q(\cdot)$$
$$+\sum_{z=1}^{N}(\nu(P_{e_2}^z+P_{e_3}^z+\ldots+P_{e_N}^z))\rho^z Q(\cdot)=\delta$$

$$\sum_{z=1}^{N}P^z(\cdot)\rho^z(\alpha/e_1^{.5})+\sum_{z=1}^{N}P^z(\cdot)\rho^z\alpha\nu(1/e_2^{.5}+1/e_3^{.5}+\ldots+1/e_N^{.5})+\sum_{z=1}^{N}P_{e_1}^z\rho^z Q(\cdot)$$
$$+\sum_{z=1}^{N}(\nu(-P_{e_1}^z))\rho^z Q(\cdot)=\delta \quad \text{since } \sum_{j\neq 1}^{N}P_{e_j}^z=-P_{e_1}^z$$

$[(1/e_1^{.5}))+((v(1/e_2^{.5}+\ldots+1/e_N^{.5}))]\ \alpha \sum_{z=1}^{N}P^z(\cdot)\rho^z + (1-v)\ \sum_{z=1}^{N}P_{e_1}^z\rho^z Q(\cdot) = \delta$

$[(1/e_1^{.5}))+((v(1/e_2^{.5}+\ldots+1/e_N^{.5}))]\ \alpha\Phi + (1-v)\ )\ \Delta = \delta$ where $\Phi = \sum_{z=1}^{N}[P^z(\cdot)\rho^z]$ and $\Delta = \sum_{z=1}^{N}[P_{e_1}^z\rho^z Q(\cdot)]$

$(1/e_1^{.5})\ \alpha\Phi = \delta - ((v(1/e_2^{.5}+\ldots+1/e_N^{.5}))\ \alpha\Phi) - \Delta + v\Delta$

$1/e_1^{.5} = \delta - ((v(1/e_2^{.5}+\ldots+1/e_N^{.5}))\ \alpha\Phi) - \Delta + v\Delta/\alpha\Phi$

$e_1^{.5} = \alpha\Phi/\ \delta - ((v(1/e_2^{.5}+\ldots+1/e_N^{.5}))\ \alpha\Phi) - \Delta + v\Delta$

$e_1 = [\alpha\Phi/\ \delta - \Delta + v\Delta\ \ ((v(1/e_2^{.5}+\ldots+1/e_N^{.5}))\ \alpha\Phi)]^2$

In equilibrium,

$e_1 = [\alpha\Phi/\ \delta - \Delta + v\Delta - (v(N-1)(1/e_1^{.5}))\ \alpha\Phi)]^2$

$e_1^{.5} = [\alpha\Phi/\ \delta - \Delta + v\Delta - (v(N-1)(1/e_2^{.5}))\ \alpha\Phi)$

$e_1^{.5}[\delta - \Delta + v\Delta - (v(N-1)(1/e_2^{.5}))\ \alpha\ \Phi)] = \alpha\Phi$

$e_1^{.5}\delta - e_1^{.5}\Delta + e_1^{.5}v\Delta - ((N-1)v\alpha\Phi) = \alpha N$

$e_1^{.5}(\delta - \Delta + v\Delta) = \alpha\Phi + (v(N-1)\ \alpha\Phi)$

$e_1^{.5} = \alpha\Phi\ (1 + (v(N-1)))/\ (\delta - (\Delta\ (1-v)))$

$e_1 = [\alpha\Phi\ (1 + (v(N-1)))/\ (\delta - (\Delta\ (1-v)))]^2$

Worker 1 maximizes:

$$\partial W_1/\partial h_{12} = \sum_{z=1}^{N} \begin{matrix} [P^z(\cdot)\rho^z[(\partial Q(\cdot)/\partial(\sum_{j\neq 1}^{N} h_{j1})\cdot\partial(\sum_{j\neq 1}^{N} h_{j1})/\partial h_{12}) + (\partial Q(\cdot)/\partial(\sum_{j\neq 2}^{N} h_{j2})\cdot\partial(\sum_{j\neq 2}^{N} h_{j2})/\partial h_{12}) + \ldots \\ +(\partial Q(\cdot)/\partial(\sum_{j\neq 3}^{N} h_{j3})\cdot\partial(\sum_{j\neq 3}^{N} h_{j3}/\partial h_{12})] + [(\partial P^z(\cdot)/\partial h_{12}) + (\partial P^z(\cdot)/\partial h_{21}\cdot\partial h_{21}/\partial h_{12}) + \ldots \\ +(\partial P^z(\cdot)/\partial h_{N(N-1)}\cdot\partial h_{N(N-1)}/\partial h_{12})](\rho^z Q(\cdot)]] \end{matrix} - \delta = 0.$$

where $(\sum_{j\neq 1}^{N} h_{j1}) = \partial h_{21}/\partial h_{12} + \partial h_{31}/\partial h_{12} + \ldots + \partial h_{N1}/\partial h_{12}$.

$$\sum_{z=1}^{N} \begin{matrix} [P^z(\cdot)\rho^z[\alpha(1/(\sum_{j\neq 1}^{N} h_{j1})^{.5})(N-1)(v/(N-1))] + \\ [\alpha(1/(\sum_{j\neq 2}^{N} h_{j2})^{.5})(1+((N-2)(v/(N-1)))] + \ldots + [\alpha(1/(\sum_{j\neq 2}^{N} h_{jN})^{.5})(N-2)(v/(N-1))]] \end{matrix}$$
$$+ \sum_{z=1}^{N}[(P_{h_{12}}^{z} + ((v/(N-1))P_{h_{21}}^{z} + \ldots + P_{h_{N(N-1)}}^{z}))\rho^z Q(\cdot)] = \delta.$$

$$\sum_{z=1}^{N} \begin{matrix} [P^z(\cdot)\rho^z[\alpha(1/(\sum_{j\neq 1}^{N} h_{j1})^{.5})(N-1)(v/(N-1))] + \\ [\alpha(1/(\sum_{j\neq 2}^{N} h_{j2})^{.5})(1+((N-2)(v/(N-1)))] + \ldots + [\alpha(1/(\sum_{j\neq 2}^{N} h_{jN})^{.5})(N-2)(v/(N-1))]] \end{matrix}$$
$$+ \sum_{z=1}^{N} P_{h_{12}}^{z}\rho^z Q(\cdot) + \sum_{z=1}^{N}((\nu/(N-1))(-(N-1)P_{h_{12}}^{z}))\rho^z Q(\cdot) = \delta$$

since $\sum_{j\neq 1, k\neq j}^{N} P_{h_{jk}}^{z} = -(N-1)P_{h_{12}}^{z}$.

