ESSAYS ON TEAM-BASED INCENTIVES

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Hua Chen

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To my wife, Haijing, and my son, Lehan. I love you with all of my heart.

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Abstract

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Abstract

Over the past few decades, team-based incentives are used by more and more organizations to motivate their agents to exert effort. The usage of team incentives creates many challenges, especially the "free-riding" problem. In current dissertation, I provide the evidence from the laboratory and field experiments to answer several critical questions faced by managers: Given the potency of free-riding and without task complementary, could team-based incentives be at least as effective as individual-based incentives or even better? If so, under what condition would the team-based incentives be effective? Furthermore, what are the driving forces that make team-based incentives effective?

In essay 1, I focus on the piece rates compensation scheme. Specifically, I examine three types of incentives: Individual incentive where agents are paid by a commission rate purely on their individual output; Team-based incentive where agents are paid by a commission rate on the weighted average of individual output and team output (the average of output of all the members in the team). Team-based incentive can be further categorized as Team incentive when the weight of individual output is zero and Hybrid incentive with the weight greater than zero but less than one. I find that team-based incentives could be as effective as individual-based incentives under certain environment. More important, changing the structure of team-based incentives by varying the proportion of individual output and team output can make team-based incentives even

more effective. Last, appropriate mutual monitoring is helpful but "perfect" mutual monitoring may induce negative effect on agents' effort.

In essay 2, I compare the efficacy of team-based versus individual-based incentives using economic experiments, answering the following question: when designing contests to motivate employees, should managers organize employees to compete in teams or as individuals? I develop a behavioral economics model that shows that if contestants are averse to being responsible for their team's loss, a team-based contest can yield higher effort as compared to an individual-based contest. I test this prediction for a four-person contest using a laboratory economics experiment. The results show that when contestants do not know each other, average effort levels in the individual-based and team-based contests are no different. However, when I allow contestants to socialize with potential teammates before making effort decisions, team-based contests yield higher effort relative to individual-based contests. I also conduct a field experiment that compares team-based and individual-based contests in a setting where contestants are familiar with one another. The results parallel those from the lab and indicate that team-based contests generate higher sales.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

DO TEAM-BASED INCENTIVES WORK? EVIDENCE FROM THE LABORATORY AND FIELD

1. Introduction

How to design a compensation plan that can motivate employees to provide appropriate effort in the way as employers or managers want is always a critical question in economics and marketing research. Over the past few decades, team-based incentives are used by more and more organizations to motivate their agents to exert effort. The usage of team-based incentives creates many challenges, especially the "free-riding" problem. This problem arises because agents fail to internalize the benefits that accrue to other members in the team when making effort decisions and as a consequence they may hesitate to behave as managers wish (Prendergast 1999). The prediction of free-riding is based on the classical assumption that agents are self-interested when making decision, that is, they only care about their monetary payoff and the objective is to maximize it. However, this self-interested assumption has been challenged by research in behavioral economics. Evidence from both the lab and filed experiments (e.g, Fehr and Schmidt 1999; Fehr and Fischbacher 2002; Bandiera et al 2005; Lim 2010) has shown that people show social preferences, i.e., they also care about the payoffs of others, including competitors, co-workers etc., and consequently social preferences may influence how people make their decisions. Given the findings from behavioral economics, it is very natural to ask: now that the self-interested assumption on which the free-riding prediction is based has been refuted, will free-riding in team-based incentives always be the case?

In this paper, I provide the evidence from lab and field experiments to answer several critical questions faced by managers: Given the potency of free-riding and without task complementary, could team-based incentives be at least as effective as individual-based incentives or even better? If so, under what condition would the team-based incentives be effective? Furthermore, what are the driving forces that make team-based incentives effective?

Specifically, I focus on the piece rates scheme and examine three types of incentives: Individual-based incentive where agents are paid by a commission rate purely on their individual output; Team-based incentive where agents are paid by a commission rate on the weighted average of individual output and team output (the average of output of all the members in the group). Team-based incentive can be further categorized as Team incentive when the weight of individual output is zero and Hybrid incentive with the weight greater than zero but less than one.

I choose to study piece rates for two reasons. First, piece rates scheme is widely used and perceived to be effective in motivating employees, by managers and scholars. Second, piece rates has been studied by most of the research on team-based incentives but with inconsistent results. On the one hand, evidence from the lab (e.g, Nalbantian and Schotter 1997) and filed experiments (e.g, Erev et al 1993) show that team piece rates, which is also known as "revenue sharing", will induce lower effort or outcome than individual piece rates does when co-workers are matched to form a team randomly and anonymous or they don't know each other. On the other hand, Van Dijk et al (2001) and Hamilton et al (2003) show that team piece rates can work better than individual piece rates if workers can perceive non-pecuniary benefits from working in a team. Given the importance of piece rates in managerial practice and the controversial findings in academia, my research questions in this paper are with considerable managerial implication.

First, I designed and implemented a 3 (Individual, Hybrid, and Team incentive) × 2 (social conditions A and B) experiment to address the questions of under what condition and why team-based incentive may be effective. In social condition A, subjects were randomly paired up to form a group and not allowed to communicate whereas subjects in social condition B knew who they are working with and were allowed to discuss about their strategies before and at the middle of decision rounds. I got a few interesting findings: 1) free-riding happened in social condition A where the average effort is the highest under Individual incentive and the lowest under Team incentive. However, in social condition B there is no different in average effort under Hybrid and Team incentives (effort under Hybrid is directionally higher though), and more importantly, both are higher than that effort in Individual incentive; 2) across the social settings, there is no difference in average effort for Individual incentives. But the average effort of Hybrid and Team incentives in social condition B are significantly higher than effort of corresponding incentives in social condition A respectively.

Second, I implemented another similar experiment but with only one change: the effort information was revealed to partner under Hybrid incentive and Team incentive in social condition B. Surprisingly, I find that with the perfect information of partner's effort, the average effort levels in both Hybrid incentive and Team incentive are actually lower than before when the effort information is not known by partner.

Last, I ran a field experiment with randomly assigning subjects into Individual and Hybrid incentives respectively. All the subjects received professional training in sales and were responsible for fund-raising activities. They worked independently and their performance was measured by the cash sales they made. The result showed that the average cash sales of subjects under Hybrid incentive are significantly higher than that of subjects under Individual incentive. That means team-based incentive could be more effective than individual-based incentive.

This study provides several unique contributions to the literature of team-based incentives. First, it examines the relative efficacy of team-based incentives versus individual-based incentives in lab experiment across different social settings and in a field study. I find that team-based incentives could be as effective as individual-based incentives under certain environment. Second, it is the first paper that investigates the effect of varied proportion of individual and team incentives on agents' behavior. Third, it deepens the understanding of the driving forces that make team-based incentives effective, especially shows that "perfect" mutual monitoring actually prevents the agents from exerting higher effort. Appropriate mutual monitoring is helpful (Kandel and Lazear, 1992; Knez and Simester 2001), but "perfect" mutual monitoring may induce negative effect on agents' effort.

The remainder of this paper is organized as follows. The next section presents a simple theoretical model and results that characterize how varying the proportion of individual-based and team-based incentives affects workers' effort in a work without interdependence. In section 3 and 4, I describe the experimental design and the results of the lab experiments 1 and 2. Section 5 shows the results of a randomized field experiment. Finally, I conclude with the managerial implications and directions for future research.

2. Theory

Since the main focus of this paper is experimentally rather than analytically examining whether team-based incentives can work as good as, or even better than, individual incentives, I restrict the attention to the simplest case where 2 salespeople work in a team. The two salespeople are assumed to be risk neutral and have identical utility functions that are separable in the reward received and the cost of effort exerted. Salesperson i puts forth a nonnegative effort level e_i, which will lead to the output $y_i = e_i + \varepsilon_i$, where ε_i is assumed to be uniformly distributed on the interval $[-q, q]$ and independent across salespeople, capturing the uncertainty faced by salespeople.

The reward each salesperson receives from her output y_i and the other salesperson *j*'s output y_j is determined as follows:

$$R_i = m * [\alpha * y_i + (1 - \alpha) * \frac{y_i + y_j}{2}], \quad (1)$$

where m can be treated as the commission rate, and $0 \leq \alpha \leq 1$ is used to adjust the proportion of reward comes from the individual performance. Under this compensation system, each salesperson keeps a fraction, α, of her output, and equally shares the rest, $(1 - \alpha)$, with the other salesperson. So, actually $(\alpha + \frac{1-\alpha}{2})$ of each salesperson's reward comes from her own output in fact. When $\alpha = 1$, a salesperson's reward doesn't depend on the performance of the other salesperson, so I define it as Individual incentive. When $0 \leq \alpha < 1$, a salesperson's reward is partially affected by the other salesperson's output, so I define it as team-based incentives. Specifically, when $\alpha = 0$, a salesperson's reward is purely determined by the average output of the two salespeople, which is termed as Team incentive (also known as "revenue sharing"); when $0 < \alpha < 1$, a salesperson's reward is determined by both individual output and the average output of the two salespeople, which is termed as Hybrid incentive. Notice that, these two salespeople in my model work totally independently, i.e., there is no task complementary, and only are linked by influencing the payoff of each other.

In the self-interested model, all salespeople operate under the standard economic assumption that they care solely about the payoffs from the rewards they receive and try to maximize their expected utility:

$$EU_i = ER_i - c(e_i) = m * [\alpha * e_i + (1-\alpha) * \frac{e_i + e_j}{2}] - c(e_i) \quad (2)$$

where $c(e_i)$ is the cost of effort exerted by salespeople, which is assumed to be strictly increasing and convex. Furthermore, assuming $c(e_i) = \frac{e_i^2}{k}$, the pure-strategy Nash equilibrium can be obtained as:

$$e_i^* = \frac{km}{2}\left[\frac{1+\alpha}{2}\right]. \quad (3)$$

From equation (3), it is easily to find that the higher the value of α, the more effort each salesperson will exert, i.e., the equilibrium effort each salesperson exerts is an increasing function of α given all the other parameters. Especially, when $\alpha = 1$, $e_i^* = \frac{km}{2}$, and when $\alpha = 0$, $e_i^* = \frac{km}{4}$. That means salespeople will exert the highest effort in Individual incentive and exert the lowest effort in Team incentive. To sum up these findings, we will have

Proposition 1: *The Equilibrium Effort in Individual incentive is higher than that in Hybrid incentive, which is then higher than effort in the Team incentive.*

3. Laboratory Experiment 1

Experimental Design and Procedure

Laboratory experiment 1 examines the effort decisions in three different incentive systems (individual, hybrid, and team) across two social settings (social condition A and social condition B), so there are six treatments in total, which are labeled as IA, HA, TA, IB, HB, and TB, respectively. Social conditions A and B are different in the interaction among subjects and in the extent to which the social preferences can affect subjects' effort decision consequently, which will be described in detail later.

The parameter values used in the experimental test were k=230, q=15, and m=0.5. Given these parameters, the point predictions of effort based on the theory are shown in Table 1. I choose this set of parameter values because they ensure that: 1) there is sufficient spread in the point predictions in the salesperson's effort across different compensation systems; 2) the effort predictions are not focal numbers; and 3) the participation constraints given the equilibrium effort levels for salespeople are satisfied.

[Insert Table 1 here]

Subjects were business undergraduates at a large public research university in the United States. Participants received course credits and made cash earnings based on their performance. I use the procedure of HB treatment as the example to describe the experimental procedure and then address the differences that other treatments have.

At the start of every experimental session, each subject was assigned to a group of 4 people and then they were asked to talk with each of the subjects in the same group for 2 minutes respectively, introducing themselves and discovering three personal interests in common. Then, each group participated in a Word Roundup game, all subjects in a group working together to solve the puzzles according to the hints. Most of the groups completed the task within 3 minutes, which is the time allowance.

After the game, the instructions for the experiment were handed out and read out loud. In each treatment, subjects were told that they would complete a total of 18 rounds in this experiment. Each subject was matched with a partner from his group for 6 rounds and then re-matched with a new partner until he had been matched with all the other 3 agents within the same group. The experiment was implemented using the z-Tree software (Fischbacher 2007). Subjects were told that their task was to select a Decision Number (e_i) from 0 to 100. Every Decision Number carried a Decision Cost ($\frac{e_i^2}{230}$) which increases with the Decision Number they choose. The Decision Cost corresponding to each Decision Number was provided to each subject using a "Decision Cost Table." Subjects were then told that they were to enter their Decision Number into the computer program, and once they had done so the program would generate a Random Number (ε_i) that ranged from -15 to 15 (q). Each Random Number in this range has an equal chance of being drawn. The computer would then add the Decision Number and the Random Number to form the Final Number.

Before the first round with each new partner, the two matched-up subjects were allowed to talk with each other for 1 minute, discussing the strategy of Decision Number they are going to take. After 3 rounds with the same partner, they were allowed to talk with each other for another 1 minute. They could choose whether to talk or not and what to discuss except the Decision Numbers they already chose in the past 3 rounds. After privately selecting a Decision Number, each participant viewed an output screen for each round revealing their Decision Number, Random Number, Final Number, partner's Finial Number, Average Team Final Number and their own Point Earnings.

The IB and TB treatments have the same procedure as the HB treatment does except the way to calculate the Point Earnings of each decision round. Also, for IB treatment, there was no information about partner's Final Number. However, for the IA, HA, and TA treatments, there were no self-introduction and Word Roundup game before the instructions were hand out and read out. During the experimental session of HA and TA treatments, subjects didn't know with whom they were matched up, and consequently they were not allowed to talk with partner or discuss the strategy should be taken. Table 2 summaries the difference in experimental procedure between social conditions A and B. The full instructions that were presented to participants in the Hybrid incentive under social condition B can be found in Appendix 1.

[Insert Table 2 here]

Across the six treatments, the range of Decision Numbers and the Decision Costs faced by subjects, the distribution of Random Numbers and how payoffs would be determined were common knowledge to all subjects. In the hybrid and team incentives treatments, all subjects knew partner's Final Number after each decision round. Only the actual Decision Number chosen, the Decision Costs incurred, the Random Number drawn, partner's payoffs in each round were private knowledge to each subject. At the end of the each experimental session, the Total Point Earnings were converted to dollar values and all subjects were paid privately according to their payoffs and directed to leave the room. Each participant earned $10 on average and the range was from $7 to $18. The instructions for the experiments are available upon request.

Experimental Results

I recruited a total of 271 undergraduate business students from a large public research university, with 3 or 4 sessions for each treatment and 12 or 16 subjects in each session (except for one session for IA where there were 15 subjects). The mean effort levels of the subjects are displayed in Table 1. Figure 1 graphically present the average effort for each treatment. For the treatments in social condition A, the average effort levels of the subjects are 53.2, 44.4, and 35.6 for individual, hybrid, and team incentives respectively. While for in social condition B, the subjects' average effort levels are 52.7, 59.3, and 56.7 for individual, hybrid, and team incentives respectively. As we can see, the pattern of mean effort in social condition A is consistent with proposition 1, i.e., the effort in IA treatment is the highest, followed by HA and then TA. However, in social condition B, the average effort levels of both HB and TB are higher than that of the IB treatment, with HB being the highest.

[Insert Figure 1 about here]

I then proceed to conduct formal statistical tests of the results. I begin by testing the actual average effort level of in each treatment against the point prediction by the theoretical model. Because subjects made multiple decisions, I cluster the standard errors at the subject level in all the statistical tests to account for potential within-subject correlation. The results of these t-tests are also reported in Table 1. It shows that subjects in the TA, HB and TB treatments overexerted effort while under-exerted effort in both IA and IB treatments.

The results of comparison across social conditions for each type of incentive are also included in Table 1 and graphically presented in Figure 2. There is no difference between the effort levels of the IA and IB treatments, however, subjects exerted significantly higher effort in social condition B for both hybrid and team incentives.

[Insert Figure 2a, 2b, and 2c here]

Table 3 reports the results of t-test of hybrid and team incentive effort levels against 57.5, the Pareto-optimal equilibrium effort (which is also the equilibrium effort in individual incentive). The effort levels of HA and TA treatments are significantly lower than 57.5, providing the evidence of free-riding in team-based incentive. However, the effort levels of HB and TB are not different from the Pareto-optimal equilibrium, which means free-riding is offset by some factors unique in social condition B.

[Insert Table 3 here]

Next, I examine proposition 1 formally and the results are shown in Table 4. I begin with the subject effort in social condition A. Proposition 1 states that subject effort level would be highest in individual incentive and lowest in team incentive. The results of t-test support proposition 1. Figure 3a displays the average effort of each decision round across different incentives in social condition A. It is easy to find that effort level of subjects in individual incentive is always higher than that in hybrid incentive, and then the effort level in hybrid incentive is higher than that in team incentive. However, I find that in social condition B, there is no significant difference between the effort levels of hybrid incentive and team incentive. More importantly, effort levels in the HB and TB treatments are both significantly higher than the effort level in the IB treatment. From Figure 3b, we can see that in most decision rounds (13 of 18 rounds), the mean effort in the HB treatment is always higher than that in the TB treatment, and it is also the case when compared to the IB treatment after decision round 3. Specifically, if we compare the average effort of last 15 rounds, subjects in the HB treatment exerted significantly higher effort than those in the TB treatment did (t=3.42, p=0.001). At last, the mean effort in the TB treatment is always higher than that in the IB treatment for 17 of 18 decision rounds (except for round 16).

[Insert Table 4 here]

[Insert Figure 3a and 3b here]

Table 5 and Figure 4 indicate the proportion of effort levels fall in specific ranges, including 55~60, 61~65, 66~70, and 59~70. Note that subjects can only choose integers as their Decision Number and 57.5 is the Pareto-optimal equilibrium effort. We can see that in social condition A, the IA treatment is not only with highest proportion in the "rational range" (55~60), but also in the "high effort ranges" (61~65 and 66~70). Overall, subjects in the IA treatment are with the highest proportion to choose effort higher than the rational equilibrium effort. However, in social condition B, although the IB treatment is still with the highest proportion in the range of 55~60, HB is with the highest proportion in both ranges of 61~65 and 66~70. And consequently, subjects in the HB treatment are with the highest proportion for choosing the effort level higher than the Pareto-optimal equilibrium effort.

[Insert Table 5 here]

[Insert Figure 4a and 4b here]

In the end, I check whether the "last-round effect" happened in out experiment. Table 6 reports the results of t-test of the mean effort the "5^{th}" round against that of the

"6th" round for both hybrid and team incentives in two social conditions.[1] I didn't find the last-round effect in any treatments.

[Insert Table 6 here]

In summary, I find that although the theoretical model correctly predicts that team-based incentives (hybrid and team) will induce lower effort than individual-based incentive does in a social condition where subjects are randomly and anonymously matched, it doesn't capture the behavior of subjects in social environment where they socialized before the experiment and were allowed to communicate with their teammate (in both hybrid and team incentives) during the experiment. Specifically, hybrid and team incentives induced higher effort than individual incentive did, not different from the Pareto optimal effort level. This finding suggests that social preferences really exists and affects behavior. In the next section, I show the results of another lab experiment, by which I try to explore the effect of social preferences deeper.

4. Laboratory Experiment 2

There are two treatments in lab experiment 2, hybrid and team incentives in social condition B. The experimental design and procedure of lab experiment 2 are identical to that of lab experiment 1, except that after each decision round, the decision number chosen by each subject is publicized to his teammate. I label these two treatments as HBP and TBP respectively. There were 32 subjects in HBP and 28 subjects in TBP, depending on the number of students who registered for each session.

[1]Each subject was matched up with 3 partners for 6 rounds each, so the "5th" round includes round 5, 11, and 17. Similarly, the "6th" round includes round 6, 12, and 18.

The mean effort in HBP and TBP are 52.9 and 49.4 and significantly higher the theoretical prediction respectively (t=7.0, p=0.000 and t=16.2, p=0.000). Moreover, the mean effort in HBP is directionally higher than that of TBP treatment (t=1.83, p=0.072). Figure 5 shows the mean effort of each decision round for HBP and TBP. From figure 5, we can find that the mean effort in HBP is higher than that of TBP for 14 out of 18 rounds. Table 7 reports the other main findings of lab experiment 2, including: 1) the mean effort in HBP is lower than that of HB in lab experiment 1 and so is TBP; 2) neither the mean effort in HBP or TBP is significantly different from the mean effort in the IB treatment; [2] 3) both the mean effort levels in HBP and TBP are significantly lower than the Pareto optimal effort (which is 57.5 in the lab experiment).

[Insert Figure 5 here]

[Insert Table 7 here]

These findings are very surprising to us. Mutual monitoring is considered by managers and scholars as one of the possible means by which team-based incentives can be effective and extant literature also provides some supportive evidence. In lab experiment 1, subjects knew their teammate's output (the Final Number) after each round and had the chance to communicate with each other after the third decision rounds during the experiment, which allows mutual monitoring to take effect. Note that this monitoring is with uncertainty because of the Random Number, which makes it is impossible for subjects to imply their teammate's effort decision (Decision Number) accurately. While in lab experiment 2, the effort decision was accurately shown to teammates after each round and as a result, mutual monitoring should be more effective in increasing effort in

[2] Not significantly different from the mean effort in the IA treatment as well.

team-based incentive. However, I find the opposite, that is, the effort for both hybrid and team incentives in the social condition B decreases.

5. Field Experiment

At last, I also conducted a field experiment to compare the relative effectiveness of individual-based incentive and team-based incentive. In the field experiment, subjects were asked to complete a real-effort task, where they have heterogeneous abilities. As a result, the findings in the field experiment can provide great ecological validity to the findings of the lab experiments. More importantly, the social connection among subjects in the field experiment is stronger than that in the lab experiments since they know each other relatively well and are allowed to communicate as frequently as they will. So, I expect that the effect of social preferences will be even stronger as well in the field experiment.

There were a total of 59 subjects in an undergraduate sales program participated the field experiment. At the time of the experiment, they had known one another for approximately six months by taking the same set of classes together and participating in common social activities. They were responsible for selling products of golf tournaments to raise fund for the university. All the subjects received training in areas such as sales prospecting, rapport building, sales presentations, and order requests.

Before the announcement of the experiment, they are already divided into 19 teams of 3 and 1 team of 2 for mutual support. In the experiment, 10 teams (with one team with 2 students) were randomly assigned to a treatment where each of them was paid a commission rate of 3% on their own dollar sales (individual incentive). The rest 10 teams were assigned to hybrid incentive, where each subject working with 2 teammates and being paid a commission rate of 3% on 50% of their own dollar sales and 50% of the average dollar sales of the entire team. There is no significant difference between subjects in individual and hybrid incentives in terms of gender ratio (52% and 50% women respectively, z=0.13, p=0.895) and sales/service related work experience (43 and 53 months respectively, t=-0.11, p=0.272). The nature of the selling task was such that there were no task complementarities among team members.

The average sales of the subjects were $1,005 and $694 in hybrid and individual incentives respectively, with sales significantly higher in the former (t=2.31, p=0.024). The median sales of hybrid and individual incentives are $1,000 and $700, the result of Wilcoxon rank-sum test shows that the treatment effect is significant (z=2.174, p=0.030). As we can see from Figure 6, the proportions of sales in the range $501~$1,000 and $1,001~$1,500 are almost the same for hybrid and individual incentives. However, individual incentive is with higher percentage in the sales below $500 than hybrid incentive is, and the opposite is true in the range of sales greater than $1,500. Table 8 presents the results of regression of dollar sales on incentive and other covariates. The results of the field experiment hence appear to support the existence of social preferences.

[Insert Figure 6 here]

[Insert Table 8 here]

6. Discussion and Conclusion

In this paper, I compare the relative effectiveness of individual-based incentive and team-based incentives across two social settings. Specifically, I examine 3 compensation schemes: Individual, Hybrid, and Team. I began by an economics model with self-interested assumption and the model predicts the effort will be highest in

Individual incentive, followed by that in Hybrid incentive, and lowest in Team incentive. I test this prediction for a 2-person team using 2 laboratory economics experiments. The results of lab experiment 1 show that, consistent with the predictions of the model, effort in Individual incentive is higher than effort in Hybrid incentive, and then the effort in Team incentive in social condition A where subjects were anonymously and randomly matched to form a team and make decision. However, in social condition B, where subjects engaged in socialization activities with their teammates and were allowed to communicate during the experiment, effort of team-based incentives (Hybrid and Team) is higher than that of Individual incentive. Moreover, the effort is directionally higher in Hybrid incentive than Team incentive. In lab experiment 2, I further examine team-based incentives by allowing subjects to know their teammate's effort decision accurately. Surprisingly, the effort levels in both Hybrid and Team incentives are lower than that of corresponding incentive in lab experiment 1 and not different from the effort in individual incentive. I test the theory further using a field experiment that compares Individual and Hybrid in a setting where contestants know one another relatively well and the results parallel those found in the lab.