$$\alpha\Phi\,[(1/(\sum_{j\neq 2}^{N} h_{j2})^{.5})(1+((N-2)(v/(N-1)))]$$
$$+ \alpha\Phi\{[(1/(\sum_{j\neq 1}^{N} h_{j1})^{.5})(N-1)(v/(N-1))] + \ldots + [(1/(\sum_{j\neq N}^{N} h_{jN})^{.5})(N-2)(v/(N-1))]\} - \Delta + v\Delta = \delta$$

where $\Phi = \sum_{z=1}^{N}[P^z(\cdot)\rho^z]$ and $\Delta = \sum_{z=1}^{N}[P_{e_1}^{z}\rho^z Q(\cdot)] = -\sum_{z=1}^{N}[P_{h_1}^{z}\rho^z Q(\cdot)]$.

$(1/(\sum_{j\neq 2}^{N} h_{j2})^{.5})(\alpha\Phi\,(1+((N-2)(v/(N-1))) = \delta - \alpha N\{\ldots\} + \Delta - v\Delta.$

$(1/(\sum_{j\neq 2}^{N} h_{j2})^{.5}) = [\delta - \alpha\Phi\{\ldots\} + \Delta - v\Delta]/(\alpha\Phi\,(1+((N-2)(v/(N-1))).$

$(\sum_{j\neq 2}^{N} h_{j2})^{.5} = (\alpha\Phi\,(1+((N-2)(v/(N-1)))\,/\,[\delta - \alpha\Phi\{\ldots\} + \Delta - v\Delta].$

$(\sum_{j\neq 2}^{N} h_{j2}) = [(\alpha\Phi\,(1+((N-2)(v/(N-1)))\,/\,[\delta - \alpha\Phi\{\ldots\} + \Delta - v\Delta]]^2.$

$h_{12} = [(\alpha\Phi\,(1+((N-2)(v/(N-1)))\,/\,[\delta - \alpha\Phi\{\ldots\} + \Delta - v\Delta]]^2 - (h_{32} + \ldots + h_{N2}).$

In equilibrium,

$h_{12} = [(\alpha\Phi\,(1+((N-2)(v/(N-1)))\,/\,[\delta - \alpha\Phi\{(v/(N-1))(N^2-3N+3)(1/((N-1)h_{12})^{.5})\}] + \Delta - v\Delta]]^2 - ((N-2)h_{12}).$

$(N-1)h_{12} = [(\alpha\Phi\,(1+((N-2)(v/(N-1)))\,/\,[\delta - \alpha\Phi\{(v/(N-1))(N^2-3N+3)(1/((N-1)h_{12})^{.5})\}] + \Delta - v\Delta]]^2$

$[(N-1)h_{12}]^{.5} = (\alpha\Phi\,(1+((N-2)(v/(N-1)))\,/\,[\delta - \alpha\Phi\{(v/(N-1))(N^2-3N+3)(1/((N-1)h_{12})^{.5})\}] + \Delta - v\Delta]$

$[(N-1)h_{12}]^{.5}\,[\delta - \alpha\Phi\{(v/(N-1))(N^2-3N+3)(1/((N-1)h_{12})^{.5})\}] + \Delta - v\Delta] = (\alpha\Phi\,(1+((N-2)(v/(N-1)))$

$\delta[(N-1)h_{12}]^{.5} + \Delta\,[(N-1)h_{12}]^{.5} - v\Delta\,[(N-1)h_{12}]^{.5} - \alpha\Phi\{(v/(N-1))(N^2-3N+3)\} = (\alpha\Phi\,(1+((N-2)(v/(N-1)))$

$[(N-1)h_{12}]^{.5}(\delta + \Delta - v\Delta) = (\alpha\Phi\,(1+((N-2)(v/(N-1))) + \alpha\Phi\{(v/(N-1))(N^2-3N+3)\}$

$[(N-1)h_{12}]^{.5} = (\alpha\Phi) + (\alpha\Phi\,(v/(N-1)))(N-1)^2)\,/\,(\delta + \Delta - v\Delta)$

$(N-1)h_{12} = [\alpha\Phi\,(1 + (v(N-1))\,/\,(\delta + (\Delta\,(1-v))]^2$

$h_{12} = [\alpha\Phi\,(1 + (v(N-1))\,/\,(\delta + (\Delta\,(1-v))]^2/(N-1)$

$h_1 = (N-1)[\,\alpha\Phi\,(1 + (v(N-1))\,/\,(\delta + (\Delta\,(1-v))]^2/(N-1)$

$h_1 = [\alpha\Phi\,(1 + (v(N-1))\,/\,(\delta + (\Delta\,(1-v))]^2$

(a) Demonstration that at the equilibrium $e_1 > (1/N^2)[\alpha(1+((N-1)v))/\delta)^2$ and $h_1 < (1/N^2)[\alpha(1+((N-1)v))/\delta)^2$:

As demonstrated in Appendix G, under RP:

$$e_1 = \{\Phi\alpha(1 + ((N-1)v))/(\delta - (\Delta(1-v)))\}^2 \text{ where } \Phi = \Sigma_{z=1}^{N}(P(\cdot)^z \rho^z) \text{ and } \Delta = Q(\cdot)\Sigma_{z=1}^{N} Pe^z(\rho^z - p^N).$$

In any equilibrium, $P^z(\cdot) = (1/N)$ (since all workers supply same effort and faced same technology). Then

$$e_1^* = \{(1/N)\alpha(1 + ((N-1)v))/(\delta - (\Delta(1-v)))\}^2$$

If $\rho = (1/N)$ (i.e. there is no competition), then $\Delta = 0$ and $e_1 = (1/N^2)[\alpha(1+((N-1)v))/\delta)^2$ as in ES. If $(1/N) < \rho \le 1$ (there is competition), then Δ is positive and $e_1 > (1/N^2)[\alpha(1+((N-1)v))/\delta)^2$. As ρ increases, e_1 increases also.