The experimental results suggest that team-based incentives could be considered by managers as a candidate to motivate their salespeople. But, to make team-based incentives to be effective, managers need to create a "right" social environment where employees who are in the same team know each other well and care about their teammates' payoff form their work. Another important managerial implication from the findings of this study is "perfect" mutual monitoring may not always be a good practice. Conventionally, reducing information distortion among employees is beneficial to maintaining good relationship among co-workers. However, as shown in the lab experiment, keeping a certain level of noise in the mutual monitoring process could be helpful to induce higher effort. Last, changing the relative proportion of payoff from individual output and the average output of the team can also be a useful method for manager to motivate employees. The task for managers is to find out the optimal proportion that works best for their business or company.

Although I find that team-based incentives could be as effective as, or even more effective than, individual incentives, there are some caveats that I want to point out. First, I studied very simple team-based incentives where a team only consists of two members. If a team consists of many members, there may be greater incentive to free ride. Second, I have assumed that contestants are identical in sales ability or market endowments. If teammates are heterogeneous, the effectiveness of team-based incentives may be mixed, which deserves a further examination. For example, salespeople with higher ability may not be willing to work with lower ability salespeople since they can earn more if they work by themselves. However, some research (e.g., Hamilton et al. 2003) finds that high ability workers could like to join the team since they can receive some non-pecuniary benefits such as higher social status within the team.

Table 1 Theory Predictions and Summary Results of Lab Experiment 1

Incentive Scheme	Theory Prediction	Social Condition A	Social Condition B	Comparison across Social Settings
Individual	57.5	53.2	52.7	
(α=1)		(9.6)[#]	(12.1)	t=0.23
		t=-2.78*, p=0.008	t=-3.18, p=0.002	p=0.817
Hybrid	43.1	44.4	59.3	
(α=0.5)		(10.1)	(7.4)	t=-7.54
		t=0.79, p=0.429	t=13.77, p=0.000	p=0.000
Team	28.8	35.6	56.7	
(α=0)		(10.2)	(8.2)	t=-10.52
		t=4.26, p=0.000	t=23.51, p=0.000	p=0.000

#Numbers in parentheses are the standard deviations.
* Test against the theory prediction.
Note: The parameter values used in the experiment are: N=2, k=230, q=15, and m=0.5.

Table 2 Differences in Experimental Procedure across Social Conditions A and B

Activity	Social Condition A	Social Condition B
Self-introduction & Common Interests	–	✓
Word Roundup game	–	✓
Partner is known	–	✓
Talking with the partner before the 1st round	–	✓
Talking with the partner after the 3rd round	–	✓

Figure 1 Theory Predictions and Mean Effort

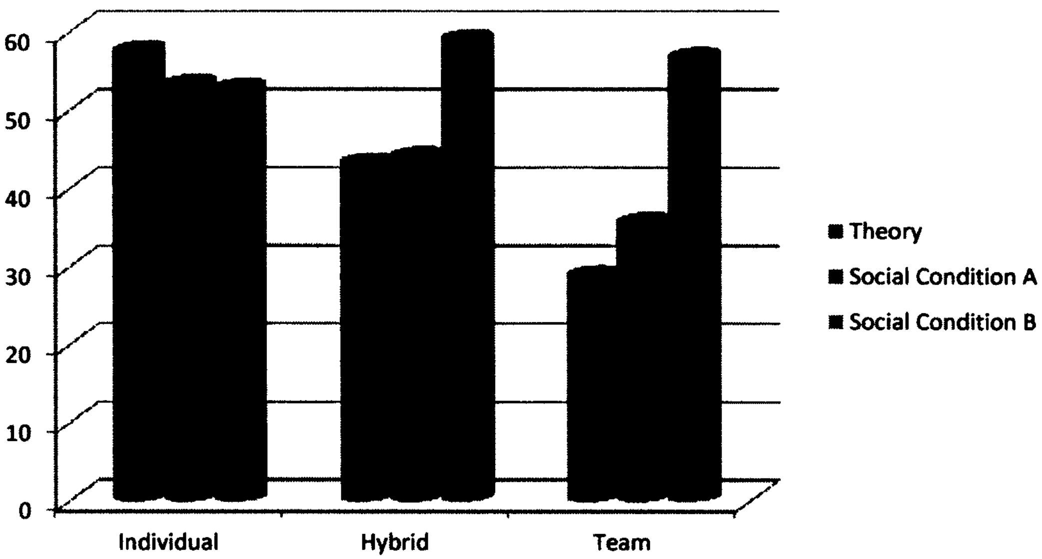

Figure 2a Mean Effort of each Decision Round in Individual Incentive

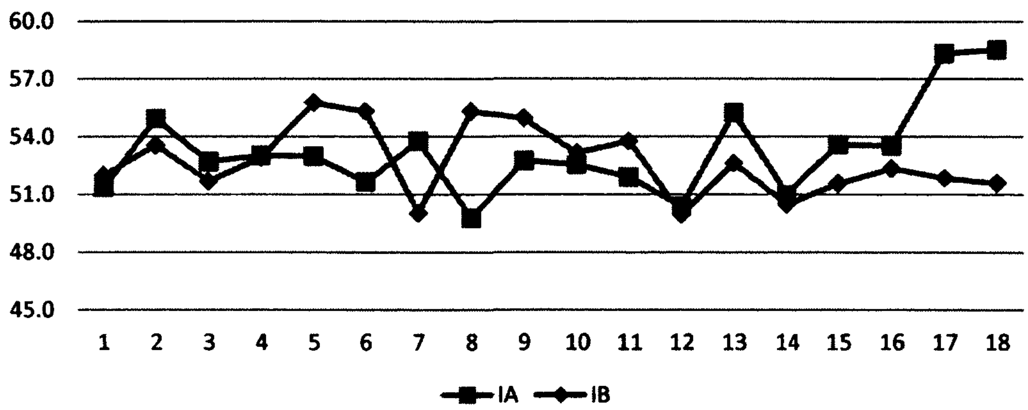

Figure 2b Mean Effort of each Decision Round in Hybrid Incentive

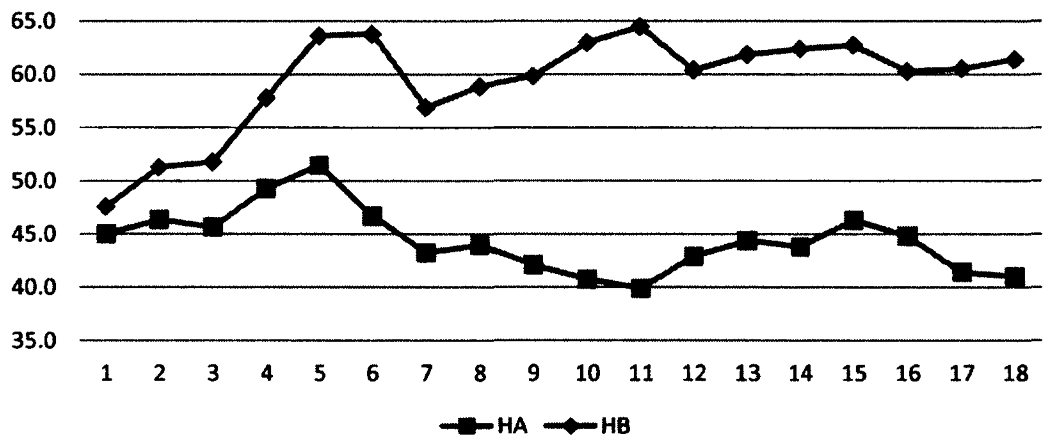

Figure 2c Mean Effort of each Decision Round in Team Incentive

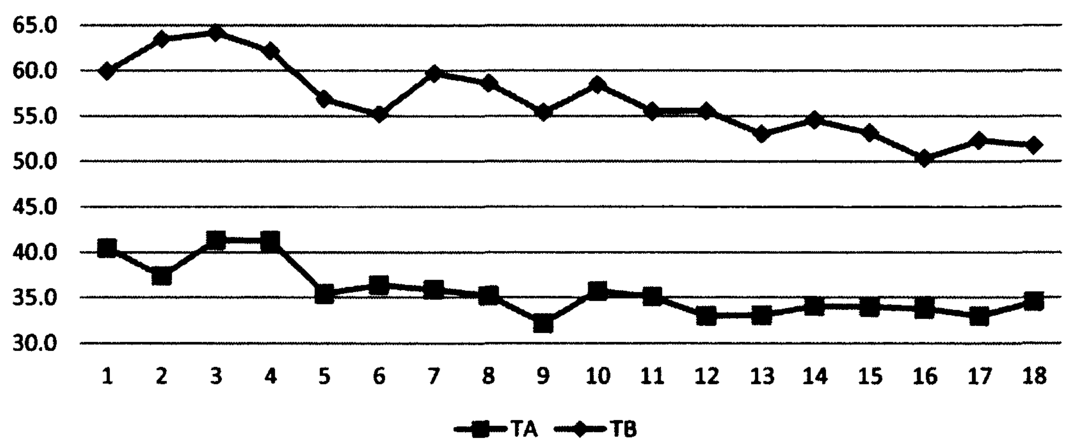

Table 3 Comparison against the Pareto-optimal Effort (57.5)

Incentive	Social Condition A	Social Condition B
Hybrid	t=-8.17, p=0.000	t=1.53, p=0.132
Team	t=-13.45, p=0.000	t=-0.67, p=0.504

Table 4 Comparison across Incentives

Incentives	Social Condition A	Social Condition B
Individual vs. Hybrid	t=7.85, p=0.000	t=-3.48, p=0.001
Individual vs. Team	t=3.97, p=0.000	t=-2.06, p=0.041
Hybrid vs. Team	t=3.85, p=0.000	t=1.62, p=0.110

Figure 3a Mean Effort of each Decision Round in Social Condition A

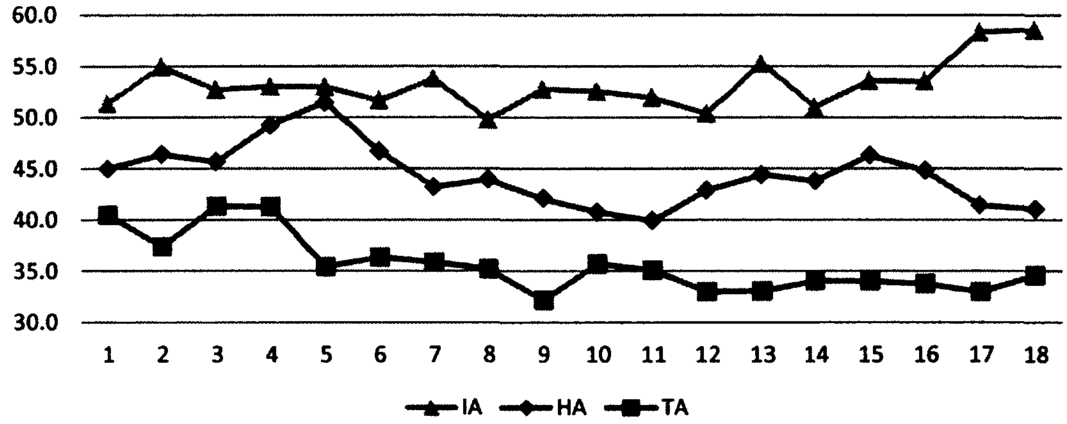

Figure 3b Mean Effort of each Decision Round in Social Condition B

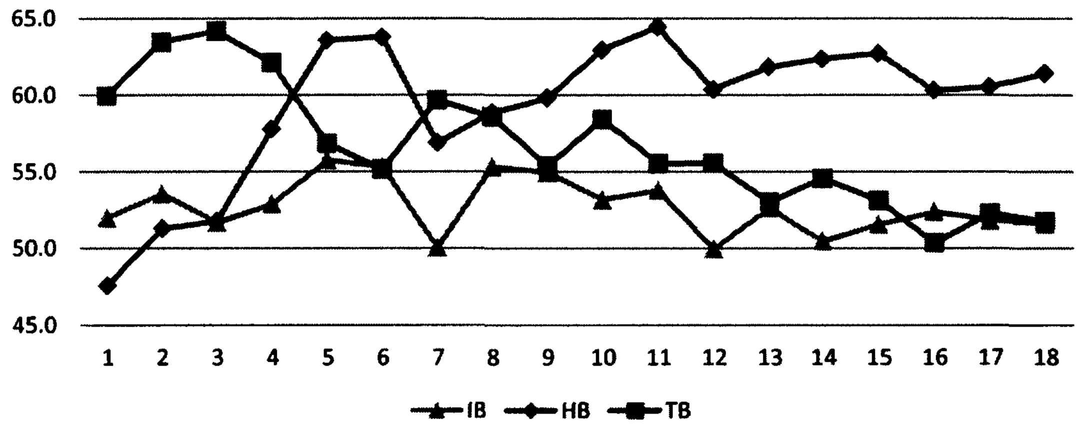

Table 5 Percentage of Effort in Certain Ranges

Incentive	55~60		56~61		66~70		59~70	
	A[#]	B	A	B	A	B	A	B
Individual	28.2	23.7	8.4	5.6	7.8	6.9	25.8	24.8
Hybrid	14.0	17.6	4.6	12.9	4.2	11.1	12.7	32.6
Team	6.11	22.7	2.2	11.0	2.5	7.9	6.0	26.5

#: "A" and "B" represent "Social Condition A" and "Social Condition B" respectively.

Figure 4a Percentage of Effort in Certain Ranges in Social Condition A

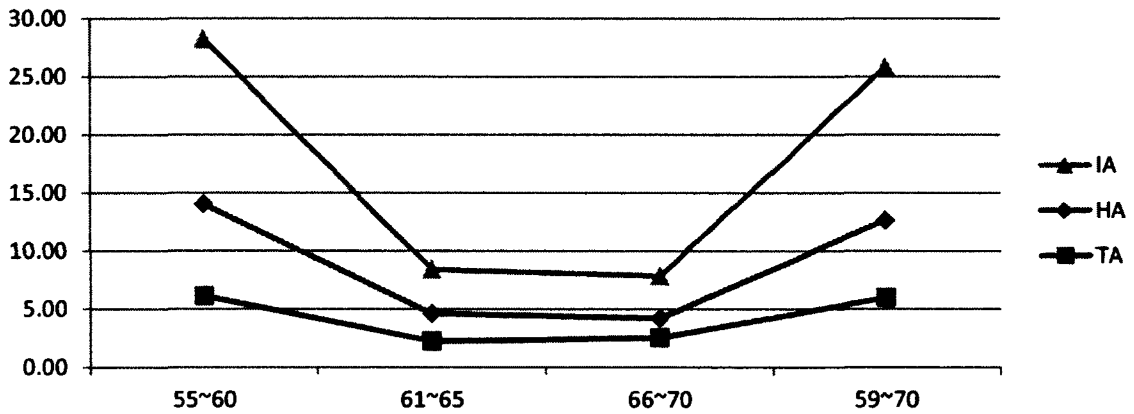

Figure 4a Percentage of Effort in Certain Ranges in Social Condition B

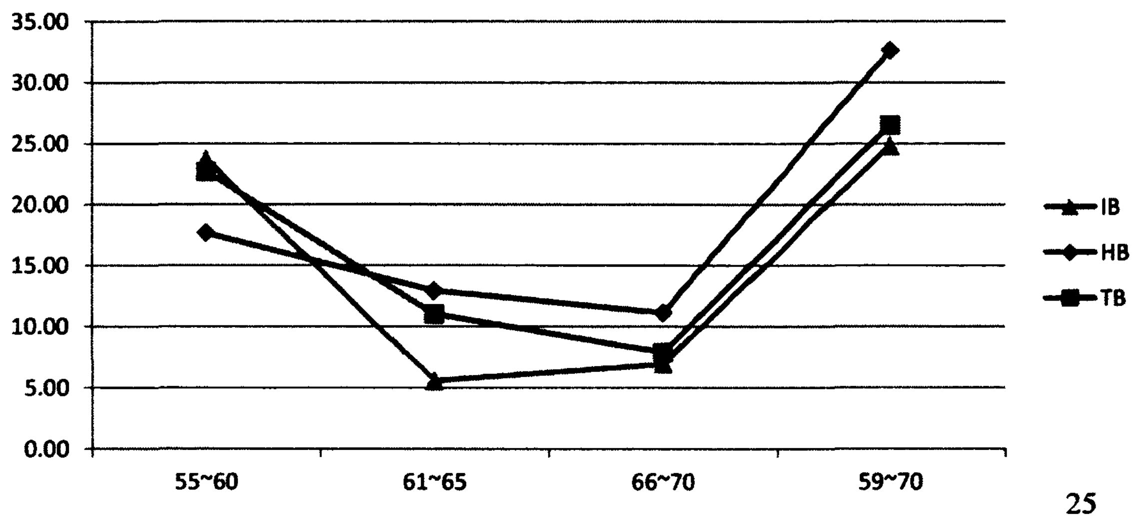

Table 6 Test for the Last-Round Effect

Incentive	Social Condition A			Social Condition B		
	5th round	6th round	t-stat	5th round	6th round	t-stat
Hybrid	44.3 (11.2)#	43.5 (12.8)	t=0.43 p=0.666	62.9 (10.7)	61.9 (10.2)	t=0.68 p=0.498
Team	34.5 (12.4)	34.6 (11.6)	t=-0.08 p=0.937	54.9 (12.2)	54.1 (12.3)	t=0.75 p=0.454

#Numbers in parentheses are the standard deviations.

Figure 5 Mean Effort of each Decision Round in HBP and TBP treatments

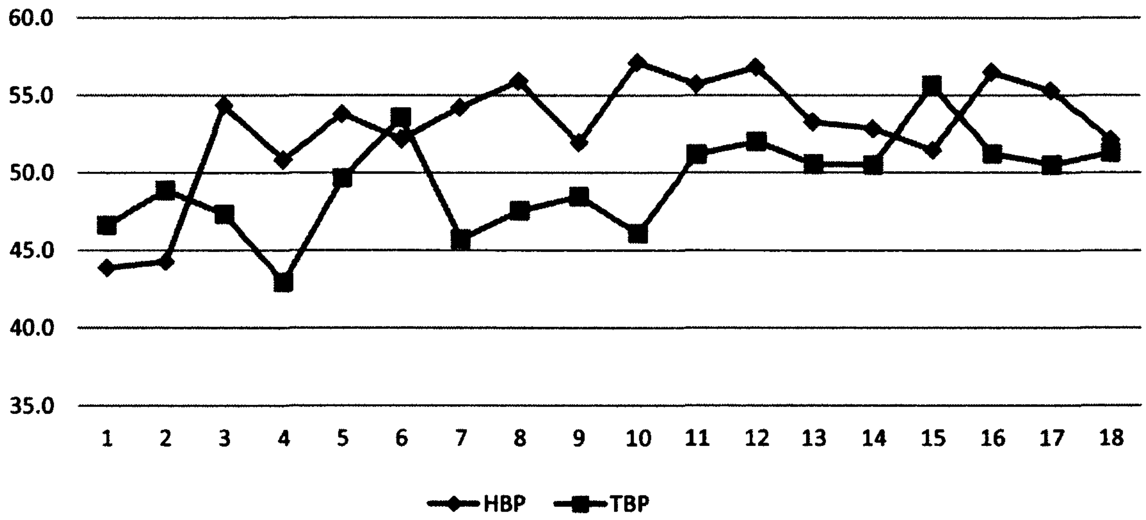

Table 7 Summary of the Results in Lab Experiment 2

Treatment	Mean Effort	Comparison against HB / TB	Comparison against IB	Comparison against the Pareto optimal effort
HBP	52.9 (7.9)#	t=-3.52 p=0.001	t=0.10 p=0.924	t=-3.29 p=0.001
TBP	49.4 (6.7)	t=-4.15 p=0.000	t=-1.66 p=0.100	t=-6.38 p=0.000

#Numbers in parentheses are the standard deviations.

Figure 6 Percentages of Sales in Certain Ranges

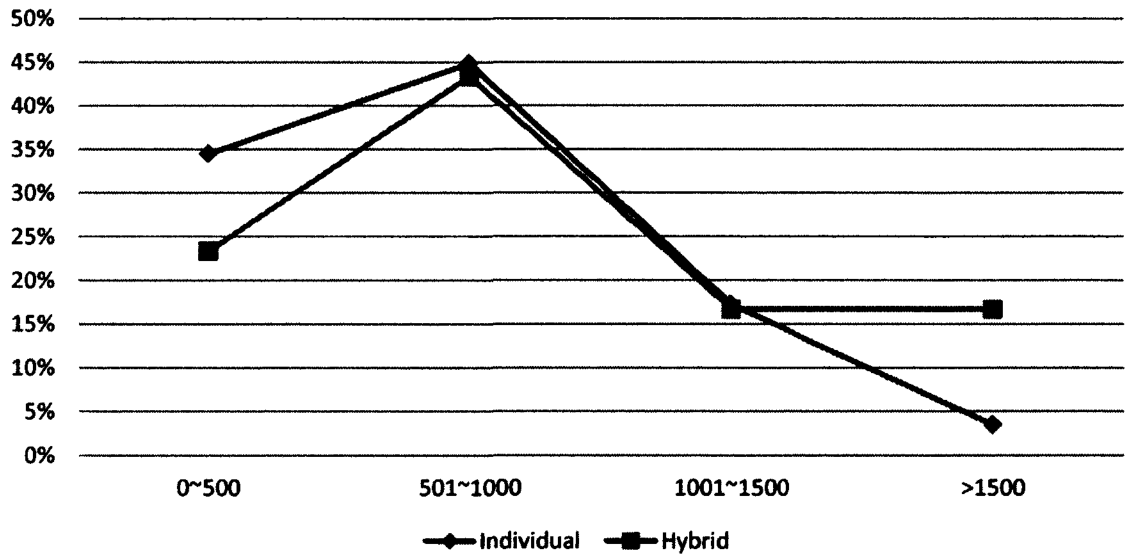

Table 8 OLS Regression of Sales on Incentive and Controlling Factors

	Coefficient	S.E.	*t*-stat	*p*-value
Constant (Base=Individual)	665.9	146.5	4.54	.000
Hybrid	323.2	137.5	2.35	.022
Female	126.2	136.2	0.93	.358
Experience (in months)	-.865	1.9	-.46	.648

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Appendix 1: Experimental Instructions for Hybrid Incentive in Social Condition B

Introduction

This is an experiment in decision making. The instructions are simple, and if you follow them carefully and make good decisions, you could earn a considerable amount of money, which will be paid to you in cash immediately and privately after the experiment. What you earn today partly depends on your decisions, partly on the decisions of others, and partly on chance. It is important that you do not look at the decisions of others or engage in any activities unrelated to the experiment. You will be warned if you violate this rule the first time. If you violate this rule twice, we will cancel the experiment immediately and your earnings will be $0.

1. Decision Steps

At the start of the experiment, each of the participants will be assigned to a group of 4 and then the computer will pair every participant with another member from your group. Your task in every round is to select a Decision Number, which ranges from 0 to 100. This is given in the first column of Sheet 1. Associated with each decision number is a Decision Cost, which is listed on the same row in the second column.

The computer will generate your Random Number after you have selected your Decision Number. The Random Number ranges from -15 to 15. Each number in this range has an equal chance of being drawn.

The computer will then compute your Final Number, which is calculated as follows:

Your Final Number = Your Decision Number + Your Random Number

If you choose a higher Decision Number, your Final Number will be higher. However, choosing a higher Decision Number also means that you will have to pay a higher Decision Cost which will be subtracted from your Point Earnings as will be further described below. We will ask you to enter your Decision Number into a computer program.

2. Determining Your Point Earnings and Cash Earnings

Your Point Earnings in each round will be:

Your Point Earnings = [0.5*Your Final Number + 0.5*Average Team Final Number]*0.5 –Your Decision Cost

The Average Team Final Number = (Your Final Number + Your Partner's Final Number)/2

That is, your earnings will be the sum of half your Final Number and half of the average of the Team Final Number multiplied by 0.5, minus your own Decision Cost.

You will complete a total of 18 rounds in this experiment. You will be matched with the same partner for six rounds and then re-matched with a new partner for six rounds until you have been matched with all the other three members within the same group. In each round, you choose a Decision Number again (though of course you may pick the same one) and the computer will generate the Random Number, calculate the Final Number, and display your Point Earnings. Also, note that the computer will generate a Random Number separately in every round and that the values of Random Numbers that have been drawn do not affect the values of future numbers that will be drawn.