A similar argument holds for the help. As demonstrated in Appendix G, under RP:

$$h_1 = \{\Phi\alpha(1 + ((N-1)v))/(\delta + (\Delta(1-v)))\}^2 \text{ where } \Phi = \Sigma_{z=1}^{N}(P(\cdot)^z \rho^z) \text{ and } \Delta = Q(\cdot)\Sigma_{z=1}^{N} Pe^z(\rho^z - p^N)$$

With $P^z(\cdot) = (1/N)$, help becomes

$$h_1^* = \{(1/N)\alpha(1 + ((N-1)v))/(\delta + (\Delta(1-v)))\}^2$$

If $\rho = (1/N)$, then $\Delta = 0$ and $h_1 = (1/N^2)[\alpha(1+((N-1)v))/\delta)^2$ as in ES. If $(1/N) < \rho \le 1$, then Δ is positive and $h_1 < (1/N^2)[\alpha(1+((N-1)v))/\delta)^2$. As ρ increases, h_1 decreases.

(b) Demonstration that at the equilibrium $t_1 > (2/N^2)[\alpha(1+((N-1)v))/\delta)^2$:

It was demonstrated above [Appendix G(a)] that under the RP, $e_1 > (1/N^2)[\alpha(1+((N-1)v))/\delta)^2$ while $h_1 < (1/N^2)[\alpha(1+((N-1)v))/\delta)^2$. *It may well be that the increase in e_1 compensates for the decrease in h_1*, so that total total effort $t_1 = e_1 + h_1$ may be greater or less than $(2/N^2)[\alpha(1+((N-1)v))/\delta)^2$ as in the ES case. I will demonstrate that the increase in e_1 exceeds the decrease in h_1, so that $t_1 > (2/N^2)[\alpha(1+((N-1)v))/\delta)^2$.

Under RP, $e_1 = \{(1/N)\alpha(1 + ((N-1)v))/(\delta - (\Delta(1-v)))\}^2$ and $h_1 = \{(1/N)\alpha(1 + ((N-1)v))/(\delta + (\Delta(1-v)))\}^2$.

I want to show that $[e_1^{RP} - e_1^{ES}] > [h_1^{ES} - h_1^{RP}]$

$$\{(1/N)\alpha(1 + ((N-1)v))/(\delta - (\Delta(1-v)))\}^2 - (1/N^2)[\alpha(1+((N-1)v))/\delta]^2$$
$$> (1/N^2)[\alpha(1+((N-1)v))/\delta]^2 - \{(1/N)\alpha(1 + ((N-1)v))/(\delta + (\Delta(1-v)))\}^2$$

$$\{(1/N)\alpha(1 + ((N-1)v))/(\delta - (\Delta(1-v)))\}^2 + \{(1/N)\alpha(1 + ((N-1)v))/(\delta + (\Delta(1-v)))\}^2 > (2/N^2)[\alpha(1+((N-1)v))/\delta]^2$$

$$\{(1/N^2)(\alpha(1 + ((N-1)v)))^2(\delta - (\Delta(1-v)))^{-2}\} + \{(1/N^2)(\alpha(1 + ((N-1)v)))^2(\delta + (\Delta(1-v)))^{-2}\} > (2/N^2)(\alpha(1+((N-1)v))/\delta)^2$$

If $\Delta = 0$, than LHS = RHS
However in my model $\Delta > 0$. Let us see how LHS is affected by an increase in Δ.

$$\partial LHS/\partial\Delta = \{(1/N^2)(\alpha(1 + ((N-1)v)))^2(\delta - (\Delta(1-v)))^{-2}\} + \{(1/N^2)(\alpha(1 + ((N-1)v)))^2(\delta + (\Delta(1-v)))^{-2}\}$$

$$\{-(2/N^2)(\alpha(1 + ((N-1)v)))^2(\delta - (\Delta(1-v)))^{-3}(-1+v)\} + \{-(2/N^2)(\alpha(1 + ((N-1)v)))^2(\delta + (\Delta(1-v)))^{-3}\}(1-v)\}$$

$$(1-v)(2/N^2)(\alpha(1 + ((N-1)v)))^2 [1/(\delta - (\Delta(1-v)))^3 - 1/(\delta + (\Delta(1-v)))^3]$$

Since $(\delta + (\Delta(1-v)) > (\delta - (\Delta(1-v)) > 0$ and $(\delta - (\Delta(1-v))^3 < (\delta + (\Delta(1-v))^3$

then $[1 / (\delta - (\Delta(1-v))^3] > [1 / (\delta + (\Delta(1-v))^3]$

Thus, $\partial LHS/\partial\Delta = (1-v)(2/N^2)(\alpha(1 + ((N-1)v)))^2 [1/(\delta - (\Delta(1-v)))^3 - 1/(\delta + (\Delta(1-v)))^3] > 0$,

and since $\partial RHS/\partial\Delta = 0$, LHS > RHS when $\Delta > 0$. QED

(c) Demonstration that at the equilibrium $Q > 4(\alpha^2(1 + ((N-1)v))/\delta)$:

$Eq_1 = 2\alpha[e_1^{.5} + (\sum_{i\neq 1}^{N} h_{i1})^{.5}] = 2\alpha\,[e_1^{.5} + (h_{21}+h_{31}+\ldots+h_{N1})^{.5}]$

Under RP, $e_1 = \{(1/N)\alpha(1 + ((N-1)v))/(\delta - (\Delta(1-v)))\}^2$ and $h_1 = \{(1/N)\alpha(1 + ((N-1)v))/(\delta + (\Delta(1-v)))\}^2$ so that:

$$Eq_1 = \{2\alpha\,\{\{(1/N)\alpha(1 + ((N-1)v))/(\delta - (\Delta(1-v)))\}^2\}^{.5}\} + \{2\alpha\,\{\{(1/N)\alpha(1 + ((N-1)v))/(\delta + (\Delta(1-v)))\}^2\}^{.5}\}$$

$$Eq_1 = \{2\alpha\,(1/N)\alpha(1 + ((N-1)v))/(\delta - (\Delta(1-v)))\} + \{2\alpha\,(1/N)\alpha(1 + ((N-1)v))/(\delta + (\Delta(1-v)))\}$$

$$Eq_1 = \{(2\alpha^2/N)(1 + ((N-1)v))/(1/(\delta - (\Delta(1-v))))\} + \{(2\alpha^2/N)\alpha(1 + ((N-1)v))/(1/(\delta + (\Delta(1-v))))\}$$

As demonstrated in Appendix E, under ES, $Eq_1 = (4/N)(\alpha^2(1 + ((N-1)v))/\delta)$:

I want to show that $[q_1^{RP} > q_1^{ES}]$

$$\{(2\alpha^2/N)(1 + ((N-1)v))/(1/(\delta - (\Delta(1-v))))\} + \{(2\alpha^2/N)\alpha(1 + ((N-1)v))/(1/(\delta + (\Delta(1-v))))\} > (4/N)(\alpha^2(1 + ((N-1)v))/\delta)$$

$$\{(2\alpha^2/N)(1 + ((N-1)v))(\delta - (\Delta(1-v)))^{-1}\} + \{(2\alpha^2/N)\alpha(1 + ((N-1)v))(\delta + (\Delta(1-v)))^{-1}\} > (4/N)(\alpha^2(1 + ((N-1)v))/\delta)$$

If $\Delta = 0$, than LHS = RHS. Also,

$$\partial LHS/\partial\Delta = \{-(2\alpha^2/N)(1 + ((N-1)v))(\delta - (\Delta(1-v)))^{-2}(-1+v)\} + \{-(2\alpha^2/N)\alpha(1 + ((N-1)v))(\delta + (\Delta(1-v)))^{-2}(1-v)\}$$

$$= (1-v)(2\alpha^2/N)(1 + ((N-1)v))\,[1/(\delta - (\Delta(1-v)))^2 - 1/(\delta + (\Delta(1-v)))^2]$$

Given that $(\delta - (\Delta(1-v))^2 < (\delta + (\Delta(1-v))^2$

$[1 / (\delta - (\Delta(1-v))^2] > [1 / (\delta + (\Delta(1-v))^2]$

and $(1-v)(2\alpha^2/N)(1 + ((N-1)v))\,[1/(\delta - (\Delta(1-v)))^2 - 1/(\delta + (\Delta(1-v)))^2] > 0$

Thus, $\partial LHS/\partial\Delta > 0$ and $\partial RHS/\partial\Delta = 0$ so LHS > RHS when $\Delta > 0$. QED

Appendix H
Document entitled "Information-Consent Letter"

Information-Consent Letter

As stated in the syllabus, students enrolled in ACC131 will receive thirty out of a possible one thousand and forty points (3%) from either participating in the experimental study described below or submitting an alternative assignment. The alternative assignment consists of writing a three-page essay on new forms of compensation in organisations. This essay must be handed in by the 12th of November 1999.

Information about the experimental study

The experimental study examines the effect of compensation on performance. Professor Marie-Josée Ledoux (ext. 5731) is conducting this study under the supervision of Dr. Steven Salterio (ext. 5778) of the School of Accountancy at University of Waterloo. Information collected will be used by Ms. Ledoux to complete her Ph.D. thesis in Accounting.

The participants must register with their work team members for one of the laboratory sessions by the 8th of October 1999. The laboratory sessions will take place between the 25th of October 1999 and the 5th of November 1999, mostly during late afternoon and early evening (although some daytime sessions will also be available). The total number of sessions available will depend on how many students choose to participate in this study. The list of available laboratory sessions will be posted on the experiment's website (which can be reached through the ACC131 website) beginning the 28th of September 1999. The list will be updated continually as people register. Determine your team's preferred time and e-mail me your names, student IDs, and preferred time at mledoux@uwaterloo.ca. Each laboratory session can facilitate 20 participants and the sessions will be assigned on a "first come first served" basis.

During the laboratory session, the participants will be asked to perform a task that involves interacting with a computer and other participants. The task is to answer simple questions of the following level of difficulty: 2 + 7 + 4. In addition, the participants will have to answer some straightforward questions about themselves, their experience working in teams, and their understanding of the experiment.

The laboratory session will take one hour for which each person will receive thirty points out of a possible one thousand and forty points (3%) towards their ACC131 mark. Each participant will also receive tickets for a draw in which the prize is $100.00. There will be one draw per session. The number of tickets received by the students will depend on their performance during the experiment. Once all laboratory sessions are over, I will visit each class and present the preliminary results of my study.

There are no anticipated risks associated with participating in this study. All information collected as a result of your participation in the study will be used for teaching or research publication purposes. By participating in this study, you will increase knowledge about compensation that could be useful to managers in actual practice. Your anonymity is guaranteed and you will not be identified for any reports or publications. Consent to participate, or consent for the use of information you provide may be withdrawn at any time by advising the student researcher without reprisal.

This study has been reviewed by, and received ethics clearance, through the Office of Research Ethics at the University of Waterloo. Any comments or concerns about the study or your participation may be directed to this office (ext. 6005).

Appendix H (continued)

Document entitled "Information-Consent Letter"

Indication of choice

Indicate your choice by checking the appropriate box. If you choose to participate in the experimental study, please sign the following consent form. You may withdraw from the experiment and opt for the alternative assignment at any time.

Experimental research ☐ Alternative assignment ☐

Consent to participate in the experimental study

I have read the information about the study above and any additional questions I had have been answered. I understand that my anonymity is guaranteed and that I may withdraw my participation at any point throughout the study without reprisal. I further understand that I will receive 30 points for ACC131, and will be eligible for a $100.00 draw, upon completion of my involvement in the study.

Participant's Name (please print): ______________________________

Participant's Signature: ______________________________

Witness's Signature: ______________________________

Date: / /
D M Y

Appendix I

Document entitled "Index of Cohesion"

Index of Cohesion

Answer the following questions about your experimental team by checking the appropriate boxes.

● My team is very attractive in terms of being interesting, fun to be with, and enjoyable.

Completely disagree	Generally disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Generally agree	Completely agree
☐	☐	☐	☐	☐	☐	☐

● I look forward to being with the members of my team.

Completely disagree	Generally disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Generally agree	Completely agree
☐	☐	☐	☐	☐	☐	☐

● I have confidence and trust in my team members.

Completely disagree	Generally disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Generally agree	Completely agree
☐	☐	☐	☐	☐	☐	☐

● I feel I am really a part of my team.

Completely disagree	Generally disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Generally agree	Completely agree
☐	☐	☐	☐	☐	☐	☐

● I would like to work with this team again on a similar project.

Completely disagree	Generally disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Generally agree	Completely agree
☐	☐	☐	☐	☐	☐	☐

The last question does not refer to your experimental team but evaluates your general feeling about working in a group relative to individually.

● How do you feel about working in a group relative to individually?

Completely disagree	Generally disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Generally agree	Completely agree
☐	☐	☐	☐	☐	☐	☐

Appendix J

Document entitled "Instructions"

Instructions

This session has four parts. First, you will go through the team member identification process. Second, you will practice how to do the exercise. Third, you will perform the exercise that will allow you to cumulate tickets for the draw. And fourth, you will answer some follow-up questions.

(1) Personal Identification

Each of you is part of a team. Each team consists of four or three people. Your team number is indicated on the laminated sheet in front of you. Within a team, each member is associated with a specific colour. In a four-person team, colours are red, blue, green and purple. In a three-person team, colours are red, blue and green. Your colour is also indicated on your laminated sheet. To make sure that everybody knows his or her team number and colour, I will ask each of you to stand up and say your assigned colour when I call your team's number. Team number 1, team number 2, etc.

You are facing the "**gateway screen**". I would like you to locate on this screen the column that corresponds to your team number and, under it, your colour. Once you have located it, write your first name in the empty space. This will be the name used while you communicate with the other members of your team.
Please, make sure that you are writing your name in the appropriate box, this is essential for the rest of this experiment to succeed. When your name is written, click on "**GO**".

You are now facing the "main screen", which is divided into three sections. The large yellow area dominating your screen will be use for practice right now but later on, this is where you will do the exercise. The practice example that you have on your screen is designed for four person teams. If you are a three person team, please click on the number 3 at the top right corner of your screen. Let's start the practice example.

(2) The practice example

Your task is to **<u>answer arithmetic questions</u>** from the list provided in your screen. During the exercise, each correct answer will be worth a certain amount of tickets for the draw. The number of tickets per correct answer will be listed in the second column of the exercise section. In the practice example, this column is filled with "none". This is because the practice questions are used to learn how to answer your questions and to communicate with your team members, not to accumulate tickets.

Each question requires you to add three numbers. Type your answers in the blank space. You can use your Tab key to move from one question to the next. The first three practice questions were designed to familiarise you with the computer package. You may answer these three questions now. I repeat, you may answer questions 1, 2, and 3 of the practice example now.

[Practice example – questions 1, 2, and 3 – in process.]

The exercise requires you to add three numbers just as you did, however, one of these numbers has to be traced from a matrix. An example of the matrix is given on the back of the laminated sheet in front of you. Take a look at it. As you see, this matrix of numbers includes cells from ***A/a*** to **Z/z**. The capital letters correspond to the vertical axis while the small letters correspond to the horizontal axis.

Each of you holds only the numbers for one-quarter of the complete matrix, and the other members of your team hold the rest of them. In particular, you hold the numbers corresponding to your colour. Note that this matrix is only used for the practice example. Each of you has another matrix in the small envelope under your keyboard, which is similar except there is a number in each cell (instead of an X that you see on your practice matrix).

During the exercise, some questions will require you to retrieve numbers from your own matrix. The three following questions, that is, questions 4, 5, and 6, were designed to verify that you can retrieve numbers from your matrix. You may answer these three questions now. I repeat, you may answer questions 4, 5, and 6 of the practice example now.

[Practice example – questions 4, 5, and 6 – in process.]

Other questions will require the help of the other members of your team. At the bottom of your screen is a form consisting of six inputs and a submit button. It is through this form that you will communicate with your team members. The first input on the form is entitled "**Target**" and contains the colours of your team members. It is through this input that you will choose which team member you wish to communicate with. It is essential to identify a target each time you communicate with one of your team members. If you don't choose a target, your message will be send to yourself.

The second and third inputs on the form are entitled, respectively, "***A to Z***" and "**a to z**". It is through these inputs that you will indicate which cell of the matrix you are interested in. The fourth input on the form are entitled "**?/=**". The question mark is used to ask a question while the equal sing is used to provide an answer. The fifth input is entitled "**Answer**" and contains numbers from 1 to 9. This will be used to answer your team member questions. Finally, you can add any comments in the sixth input. This is not necessary but you can do it if you want.