Your **Total Point Earnings** in this experiment will be the sum of your Point Earnings across 18 rounds. Your **Cash Earnings** will be your **Total Point Earnings multiplied by 0.05**.

SHOULD MANAGERS USE TEAM-BASED CONTESTS?
AN EXPERIMENTAL STUDY

1. Introduction

Contests are among the most widely used forms of incentive contracts in practice. To better understand how contests can be designed to motivate employees, the extant literature has focused on three major questions: 1) When employees compete as individuals, what are the optimal number of winners and prize values in a contest (Kalra and Shi 2001; Lim, Ahearne and Ham 2009; Chen, Ham and Lim 2011)? 2) When employees work together in teams, how do team-based contests perform relative to other types of team-based incentive contracts (Nalbantian and Schotter 1997; Erev, Bornstein and Galili 1993)? 3) How does effort in a team-based contest depend on team-based characteristics and the prize structure, such as the roles team members play, whether the team members split the winning prize equally (Amaldoss et. al 2000; Amaldoss and Staelin 2010) and the degree to which team members communicate (Sutter and Strassmair 2009)? Interestingly, no study to date has examined the following question: When designing contests, should managers organize employees to compete as individuals or have them compete with each other in teams? One major reason why this gap in the literature exists is that conventional economic wisdom predicts that employees who are offered team-based incentive contracts will "fail to internalize the benefits that accrue to other members in the group when making effort decisions" (Prendergast 1999). That is, economic models predict that free riding will occur and, consequently, effort in team-based (TB) contests will be lower than effort in individual-based (IB) contests.

However, the free-riding prediction is based on an assumption that has been challenged by recent work in behavioral economics (e.g., Fehr and Schmidt 1999; Fehr and Fischbacher 2002; Amaldoss and Jain 2008; Ho and Su 2009). This literature refutes the standard assumption that people are purely self-interested and solely concerned with maximizing their own pecuniary payoffs by showing that social preferences (e.g., altruism, inequality aversion, social comparisons and peer-induced fairness) can affect how people make decisions. Furthermore, it has been found that the strength of an individual's social preferences can vary depending on factors such as familiarity and whether outcomes are made public (e.g., Lim 2010).

In this paper, I posit that guilt aversion, which is defined as the propensity to make decisions to avoid feeling guilty (Dana, Cain and Dawes 2006; Charness and Dufwenberg 2006), is a type of social preference that may influence contestants' effort decisions in TB contests. Guilt is an emotion that is aroused when one does not live up to the expectations of others, especially when one's actions result in lesser payoffs for a relationship partner (Baumeister, Stillwell and Heatherton 1994). I apply the concept of guilt aversion to TB contests by examining whether contestants' aversion to feeling responsible for their team's loss will influence them to exert more effort than that which would be predicted by standard economic models. Further, I investigate whether this psychological driver of behavior is strong enough to outweigh the economic incentive to free ride. If this is the case, then effort in TB contests should be higher than effort in IB contests because there is little scope for guilt aversion in the latter.

Specifically, I develop a behavioral economics model that accounts for the possibility that employees, when organized to compete in a TB contest, will exhibit guilt aversion with respect to being responsible for the team's loss. I then compare effort in TB contests to that in IB contests and demonstrate that if guilt aversion is sufficiently strong, TB contests yield higher effort than IB contests. Next, I conduct a laboratory experiment to compare TB and IB contests under two different social settings, which differ with respect to the degree to which participants are likely to feel guilt aversion. In the first social setting, participants were randomly and anonymously assigned to teams, making them as similar to economic agents as possible. Interestingly, the experimental results show that even in this conservative environment, effort in TB contests is not lower than effort in IB contests. In the second social setting, participants socialized prior to making effort decisions, so that those in the TB contest condition are more likely to act in favor of social preferences due to feelings of guilt aversion. The results from this social setting support the analytical model and show that effort in TB contests can be higher than effort in IB contests.

I also compare TB and IB contests by means of a field experiment for two important reasons. First, I expected guilt aversion to have an even stronger effect on effort decisions in the field experiment because the contestants were more familiar with one another than the participants in the laboratory experiment and therefore, more likely to be influenced by social preferences. Second, the laboratory experiment was designed to manipulate the degree of guilt aversion, holding all other (potentially competing) social preferences constant. In contrast, the field experiment provides a social setting that allows us to investigate how TB and IB contests compare in an environment where many social preferences are potentially at play. One particular psychological factor that may favor IB contests in the field experiment that I did not manipulate in the laboratory experiment, for instance, is social comparison effects (i.e., one's feelings of triumph or defeat in the presence of others). Nonetheless, when I assigned the field experiment contestants into either a TB contest or an IB contest and tracked their sales during a fundraising event for a university, the results showed that TB contests yield higher sales.

To the best of our knowledge, there is no work that has directly examined effort across the TB and IB contests. Amaldoss et al. (2000) and Amaldoss and Staelin (2010) examined TB contests in a context where companies form strategic alliances to compete in patent races. These papers show that firms' investment (effort) levels depend on whether a prize is equally or proportionally split between team members and whether the member companies that form a team perform the same or different functions in determining team output. Nalbantian and Schotter (1997) show using laboratory experiments that TB contests can yield higher effort compared to other types of team-based contracts. Erev, Bornstein and Galili (1993) conducted a field experiment that compares TB contests with team revenue-sharing contracts and individual piece-rate contracts (i.e., commission contract) in a social environment where participants who do not know one another were randomly matched into teams. They show that team contests induce output that is identical to output in individual piece-rate contracts and higher than output in revenue-sharing contracts. However, their paper did not examine IB contests. Sutter and Strassmair (2009) conducted laboratory experiments that examined different forms of communication in TB contests (e.g., within-team, across teams, and both) and found that allowing within-team communication during a decision task increases effort. Finally, as mentioned earlier, there is a stream of research that examines how to design optimal contests when contestants compete as individuals (e.g., Kalra and Shi 2001; Lim, Ahearne and Ham 2009; Chen, Ham and Lim 2011), but these papers did not study TB contests.

This paper extends the above literature by asking: If managers have a choice between organizing employees to compete in teams or as individuals, should they ever consider favoring the TB contest? My approach differs from the previous work on TB contests by modeling a psychological driver of behavior (i.e., guilt aversion) that can explain why TB contests may induce higher effort than predicted by standard economic models, and also experimentally examining how effort in TB contests may vary in different social settings. This study also differs from Sutter and Strassmair (2009) in that I do not study the effects of communication on effort – in the laboratory experiments, participants do not communicate in any of the experimental conditions.

The remainder of this article is organized as follows. In the next section, I develop a behavioral economics model that incorporates guilt aversion using a social preference parameter and delineates the conditions where effort in TB contests is higher than effort in IB contests. Then, I test the predictions of the model using laboratory (Section 3) and field (Section 4) experiments. Section 5 concludes this study with a discussion of limitations and directions for future research.

2. Theory

Consider a contest that consists of N=4 contestants.[3] The contestants are assumed to be risk neutral and have identical utility functions that are separable with respect to contest outcomes and costs of effort exerted. The output metric of contestant i is $y_i = e_i + \varepsilon_i$, where e_i is contestant i's non-negative effort level and ε_i is uniformly distributed

[3] In this paper, we restrict our attention to the case of N=4 because solving for effort in team-based contests involves characterizing the convolution of random variables, which is analytically complex. The main focus of this paper is to compare TB and IB contests experimentally rather than analytically for a general N and different team sizes.

over the interval $[-q, q]$ and independent across contestants. The stochastic term, ε_i, captures the uncertainty faced by contestant *i*, thereby reflecting the part of his output that is influenced by environmental shocks.

Contestants can be organized to compete in teams or as individuals. When the contest takes the form of a TB contest, the four contestants are divided into two teams, with two contestants in each team. The output metric for team t is $Y_t = \sum_{p=1}^{2} e_{tp} + \sum_{p=1}^{2} \varepsilon_{tp} = E_t + \eta_t$, where $E_t = \sum_{p=1}^{2} e_{tp}$, $\eta_t = \sum_{p=1}^{2} \varepsilon_{tp}$, and we use subscript $t = 1,2$ to index teams and subscript $p = 1,2$ to index contestants within teams. The team with the higher team output (Y_t) wins the contest and receives $2w_H$ as the winning prize. This prize is equally split between the two contestants so that each contestant in the winning team gets w_H. The contestants in the losing team receive w_L each, which is greater than or equal to zero but less than w_H. When the contest takes the form of an IB contest, the four contestants are ranked based on their individual output. The two contestants with the highest output receive w_H each, while the remaining contestants receive w_L each.[4] Note that with the abovementioned contest structure, the number of prizewinners (two out of four) and the total payout ($2w_H$+$2w_L$) are identical across the TB and IB contests.

Effort in Team-based Contests

In TB contests, contestants maximize their expected utility by choosing an effort level that takes into consideration the tradeoff between the utility of winning the contest and the cost of effort. Denoting the probability that a contestant receives the winning

[4] We consider an IB contest with two winners who receive w_H each, instead of a contest where only one winner receives $2w_H$, because we want to control for the number of winners and the value of the winning prize across the TB and IB contests. We also conduct a laboratory experiment that compares effort across these different IB contests and show that there is no difference in effort. The results are reported in footnote 7. Furthermore, Lim et al (2009) examine contests with 8 contestants and find that contests with more than one prizewinner elicit higher effort compared to a winner-take-all contest.

prize as $Prob(Win)_{TB}$ and the utility that a contestant gains from winning and losing the contest as $U(Win)_{TB}$ and $U(Lose)_{TB}$, respectively, the expected utility of contestant i is given by

$$EU_{iTB} = \text{Prob}(Win)_{TB} \times U(Win)_{TB} + [1 - \text{Prob}(Win)_{TB}] \times U(Lose)_{TB} - c(e_i), \quad (1)$$

where $c(e_i)$ is the cost of effort. Furthermore, assuming $c(e_i) = ke_i^2$, the symmetric pure-strategy Nash equilibrium for effort, e_{TB}^*, is the solution to the following first order condition:

$$\frac{\partial \text{Prob}(Win)_{TB}}{\partial e_i}(e_i = e_{TB}^*) \times [U(Win)_{TB} - U(Lose)_{TB}] + \frac{\partial U(Win)_{TB}}{\partial e_i} \times \text{Prob}(Win)_{TB} + \frac{\partial U(Lose)_{TB}}{\partial e_i} \times [1 - \text{Prob}(Win)_{TB}] - 2ke_{TB}^* = 0, \quad (2)$$

where the term $\frac{\partial \text{Prob}(Win)}{\partial e_i}$ is the marginal probability of winning the team contest and $\frac{\partial U(Win)_{TB}}{\partial e_i}$ and $\frac{\partial U(Lose)_{TB}}{\partial e_i}$ represent the marginal change in utility from winning and losing due to an increase in effort, respectively.

In solving for the Nash equilibrium effort, the extant models of TB contests (e.g., Nalbantian and Schotter 1997; Sutter and Strassmair 2009) has assumed that the stochastic term influencing team output enters at the team-level. However, because my objective is to compare effort across TB and IB contests, I assume that the stochastic term enters at the individual-level. With this approach, solving for equilibrium effort in TB contests involves characterizing the convolution of the distribution of individual-level noise terms, which makes the derivation of the marginal probability of winning analytically more complex. I show in Appendix 1 that when N=4, the marginal probability of winning a TB contest reduces to $\frac{1}{3q}$.