When people will send you messages, they will appear in the blank vertical area at the left of your screen. The messages will be written in the colour of the members who send you the information, and they will be followed by the name of this person. You need to know which member is sending you the request to direct your answer to him.

I will now illustrate how to ask for help. Suppose that member GREEN needs the number from cell ***A/a***. First he looks at his matrix and identify whose member has this information. Cell ***A/a*** falls in the red quarter of the matrix so that the request should be target to RED. At "**Target**", GREEN selects "**red**", at "***A-Z***", he selects "***A***", at "**a-z**", he selects "**a**", at "**?/=**", he selects"**?**". He finally clicks on "**Submit**". Within a few seconds, the expression "***Aa?***" will appear in the vertical area at the left of RED's screen. Note that this request will be in green, so that RED knows that GREEN is asking.

Now, suppose that RED decides to respond to this request. She retrieves from her matrix the number corresponding to the cell ***A/a***. Suppose that this number is **3**. At "**Target**", she selects "**green**", at "***A-Z***", she selects "***A***", at "**a-z**", she selects "**a**", at "**?/=**"she clicks on the "=", at "**Answer**", she selects "**3**", and she finally clicks on "**Submit**". Within few seconds, the expression "**Aa=3**" will appear in the vertical area at the left of GREEN's screen.

Note that you can use your mouse or the Tab key to move from one input to the next. And for each input, you can click on the arrow and select a character or you can simply type it (at "***A-Z***", you can simply type a letter and it will automatically use the capital format).

Appendix J (continued)
Document entitled "Instructions"

Each of you holds only the numbers for one-quarter of the complete matrix, and the other members of your team hold the rest of them. In particular, you hold the numbers corresponding to your colour. Note that this matrix is only used for the practice example. Each of you has another matrix in the small envelope under your keyboard, which is similar except there is a number in each cell (instead of an X that you see on your practice matrix).

Questions 7, 8, and 9 were designed to verify that you could exchange information with your team members. You may answer these three questions now. I repeat, you may answer questions 7, 8, and 9 of the practice example now.

[Practice example – questions 7, 8, and 9 – in process.]

When you have answered all nine questions, press the grey button at the end of the page. If one of your answers is wrong, a pop up box will appear. Please correct the wrong answer immediately and try to submit again. If all your questions are correct, you will pass to the main exercise.

(3) The main exercise

The three empty spaces at the top of the yellow section should be filled. At "**Student #** ", write your student's ID number. At "**Team**", click on the drop down arrow and select your team's number. At "**Session**", click on the drop down arrow and select your session number as indicated on the blackboard at the front of the class.

Please take the white sheet from your envelope. This sheet is entitled "Exercise and Incentives".

Own requests already send	Members' requests already answered

Appendix K

Document entitled "Exercise and Incentives"

ES condition / four person team

Exercise and Incentives

(Four person team)

(1) Exercise

As mentioned earlier, your task is to answer arithmetic questions from the list provided in your screen. However, you are free to answer any questions you wish. You do not have to answer all questions. You do not have to answer them in the order presented. You may scroll up and down in the list and answer the questions in the order it pleases you. You do not have to help your team members by answering their requests. You may choose to help them but you are not forced to.

You can answer every second question from your list using your own matrix (e.g. questions 1, 3, 5), but you need the help of the other members of your team to answer the rest.

(2) Incentives

● Team's pool of tickets

During the exercise, your team will accumulate tickets for the draw. Each correct answer will provide additional tickets to your team. At the end of the exercise, each team will have a pool of tickets to be shared among its members.

The number of tickets per correct answer is indicated in the second column. Note that the number of tickets per correct answer decreases as you progress through the questions.

● **Sharing rule**

At the end of the exercise, your team's pool of tickets will be equally shared among the team members. In other words, you will receive ¼ (25%) of the total number of tickets earned by your team, as illustrated in the following example:

	Tickets accumulated by each team member from his or her list of questions	Sharing rule	Tickets received by each member
Red	170	1000 X 25% =	**250**
Blue	350	1000 X 25% =	**250**
Green	230	1000 X 25% =	**250**
Purple	250	1000 X 25% =	**250**
Team's pool of tickets	**1000**		1000

● **The draw**

The more tickets you receive, the greater is your chance of winning $100.00.

Appendix K (continued)

Document entitled "Exercise and Incentives"

ES condition / three person team

Exercise and Incentives

(Three person team)

(1) Exercise

As mentioned earlier, your task is to answer arithmetic questions from the list provided in your screen. However, you are free to answer any questions you wish. You do not have to answer all questions. You do not have to answer them in the order presented. You may scroll up and down in the list and answer the questions in the order it pleases you. You do not have to help your team members by answering their requests. You may choose to help them but you are not forced to.

You can answer every second question from your list using your own matrix (e.g. questions 1, 3, 5), but you need the help of the other members of your team to answer the rest.

(2) Incentives

● Team's pool of tickets

During the exercise, your team will accumulate tickets for the draw. Each correct answer will provide additional tickets to your team. At the end of the exercise, each team will have a pool of tickets to be shared among its members.

The number of tickets per correct answer is indicated in the second column. Note that the number of tickets per correct answer decreases as you progress through the questions.

● **Sharing rule**

At the end of the exercise, your team's pool of tickets will be equally shared among the team members. In other words, you will receive 1/3 (33.3%) of the total number of tickets earned by your team, as illustrated in the following example:

	Tickets accumulated by each team member from his or her list of questions	Sharing rule	Tickets received by each member
Red	170	750 X 33.3% =	**250**
Blue	350	750 X 33.3% =	**250**
Green	230	750 X 33.3% =	**250**
Team's pool of tickets	**750**		750

● **The draw**

The more tickets you receive, the greater is your chance of winning $100.00.

Appendix K (continued)

Document entitled "Exercise and Incentives"

IP condition / four person team

Exercise and Incentives

(Four person team)

(1) Exercise

As mentioned earlier, your task is to answer arithmetic questions from the list provided in your screen. However, you are free to answer any questions you wish. You do not have to answer all questions. You do not have to answer them in the order presented. You may scroll up and down in the list and answer the questions in the order it pleases you. You do not have to help your team members by answering their requests. You may choose to help them but you are not forced to.

You can answer every second question from your list using your own matrix (e.g. questions 1, 3, 5), but you need the help of the other members of your team to answer the rest.

(2) Incentives

● **Accumulation of tickets**

During the exercise, you will personally accumulate tickets for the draw. In particular, each correct answer in your list of questions will provide you with additional tickets.

The number of tickets per correct answer is indicated in the second column. Note that the number of tickets per correct answer decreases as you progress through the questions.

It is not important whether you find your answers alone or are helped by your team members. At the end the exercise, you will receive the number of tickets accumulated from your list of questions.

● **Illustration**

The following example illustrates how the team members received the tickets they accumulated from their own list of questions during the exercise.

	Tickets accumulated by each team member from his or her list of questions	Tickets received by each member
Red	170	170
Blue	350	350
Green	230	230
Purple	250	250
Total	1000	1000

●**The draw**

The more tickets you receive, the greater is your chance of winning $100.00.

Appendix K (continued)

Document entitled "Exercise and Incentives"

IP condition / three person team

Exercise and Incentives

(Three person team)

(1) Exercise

As mentioned earlier, your task is to answer arithmetic questions from the list provided in your screen. However, you are free to answer any questions you wish. You do not have to answer all questions. You do not have to answer them in the order presented. You may scroll up and down in the list and answer the questions in the order it pleases you. You do not have to help your team members by answering their requests. You may choose to help them but you are not forced to.

You can answer every second question from your list using your own matrix (e.g. questions 1, 3, 5), but you need the help of the other members of your team to answer the rest.

(2) Incentives

- **Accumulation of tickets**

During the exercise, you will personally accumulate tickets for the draw. In particular, each correct answer in your list of questions will provide you with additional tickets.

The number of tickets per correct answer is indicated in the second column. Note that the number of tickets per correct answer decreases as you progress through the questions.

It is not important whether you find your answers alone or are helped by your team members. At the end the exercise, you will receive the number of tickets accumulated from your list of questions.

- **Illustration**

The following example illustrates how the team members received the tickets they accumulated from their own list of questions during the exercise.

	Tickets accumulated by each team member from his or her list of questions	Tickets received by each member
Red	170	170
Blue	350	350
Green	230	230
Total	750	750

- **The draw**

The more tickets you receive, the greater is your chance of winning $100.00.

Appendix K (continued)

Document entitled "Exercise and Incentives"

RP condition / four person team

Exercise and Incentives

(Four person team)

(1) Exercise

As mentioned earlier, your task is to answer arithmetic questions from the list provided in your screen. However, you are free to answer any questions you wish. You do not have to answer all questions. You do not have to answer them in the order presented. You may scroll up and down in the list and answer the questions in the order it pleases you. You do not have to help your team members by answering their requests. You may choose to help them but you are not forced to.

You can answer every second question from your list using your own matrix (e.g. questions 1, 3, 5), but you need the help of the other members of your team to answer the rest.

(2) Incentives

● Team's pool of tickets

During the exercise, your team will accumulate tickets for the draw. Each correct answer will provide additional tickets to your team. At the end of the exercise, each team will have a pool of tickets to be shared among its members.

The number of tickets per correct answer is indicated in the second column. Note that the number of tickets per correct answer decreases as you progress through the questions.

● **Sharing rule**

At the end of the exercise, your team's pool of tickets will be shared among the team members as follows. The member that performs the best will get 4/10 (40%) of the ticket pool. The second place performer will get 3/10 (30%). Third place will get 2/10 (20%). And the last place performer will get 1/10 (10%).

Your performance corresponds to the number of tickets you accumulate on your individual list of questions. It is not important whether you find your answers alone or are helped by your team members. The member that performs the best is the member who accumulates the most tickets in his or her list, as illustrated in the following example:

	Tickets accumulated by each team member from his or her list of questions		Tickets received by each member
Red	170	(4th place) 1000 X 10% =	**100**
Blue	350	(1st place) 1000 X 40% =	**400**
Green	230	(3rd place) 1000 X 20% =	**200**
Purple	250	(2nd place) 1000 X 30% =	**300**
Team's pool of tickets	**1000**		1000

● **The draw**

The more tickets you receive, the greater is your chance of winning $100.00.

Appendix K (continued)

Document entitled "Exercise and Incentives"

RP condition / three person team

Exercise and Incentives

(Three person team)

(1) Exercise

As mentioned earlier, your task is to answer arithmetic questions from the list provided in your screen. However, you are free to answer any questions you wish. You do not have to answer all questions. You do not have to answer them in the order presented. You may scroll up and down in the list and answer the questions in the order it pleases you. You do not have to help your team members by answering their requests. You may choose to help them but you are not forced to.

You can answer every second question from your list using your own matrix (e.g. questions 1, 3, 5), but you need the help of the other members of your team to answer the rest.

(2) Incentives

● Team's pool of tickets

During the exercise, your team will accumulate tickets for the draw. Each correct answer will provide additional tickets to your team. At the end of the exercise, each team will have a pool of tickets to be shared among its members.

The number of tickets per correct answer is indicated in the second column. Note that the number of tickets per correct answer decreases as you progress through the questions.

● **Sharing rule**

At the end of the exercise, your team's pool of tickets will be shared among the team members as follows. The member that performs the best will get 3/6 (50%) of the ticket pool. The second place performer will get 2/6 (33.3%). And the last place performer will get 1/6 (16.6%).