I now turn to the specification of $U(Win)_{TB}$ and $U(Lose)_{TB}$. Applying findings from the social psychology and behavioral economics literatures on guilt aversion to the model (cf. Baumeister, Stillwell and Heatherton 1994; Charness and Dufwenberg 2006), I build in the assumption that contestants organized in teams may feel guilty if they are perceived (by themselves or their teammates) to be the member who is responsible for the team's loss. This type of guilt aversion, if present, is expected to lead a contestant to exert more effort in TB contests. To capture this psychological driver of behavior in the simplest manner possible, I let the utility functions for contestant *i* from winning and losing the contest be

$$U(Win)_{TB} = w_H, \tag{3}$$

and

$$U(Lose)_{TB} = w_L - \theta * \text{Prob}(y_i < y_j) * (w_H - w_L), \tag{4}$$

where $\theta > 0$. In this utility specification, the parameter θ captures the degree of disutility contestant *i* feels from being the low performer in a losing team and the term $Prob(y_i < y_j)$ represents the probability that this guilt aversion occurs; that is, when contestant *i*'s output is lower than his teammate *j*'s output. I also assume that the disutility suffered by the contestant increases with $(w_H - w_L)$, which is the spread between the winning prize and the amount each loser receives. Importantly, the strength of the guilt aversion parameter, θ, can depend on the social setting within which a TB contest is run. For instance, how socially connected and familiar team members are with one another is likely to impact θ – I test this hypothesis experimentally in the subsequent sections of the paper. Note that if contestant *i* has no feelings of guilt aversion, so that $\theta=0$, then the model reverts to the standard economic model where $U(Lose)_{TB} = w_L$.

Given the above utility specification, I proceed to derive the symmetric pure-strategy Nash Equilibrium effort for TB contests. To begin, note that the second term in Equation 2, $\frac{\partial U(Win)_{TB}}{\partial e_i}$, is equal to zero since $U(Win)_{TB}$ is not a function of e_i. Next, note that $\frac{\partial U(Lose)_{TB}}{\partial e_i}$ is equal to $-\theta * \frac{\partial \text{Prob}(y_i<y_j)}{\partial e_i} * (w_H - w_L)$. This term reduces to $\frac{\theta}{2q}(w_H - w_L)$ because we know from the previous literature on IB contests that $\frac{\partial \text{Prob}(y_i<y_j)}{\partial e_i} = -\frac{1}{2q}$ (Kalra and Shi 2001; Chen, Ham and Lim 2011). Furthermore, both $Prob(y_i < y_j)$ and $Prob(Win)_{TB}$ are equal to $\frac{1}{2}$ when they are evaluated at the point of symmetric pure-strategy equilibrium effort. Hence, Equation 2 becomes

$$\frac{1}{3q} \times \left[(w_H - w_L) + \frac{\theta}{2}(w_H - w_L)\right] + \frac{\theta}{2q}(w_H - w_L) \times \frac{1}{2} - 2ke_{TB}^* = 0, \qquad (5)$$

and we can obtain

$$e_{TB}^* = \frac{1}{2kq}[(w_H - w_L)(\frac{1}{3} + \frac{5\theta}{12})]. \qquad (6)$$

Effort in Individual-based Contests

In IB contests, the expected utility of contestants and the first order condition with respect to effort are similar to Equations 1 and 2 for TB contests. To allow for a balanced comparison of effort in the TB and IB contests, I also allow for non-pecuniary components of utility in IB contests. Lim (2010) shows that contestants in an IB contest may exhibit social loss aversion. That is, contestants suffer disutility if they are perceived to be a "loser" when compared to other contestants. To capture this effect in the IB contest, I assume that $U(Lose)_{IB} = w_L - \beta * \left(\frac{w_H+w_L}{2} - w_L\right)$. That is, when contestants lose, they suffer disutility that increases with the difference between the average prize value and the losing prize w_L. The strength of this aversion is captured by the parameter $\beta > 0$.[5] Note that unlike the case of TB contests, $U(Lose)_{IB}$ is not a function of effort. As in Lim (2010), I assume that $U(win)_{IB} = w_H$.[6] Given the above utility specifications and assumptions, the equilibrium effort in IB contests is the solution to the following first order condition:

$$\frac{\partial \text{Prob}(Win)_{IB}}{\partial e_i}(e_i = e_{IB}^*) \times [U(win)_{IB} - U(lose)_{IB}] - 2ke_{IB}^* = 0. \quad (7)$$

The marginal probability of winning in an individual-based contest, $\frac{\partial \text{Prob}(Win)_{IB}}{\partial e_i}$, when evaluated at the symmetric pure-strategy equilibrium effort, is $\frac{1}{2q}$ when $\varepsilon_i \sim U[-q, q]$. Hence, the symmetric equilibrium effort in IB contests is given by

$$e_{IB}^* = \frac{1}{4kq}[(w_H - w_L)(1 + \frac{\beta}{2})]. \quad (8)$$

Comparing the two expressions of effort in the TB and IB contests (Equations 6 and 8, respectively) yields the following proposition:

Proposition 1. *When $\theta > \frac{2}{5} + \frac{3}{5}\beta$, equilibrium effort in team-based (TB) contests will be higher than that in individual-based (IB) contests. Otherwise, effort in IB contests will be higher.*

Proposition 1 formally shows that if a contestant's degree of guilt aversion, θ, is sufficiently strong in TB contests, then equilibrium effort in TB contests will be higher than that in IB contests. Note that because the total payout is identical across the two types of contests, the contest that yields higher effort translates into greater profits.

[5] Note that the prize structure in IB contests differs from Lim (2010) in that exactly half of the contestants win the contest, while the other half lose. Lim (2010) studies contests where either less than half of the contestants or more than half of them win. Given the prize structure of IB contests in this paper, a natural reference point for contestants to make social comparisons would be the average prize. Note that the major results in our paper would not change if we assume alternative reference points.

[6] Lim (2010) also shows that there is no "joy of winning" effect when contestants are homogeneous.

Finally, if contestants care solely about the pecuniary rewards from winning and losing the contest (i.e., $\theta=\beta=0$), effort in IB contests is higher. I proceed to test the predictions of the behavioral economics model using a laboratory experiment.

3. Laboratory Experiment

Experimental Design and Procedure

The experiment employs a 2X2 design by comparing participants' effort decisions in TB and IB contests across two social settings. The rationale behind varying the social environment in which participants operate (even though conventional economic wisdom predicts that doing so will not affect effort) is that I expect the degree of guilt aversion to be stronger in an environment where team members feel more socially connected. In turn, I predict that higher levels of guilt aversion will lead to higher levels of effort in TB contests.

The participants of this study were undergraduate business students at a large public research university in the United States. They received course credit for showing up on time to the experiment and earned cash based on their performance. Each of the four treatments consisted of 3 sessions, with each session involving either twelve or sixteen participants (depending on the number of students who signed up for that session). There were a total of fifteen decision rounds in each session and I implemented the experiment using z-Tree software (Fischbacher 2007). The parameter values used to design the experiment were $w_H=6.5$, $w_L=1$, $q=60$, and $k=0.0008$. Given these experimental parameters, the benchmark equilibrium effort predictions from the model, assuming that $\theta=\beta=0$, are 19.1 for the TB contest condition and 28.6 for the IB contest condition. I selected these parameter values to ensure that: 1) there is sufficient spread in the point predictions of effort between the TB and IB contests, 2) the effort predictions are not focal numbers, and 3) the participation constraints given the benchmark equilibrium effort levels for participants are satisfied.

In the first social environment, which I call "social condition A," participants entered the lab, were seated apart from one another at separate computer terminals, and were delivered a set of experimental instructions for the decision tasks they were about to embark on. In the second social environment, which I call "social condition B," participants were randomly seated in groups of four upon entering the laboratory and, before I delivered the experimental instructions, were asked to introduce themselves and to discuss three common interests that the group shared. After this introduction activity, I asked the participants to complete a Sudoku puzzle as a group. I then had group members sit apart from one another at computer terminals and handed out the experimental instructions.

Across all four treatments, participants were told that they would be competing in a contest and that their decision task for each decision round (of which there were fifteen) was to select a *Decision Number* (e_i) between 0 and 75. They were informed that every Decision Number comes with a corresponding *Decision Cost* ($0.0008e_i^2$). The full set of Decision Costs for each Decision Number was provided to each participant in the format of a "Decision Cost Table." During each decision round, participants entered their Decision Numbers into the computer program and, upon doing so, the computer generated a *Random Number* (ε_i). This random number ranged between −60 and 60 (q), and each Random Number in this range had an equal chance of being drawn. The computer added the Random Number to the Decision Number that the participant chose in order to arrive at a participant's *Final Number* (y_i) for a given decision round.

In the TB contest condition, participants were told that they will be paired with another participant to form a team and compete against another two-person team. I informed participants that prizes would be awarded based on team performance. That is, their *Team's Final Number* (Y_t), which amounts to the sum of their Final Number and their teammate's Final Number, would be compared with that of the team they were competing against and, depending on whether their Team's Final Number exceeded or fell short of the Competing Team's Final Number, they would each receive 6.5 points (w_H) or 1 point (w_L). In either case, win or lose, participants were told that their own Decision Cost (in points) would be subtracted from the amount awarded.

In social condition A of the TB contest condition, participants were randomly and anonymously matched with another participant to form a team and competed with another (randomly and anonymously matched) team for the first five decision rounds. Then, before the start of rounds six and eleven they were re-matched in the same manner and competed until the fifteen decision rounds were complete. In contrast, in social condition B of the TB contest condition, participants were randomly and anonymously matched with one of the three members of the group they had completed the introduction activity with to form a team and competed with another (randomly and anonymously matched) team from another group for the first five decision rounds. Again, before the start of rounds six and eleven, the same matching procedure occurred. Note that in social condition B, each participant knew that his teammate was one of the three participants in his group from the introduction activity; however, he did not know the exact identity of his team member. Further, participants did not know the identities of the contestants in the competing team; they only knew that they were not a part of their group from the introduction activity. The full instructions that were presented to participants in the TB contest condition under social condition B can be found in Appendix 2.

In the IB contest condition, participants were told that they would compete against three other participants and that prizes would be awarded based on individual performance. That is, their own Final Number (y_i) would be compared with those of the other participants they were competing against and, depending on whether their Final Number was in the top-half or the bottom-half of the complete set of four Final Numbers, they would receive 6.5 points (w_H) or 1 point (w_L). In either case, win or lose, participants were told that their own Decision Costs (in points) would be subtracted from the amount awarded.

In social condition A of the IB contest condition, participants were randomly and anonymously matched with three other participants whom they competed against for the first five decision rounds. Then, they were re-matched with another set of participants in the same manner before rounds six and eleven, and competed against these participants subsequently. Similarly, in social condition B of the IB contest condition, participants were also randomly and anonymously matched with three other participants whom they competed against for the first five decision rounds. However, the sample that the three competitors were drawn from excluded the participants who were group members of the participant in the introduction activity. In other words, participants knew that none of their competitors would be a participant whom they socialized with prior to the decision tasks. After the first set of five decision rounds, they were re-matched in a similar manner until the fifteen rounds were complete.

Note that in social condition B, participants across the two contest structures (TB and IB) competed only with participants from other groups. Moreover, in the IB contest condition, participants were equally unfamiliar with their competitors across the two social conditions. Therefore, the degree to which social comparisons were made in the IB contest condition should not have differed, which leads to the expectation that effort should not differ across these conditions either. However, I do predict that guilt aversion will be stronger and, hence, that effort will be higher in social condition B as compared to social condition A. Note also that the experiment differs from Sutter and Strassmair (2009) in that neither of the social conditions I employ allows communication to occur between team members or across competing teams during the decision rounds.

Across the four treatments in the experiment, the range of Decision Numbers and the Decision Costs faced by contestants, the distribution of Random Numbers, and how payoffs would be determined were common knowledge to all participants. In TB contests, participants were told that they would know only the Final Number of the other team member (y_j) after every decision round. The actual Decision Number chosen, the Decision Cost incurred, the Random Number drawn, and the payoff in each round were private knowledge to each participant. Before the start of the fifteen decision rounds, I conducted three practice rounds that carried no monetary consequences to familiarize participants with the experimental procedure. At the end of each experimental session, participants were paid privately in cash and escorted out of the lab. Each participant earned $9 on average and the range was from $4 to $15.

Experimental Results

To begin, I label the TB and IB contest conditions in each of the two social environments (A and B) as TB-A, TB-B, IB-A, and IB-B, respectively. I recruited a total of 180 participants across these four treatments, with 44 participants in each of the TB-A, TB-B, and IB-A treatments and 48 participants in the IB-B treatment.

[Insert Table 9 and Figure 7 about here]

Table 9 displays the summary statistics of effort in all four treatments. In social condition A, the average effort expended was 33.8 and 35.3 in the TB and IB contest conditions, respectively. In social condition B, the average effort expended in the TB and IB contests was 43.5 and 37.3, respectively. The average effort level in every decision round for each of the four treatments is plotted in Figure 7. I now proceed to discuss the formal statistical tests I conducted to examine whether effort levels are significantly different across treatments. Because participants made multiple decisions, I clustered the standard errors at the subject-level in all of the statistical tests I conducted to account for potential within-subject correlation.[7] First, I compare participants' average effort levels against the benchmark model, which assumes that $\theta=\beta=0$. Again, if the benchmark model explains participants' behavior, it means that participants make effort decisions in a manner that is based solely on pecuniary considerations. Column 5 of Table 9 shows that effort levels in all four treatments are significantly higher than those predicted by the

[7] We check for learning effects in the effort decisions by comparing the average effort in decision rounds 1 to 8 with the average effort in rounds 9 to15 for each treatment. In all four treatments, there were no differences in effort decisions across the two "halves" of the experiment at the 10% level. In the TB contest condition, because participants were matched with a team member for 5 decisions rounds, we also check for potential "latter-round defections" by comparing effort in the first 3 rounds against that in the last 2 rounds for each team. We found no differences in average effort in the first 3 rounds and the last 2 rounds in both social conditions A (t=0.90, p=0.394) and B (t=0.65, p=0.516).

standard economic model. This result suggests that contestants could also be motivated by social preferences when making effort decisions.

Next, I compare effort levels across the different social conditions when the type of contest is held constant. The OLS regression of effort in TB contests in Table 10 (Model 1) indicates that participants expend more effort when they are paired with a teammate whom they had socialized with prior to making effort decisions (t=3.44, p=0.001).[8] This result is consistent with the hypothesis that θ will be higher if participants feel more socially connected to their teammates. In the IB contest conditions, however (Model 2 of Table 10), there is no difference in effort decisions across the two social conditions (t=0.74, p=0.463). As mentioned earlier, this result is unsurprising since the two social conditions in the experiment were manipulated to affect the degree to which participants are likely to feel connected to their teammate in the TB contest condition and not the degree to which social comparisons are made in the IB contest condition.

[Insert Table 10 about here]

I now turn to a comparison between the TB and IB contest conditions. Models 3 and 4 of Table 10 display the results of the OLS regressions of effort on the Type of Contest in social conditions A and B, respectively. To begin, note that in social condition A (i.e., when participants did not socialize with one another), effort levels in the TB and IB contests are not significantly different (t= −0.52, p=0.601).[9] More importantly, in social condition B (i.e., when participants were organized into groups and did socialize

[8] For the results reported in this section, we also performed the corresponding non-parametric tests and confirmed that the results of the parametric tests hold.

[9] We also conducted an experiment to examine effort in IB contests with only one winner, where the winning prize is $2w_H$ (13 points) and $w_L = 1$, under social condition A. The average effort in this contest is 38.2, which is not significantly different from the average effort in IB contests with two winners (t=0.90, p=0.370). There is also no significant difference with effort in the TB-A condition (t=1.31, p=0.193).

with one another), effort in TB contests is significantly higher than that in IB contests (t=2.38, p=0.019). These results are consistent with the hypothesis that guilt aversion can be stronger when contestants are more familiar with their teammates, and that TB contests can yield higher effort than IB contests if the level of guilt aversion in the former is sufficiently strong.

To examine whether the participants' effort decisions are consistent with the postulate that participants with guilt aversion feel responsible for team losses in TB contests, I regressed changes in effort for each participant on the outcomes of the previous decision round – specifically, on whether a participant's team had lost the contest (*Lose=1* if his team lost the contest in the previous round, 0 otherwise) and whether his output was lower than his teammate's (*Lower*=1 if his output was lower than his teammate's in the previous round, 0 otherwise). The results are reported in Table 11 and indicate the following: First, if a participant's team lost in the previous round and his output was lower than his teammate's output, then he increases his effort in the next round (F=16.76, p=0.000). While not a direct test of the theory,[10] this result is consistent with the behavioral economics model, which posits that contestants feel guilty when their output is lower than their teammate's and their team loses. Second, if a participant wins a contest and his output is higher than that of his teammate's, he reduces his effort in the subsequent round (t=−4.66, p=0.000). This finding suggests that an alternative explanation for why effort could be higher in the TB contest – such as one that assumes utility gains from being the contestant who contributes more to the team's victory, is less plausible.

[10] Specifically, this analysis only speaks to how participants adjust their effort depending on the outcomes of the previous round, but does not explain how participants make decisions about *effort levels* in TB contests.

[Insert Table 11 about here]

Finally, I estimate the values of the parameters in the behavioral economics model for TB and IB contests implied by the experimental dataset. Specifically, I assume that $e_{irc} \sim N(e_c^*, \sigma_c^2)$, where i represents contestant i, r indicates the decision round, c indicates which treatment (TB-A, IB-A, TB-B, and IB-B) the contestant competes in, e_c^* is the equilibrium effort in treatment c, and σ_c^2 is the variance of effort in treatment c. I estimate the behavioral parameters θ and β separately for social conditions A and B using Maximum Likelihood, with the standard errors clustered at the subject-level.[11] The results are shown in Table 12.

[Insert Table 12 about here]

All the four behavioral parameters, $\theta_A, \theta_B, \beta_A$ and β_B, are positive and statistically significant at the 5% level. Note that in social condition B, $\theta_B = 1.02 > 0.4 + 0.6\,\beta_B = 0.76$ (where $\beta_B = 0.603$), so that the condition for effort to be higher in the TB contest is satisfied. The estimate also suggests that in this social condition, the contestant's disutility from feeling guilty is worth about 50 cents (1.02 multiplied by $Prob(y_i < y_j)$, which equals 0.5 in equilibrium) for every dollar difference between the winning and losing prizes. The estimates of θ_A and θ_B are also significantly different ($\chi^2(1)=4.72$, $p=0.030$), which confirms that the degree of guilt aversion is higher in social condition B.

In summary, the results of the laboratory experiment are consistent with the predictions of the model: 1) Effort in TB contests increases with familiarity between

[11] Specifically, we sum all over i, r and c to obtain the following joint log-likelihood: $LL(\theta_A, \theta_B, \beta_A, \beta_B, \sigma_c) = \sum_i \sum_r \sum_c log \frac{1}{\sqrt{2\pi\sigma_c^2}} exp^{-(e_{irc}-e_c^*)^2/2\sigma_c^2}$, where θ_A and θ_B are the parameters for social condition A and social condition B for TB contests and β_A and β_B are for social condition A and social condition B for IB contests, respectively.

members of a team, 2) TB contests can yield higher effort than IB contests, and 3) contestants increase effort when their team loses and their output is lower than their teammate's in the previous decision round.

4. Field Experiment

Next, I conducted a field experiment (FE) to compare TB and IB contests. The FE serves two main objectives. First, I tested the predictions of the behavioral economics model in the lab by manipulating the degree to which participants were likely to feel guilty if they let their teammates down by altering whether or not participants socialized with their teammates. However, I did not manipulate the degree of social comparison effects among participants in the IB contests. For the findings to be more useful to managers, comparing TB and IB contests in a social environment where both guilt aversion and social comparison effects are likely to be relatively strong in the respective contests is necessary. The FE provides such as test because the social environment of this study is such that all contestants know each other relatively well. Second, the FE allows us to compare TB and IB contests in the context of a real-effort task, where the assumptions of perfect homogeneity in abilities or market characteristics are relaxed – doing so provides greater ecological validity to the findings of the laboratory experiment.

Experimental Design

There were a total of 72 participants in the FE and all of them were students enrolled in an undergraduate sales program at a public research university in the United States. The participants had 3 years of sales experience, on average, and approximately 45% of the participants were female. At the start of the FE, the 72 participants had known each other for about six months through common classes and social activities in the sales program. All participants had received training in sales prospecting, rapport building, sales presentations, and order processing. In the FE, participants were asked to sell products associated with a golf tournament (e.g., hole sponsorship, golf balls, golf shirt sponsorship) to companies in order to raise money for the university. This selling task was a mandatory component of a required course for the students. It was not created for the purposes of the FE. All participants performed the same selling task and the nature of the selling task was such that there were no task complementarities to be reaped, even if participants were to compete in teams.

The structure of the TB and IB contests in the FE was identical to that in the laboratory experiment. At the start of the course (but before the FE was announced), the instructor, who is not a co-author on this research, divided the 72 participants into 36 two-person teams to create a "buddy system" for "mutual support" during the course. When I designed the FE, I took these two-person team assignments as given. From these 36 pairs of students, I randomly selected 20 (two-person) teams and assigned them to TB contests. Within the TB contests, these 20 teams were further randomly assigned to 10 different contests. Hence, as was the case in the laboratory experiment, there were two competing teams of two contestants each in every TB contest. Participants in the TB treatment were told that the team with the higher total dollar sales (i.e., the sum of each team member's sales) will receive $80, with the prize money split equally between the two team members. The losing team in each TB contest received nothing. The remaining 16 pairs of participants (out of the 36 pairs) were assigned to IB contests. I randomly assigned these 32 participants into 8 contests of 4 contestants each. Participants were told that in each contest, the four contestants would be ranked solely on their individual sales and that the two contestants with the highest individual sales would receive $40 each, while the remaining two contestants would receive nothing. The assignment in IB contests was such that no "buddies" from the same pair were assigned into the same IB contest. The total payout across the TB and IB contests was $1,440 and the duration of the contests was three weeks.

Note that the social environment in the FE was such that, in the TB contests, participants knew who their teammate was and knew who the contestants were in the team they were competing against. Participants in TB contests were allowed to communicate as much (or as little) as they wished with their teammate about issues such as selling strategies and what their current dollar sales were during the duration of the contest. Similarly, in the IB contests, all participants also knew who they were competing with. Participants in the IB contests were also allowed to communicate with their "buddy" (who did not compete with them) on any issues during the duration of the contest. Hence, across the TB and IB contests, the social connection and familiarity among both teammates and competitors were significantly stronger than it was in social condition B of the laboratory experiment.

Experimental Results

The summary results of the FE experiment are shown in Table 13. The average sales were $1,489 and $1,063 in the TB and IB contests, respectively. The Wilcoxon Rank Sum test (z=2.64, p=0.008) and the Kolmogorov-Smirnov test (p=0.010) indicate that sales were significantly higher in TB contests. Table 14 shows the results of an OLS regression of dollar sales on Type of Contest that controls for the effects of gender and prior sales experience (in months). The results support the prior findings that TB contests yield higher sales (t=2.42, p=0.018).

[Insert Tables 13 and 14 about here]

5. Discussion and Conclusion

In this paper, I examine whether TB contests can induce higher effort than IB contests under certain conditions. I began by developing a behavioral economics model that accounts for potential guilt aversion that contestants may have in TB contests with respect to not wanting to let the team down. I show theoretically that if guilt aversion is sufficiently strong, effort in TB contests will be higher relative to IB contests, which is contrary to conventional economic wisdom. I test this prediction for a four-person contest using a laboratory economics experiment. The results show that, consistent with the predictions of the model, effort in TB contests is higher than effort in IB contests when participants engage in socialization activities with their teammates. I test the theory further using a field experiment that compares TB and IB contests in a setting where contestants know one another relatively well and the results parallel those found in the lab.

The experimental results suggest not only that TB contests are effective incentive contracts that managers can use to motivate effort, but more importantly, that managers need to pay attention to the social environment that employees operate in when offering incentives. Specifically, TB contests are more likely to generate higher output than IB contests when the potential for guilt aversion in the former type of contest is strong. In addition, managers can also influence the factors that affect the strength of guilt aversion, for example, by pairing salespeople who know each other well as teammates, or by conducting social activities that increase team cohesion, so that team members have strong connections and empathy for one another.

I conclude with some caveats and opportunities for future research. First, I must emphasize that the results do not imply that TB contests will always perform at least as well as IB contests. The social environments in the laboratory and field experiments were such that adversarial or competitive relationships among team members were limited. If these relationships exist, then IB contests could be more effective.

Second, the utility specification that captures guilt aversion may not be the best one – there could be other functional forms that can predict behavior across a wider array of TB contests. Although I believe that aversion to feeling responsible for team losses is a primary psychological driver of behavior in TB contests and present empirical evidence that is consistent with this hypothesis, there may be other psychological factors that may also influence behavior. For example, within-group comparisons may exist among team members and some contestants may derive utility gains from being the team member that contributes the most to the team's victory. Naturally, the presence and strength of these factors will depend on the social environment and the nature of the relationships among team members. I encourage further research in this area.