Your performance corresponds to the number of tickets you accumulate on your individual list of questions. It is not important whether you find your answers alone or are helped by your team members. The member that performs the best is the member who accumulates the most tickets in his or her list, as illustrated in the following example:

	Tickets accumulated by each team member from his or her list of questions		Tickets received by each member
Red	170	(3th place) 750 X 16.6% =	**125**
Blue	350	(1st place) 750 X 50% =	**375**
Green	230	(2rd place) 750 X 33.3% =	**250**
Team's pool of tickets	**750**		750

●**The draw**

The more tickets you receive, the greater is your chance of winning $100.00.

Appendix L

Document entitled "Follow-up questions"

ES condition

Follow-up questions

● In which program are you currently involved at University of Waterloo?

☐Arts Accounting ☐Math Accounting ☐Science Accounting
☐Arts Business ☐Other. Which one

● In what year were you born?

● Are you male or female? ☐Male. ☐Female.

● Most people in this country think of themselves as Canadian. However, in addition, is there a particular nationality or ethnic group to which you think of yourself as belonging?

☐No. ☐Yes. Which one?

The following questions assess your understanding of the exercise.

During the exercise:

● The number of tickets per correct answer...

Increased as I progressed Through the questions ☐	Decreased as I progressed through the questions ☐	Was constant Across questions ☐

● Answering one of the questions from my list...

Increased my Team's pool of tickets ☐	Decreased my Team's pool of tickets ☐	Had no effect on my Team's pool of tickets ☐

● Answering one of the questions from my list...

Increased the number of tickets I received ☐	Decreased the number of Tickets I received ☐	Had no effect on the number of Tickets I received ☐

● Helping one of my team members...

Increased my Team's pool of tickets ☐	Decreased my Team's pool of tickets ☐	Had no effect on my Team's pool of tickets ☐

● Helping one of my team members...

Increased the number of tickets I received ☐	Decreased the number of Tickets I received ☐	Had no effect on the number of tickets I received ☐	Had an uncertain effect on the number of tickets I received ☐

Appendix L (continued)

Document entitled "Follow-up questions"

IP condition

Follow-up questions

● In which program are you currently involved at University of Waterloo?

☐Arts Accounting ☐Math Accounting ☐Science Accounting
☐Arts Business ☐Other. Which one

● In what year were you born?

● Are you male or female? ☐Male. ☐Female.

● Most people in this country think of themselves as Canadian. However, in addition, is there a particular nationality or ethnic group to which you think of yourself as belonging?

☐No. ☐Yes. Which one?

The following questions assess your understanding of the exercise. During the exercise:

● The number of tickets per correct answer...

Increased as I progressed Through the questions	Decreased as I progressed Through the questions	Was constant Across questions
☐	☐	☐

● Answering one of the questions from my list...

Increased the number of tickets I received	Decreased the number of Tickets I received	Had no effect on the number of Tickets I received
☐	☐	☐

● Helping one of my team members...

Increased the number of tickets I received	Decreased the number of Tickets I received	Had no effect on the number of tickets I received	Had an uncertain effect on the number of tickets I received
☐	☐	☐	☐

Defining your "team's pool of tickets" as the total number of tickets accumulated by your team, please answer the following questions:

● Answering one of the questions from my list...

Increased my Team's pool of tickets	Decreased my Team's pool of tickets	Had no effect on my Team's pool of tickets
☐	☐	☐

● Helping one of my team members...

Increased my Team's pool of tickets	Decreased my Team's pool of tickets	Had no effect on my Team's pool of tickets
☐	☐	☐

Appendix L (continued)

Document entitled "Follow-up questions" / RP condition

Follow-up questions

- In which program are you currently involved at University of Waterloo?

  ☐Arts Accounting ☐Math Accounting ☐Science Accounting
  ☐Arts Business ☐Other. Which one

- In what year were you born?

- Are you male or female? ☐Male. ☐Female.

- Most people in this country think of themselves as Canadian. However, in addition, is there a particular nationality or ethnic group to which you think of yourself as belonging?

  ☐No. ☐Yes. Which one?

The following questions assess your understanding of the exercise. During the exercise:

- The number of tickets per correct answer...

Increased as I progressed Through the questions	Decreased as I progressed through the questions	Was constant Across questions
☐	☐	☐

- Answering one of the questions from my list...

Increased my Team's pool of tickets	Decreased my Team's pool of tickets	Had no effect on my Team's pool of tickets
☐	☐	☐

- Answering one of the questions from my list...

Increased my chance of being the team member that performed the best	Decreased my chance of being the team member that performed the best	Had no effect of my chance of being the team member that performed the best
☐	☐	☐

- Answering one of the questions from my list...

Increased the number of tickets I received	Decreased the number of Tickets I received	Had no effect on the number of Tickets I received
☐	☐	☐

- Helping one of my team members...

Increased my Team's pool of tickets	Decreased my Team's pool of tickets	Had no effect on my Team's pool of tickets
☐	☐	☐

- Helping one of my team members...

Increased my chance of being the team member that performed the best	Decreased my chance of being the team member that performed the best	Had no effect of my chance of being the team member that performed the best
☐	☐	☐

- Helping one of my team members...

Increased the number of tickets I received	Decreased the number of Tickets I received	Had no effect on the number of tickets I received	Had an uncertain effect on the number of tickets I received
☐	☐	☐	☐

Appendix M
Questions on Personal Abilities

Name:
ID number:

This is the last part of Marie-Josee Ledoux's experiment. On a scale from 0 to 10, where 10 is as good as it can be and 0 is as bad as it can be, please place an X on the scale to indicate your answer. As always, the results will remain confidential.

● **How would you evaluate your ability to add numbers quickly?**

As bad as it can be — As good as it can be

0 2 5 8 10
|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|

● **How would you evaluate your computer skills?**

As bad as it can be — As good as it can be

0 2 5 8 10
|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|