Third, I have assumed that contestants are identical in sales ability or market endowments. If teammates are heterogeneous, the nature and degree of guilt aversion among the different "types" of contestants may be different. For example, a weaker contestant who is paired with a stronger team member may feel even more guilty if his team loses, because the stronger team member might have been a prizewinner if he had been matched with stronger contestant or if he had competed individually. On the other hand, implementing a TB contest in a social environment that has heterogeneous contestants may be more challenging because employees with higher abilities are likely to be reluctant to be matched with those with weaker abilities.

Finally, I studied very simple TB contests that consisted of two-member teams. Further, the prizes were equally split between members. If a team consists of many members, there may be greater incentive to free-ride; on the other hand, depending on the relationships among the team members, contestants may experience greater disutility if they are responsible for a decline in the payoffs of many team members. If the team prize can be divided unevenly among team members (e.g., proportional to output) in TB contests, effort will likely increase due to within-team competition (Rapoport and Amaldoss 1999); however, the degree of guilt aversion in contestants may decline correspondingly. It will be fruitful to compare TB and IB contests with more contestants and more complex prize structures.

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Table 9 Summary Results of the Laboratory Experiment

Treatment	(1) NE Prediction (θ=β=0)	(2) Average Effort	(3) Median	(4) Inter-quartile Range	(5) Test against the NE Prediction
TB-A	19.1	33.8 (14.4)#	35	30.5	t=6.77, p=0.000
IB-A	28.6	35.3 (12.7)	35	30.0	t=3.49, p=0.001
TB-B	19.1	43.5 (11.7)	43	21.5	t=13.63, p=0.000
IB-B	28.6	37.3 (13.0)	35	25.0	t=4.65, p=0.000

#: Numbers in the parentheses are standard deviations

Table 10 OLS Regressions of Effort on Social Settings and Types of Contest

	Coefficient	Robust S.E.	*t*-stat	*p*-value
Model 1: TB Contests				
(#obs.=1320, #clusters=88, R^2=0.066)				
Constant(Base=Social Condition A)	33.8	2.16	15.68	0.000
Social Condition B	9.6	2.80	3.44	0.001
Model 2: IB Contests				
(#obs.=1380, #clusters=92, R^2=0.003)				
Constant (Base=Social Condition A)	35.3	1.91	18.51	0.000
Social Condition B	2.0	2.67	0.74	0.463
Model 3: Social Condition A				
(#obs.=1320, #clusters=88, R^2=0.001)				
Constant (Base=IB contest)	35.3	1.91	18.51	0.000
TB contest	–1.5	2.88	–0.52	0.601
Model 4: Social Condition B				
(#obs.=1380, #clusters=92, R^2=0.034)				
Constant (Base=IB contest)	37.3	1.86	20.00	0.000
TB contest	6.2	2.58	2.38	0.019

Table 11 OLS Regressions of Effort Change on the Results of the Previous Round

	Coefficient	Robust S.E.	*t*-stat	*p*-value
Constant	–4.5	0.98	–4.66	0.000
(Base=Win the contest and Output is higher than teammate's)				
Lower	4.6	1.16	3.93	0.000
Lose	3.6	1.23	2.95	0.004

Note: #obs.=1056, #clusters=88, R^2=0.028

Table 12 Parameter Estimates of the Behavioral Models and Nested Models

Parameters	Estimates	Clustered Standard Errors	*t*-stat	*p*-value
θ_A	0.616	0.13	4.74	0.000
θ_B	1.020	0.13	7.85	0.000
β_A	0.466	0.09	5.18	0.000
β_B	0.603	0.07	8.61	0.000
σ_{TB-A}	20.203	2.07	9.76	0.000
σ_{TB-B}	15.768	1.21	13.03	0.000
σ_{IB-A}	20.778	1.89	10.99	0.000
σ_{IB-B}	16.941	1.10	15.40	0.000

Log-Likelihood (LL)

Full Model: −11675.0

Nested Models:

- $\theta_A = \theta_B = 0$: LL=−12217.6 (*Wald Stat*=83.25, *p*=0.000)
- $\theta_A = \theta_B$: LL=−11719.9 (*Wald Stat*= 4.72, *p*=0.030)
- $\beta_A = \beta_B = 0$: LL=−11790.6 (*Wald Stat*=91.12, *p*=0.000)
- $\beta_A = \beta_B$: LL=−11676.8 (*Wald Stat*=1.34, *p*=0.247)
- $\theta_A = \theta_B = \beta_A = \beta_B = 0$: −12333.2(*Wald Stat*=174.38, *p*=0.000)

+The Wald Statistic is used to test whether the restrictions in the nested models significantly reduces the fit. The likelihood ratio test is not appropriate in this context because the observations are not independent at the subject-level.

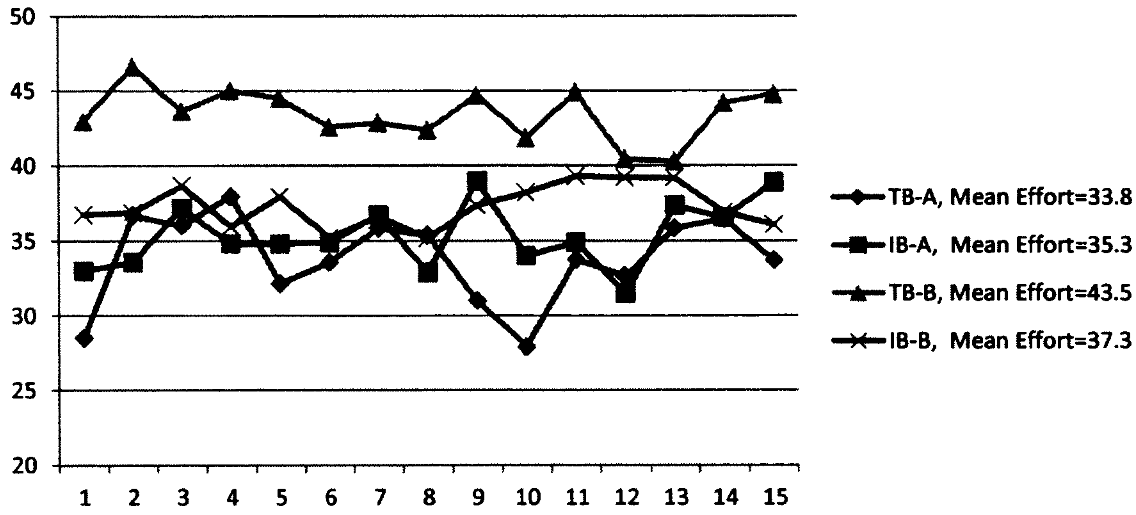
Table 13 Summary Results of the Field Experiment

Contest	Mean Sales ($)	Std. Dev.($)	Median ($)	Inter-quartile Range ($)
TB	1,489	135	1,405	690
IB	1,063	65	1,000	430

Table 14 OLS Regression of Sales on the Type of Contest and Controlling Factors

	Coefficient	S.E.	*t*-stat	*p*-value
Constant (Base=IB contest)	896.2	180.0	4.98	0.000
TB contest	396.5	163.9	2.42	0.018
Gender (Female=1)	118.8	167.0	0.71	0.479
Experience (Months)	3.6	3.0	1.22	0.228

Figure 7 Mean Effort Decisions across Decision Rounds



Appendix 2: Derivation of the Marginal Probability of Winning in Team-based Contests

In Appendix 1, I solve for the marginal probability of winning in team-based contests, where N=4 contestants are divided into 2 teams to compete, each with 2 members. The output of each team is $Y_t = \sum e_{tp} + \sum \varepsilon_{tp} = E_t + \eta_t$, where $t = 1,2$ represents the teams, $p = 1,2$ represents the contestants in each team, $E_t = \sum e_{tp}$ and $\eta_t = \sum \varepsilon_{tp}$.

The density function of η_t, the convolution of i.i.d uniformly distributed variables, is:

$$f^{\left(\frac{N}{2}\right)}(\eta) = \begin{cases} \frac{1}{\left(\frac{N}{2}-1\right)!(2q)^{\frac{N}{2}}} \sum_{i=0}^{\tilde{n}\left(\frac{N}{2},\eta\right)} (-1)^i \binom{\frac{N}{2}}{i} \left(\eta + \frac{N}{2}q - 2qi\right)^{\frac{N}{2}-1} & \text{for } -\frac{N}{2}q \leq \eta \leq \frac{N}{2}q \\ 0 & \text{otherwise} \end{cases},$$

(A1)

where $\tilde{n}\left(\frac{N}{2},\eta\right)$:=the largest integer that is no more than $\frac{\eta+\frac{N}{2}q}{2q}$ (Killmann and von Collani 2001).

When N=4, there are 2 members in each team, so the density function of η_t is

$$f^2(\eta) = \begin{cases} 0 & \text{for } \eta < -2q \\ \frac{\eta+2q}{(2q)^2} & \text{for } -2q \leq \eta < 0 \\ \frac{-\eta+2q}{(2q)^2} & \text{for } 0 \leq \eta \leq 2q \\ 0 & \text{for } \eta > 2q \end{cases}.$$

To begin, I consider the case when $E_1 - E_2 \geq 0$. Given any random realization of η_1, team 1 wins the contest only if $E_1 + \eta_1 > E_2 + \eta_2$, i.e., $\eta_2 < E_1 + \eta_1 - E_2$. I define the conditional probability that team 1 wins given the random realization of η_1 as

$$\text{Prob}(Team\ 1 wins\ |\eta_1) = \int_{-2q}^{E_1+\eta_1-E_2} f^2(\eta_2)\, d\eta_2. \quad \text{(A2)}$$

Furthermore, when $E_1 + \eta_1 - E_2 \geq 2q$, then the conditional probability of winning for team 1 will be 1. With the above setup, I solve for the probability of winning and the marginal probability of winning for each team in the contest.

Let's look at team 1 first. When $-2q \leq \eta_1 \leq -E_1 + E_2$, the density function for η_1 is $\frac{\eta_1+2q}{(2q)^2}$ and the conditional probability of winning is $\int_{-2q}^{E_1+\eta_1-E_2} \frac{\eta_2+2q}{(2q)^2} d\eta_2$; When $-E_1 + E_2 \leq \eta_1 < 0$, the density function for η_1 is $\frac{\eta_1+2q}{(2q)^2}$ and the conditional probability of winning is $\frac{1}{2} + \int_0^{E_1+\eta_1-E_2} \frac{-\eta_2+2q}{(2q)^2} d\eta_2$; When $0 \leq \eta_1 < -E_1 + E_2 + 2q$, the density function for η_1 is $\frac{-\eta_1+2q}{(2q)^2}$ and the conditional probability of winning is $\frac{1}{2} + \int_0^{E_1+\eta_1-E_2} \frac{-\eta_2+2q}{(2q)^2} d\eta_2$; When $-E_1 + E_2 + 2q \leq \eta_1 \leq 2q$, the density function for η_1 is $\frac{-\eta_1+2q}{(2q)^2}$ and the conditional probability of winning is 1. Then, I can find the unconditional probability that team 1 wins by integrating over all possible realizations of η_1 with respective density functions.

$$\text{Prob}(Team\ 1\ wins) =$$

$$\int_{-2q}^{-E_1+E_2} \left(\int_{-2q}^{E_1-E_2+\eta_1} \frac{\eta_2+2q}{(2q)^2} d\eta_2\right) \frac{\eta_1+2q}{(2q)^2} d\eta_1 +$$

$$\int_{-E_1+E_2}^{0} \left(\frac{1}{2} + \int_0^{E_1-E_2+\eta_1} \frac{-\eta_2+2q}{(2q)^2} d\eta_2\right) \frac{\eta_1+2q}{(2q)^2} d\eta_1 +$$

$$\int_0^{-E_1+E_2+2q} \left(\frac{1}{2} + \int_0^{E_1-E_2+\eta_1} \frac{-\eta_2+2q}{(2q)^2} d\eta_2\right) \frac{-\eta_1+2q}{(2q)^2} d\eta_1 + \int_{-E_1+E_2+2q}^{2q} 1 \times \frac{-\eta_1+2q}{(2q)^2} d\eta_1. \tag{A3}$$

And, it is easy to see the probability of winning for team 2 is

$$\text{Prob}(Team\ 2\ wins) = 1 - \text{Prob}(Team\ 1\ wins). \tag{A4}$$

I can find the marginal probability of winning for each member of a team by differentiating equations (A3) and (A4) with respect to e_{1p} and e_{2p}, respectively, and setting $e_{11} = e_{12} = e_{21} = e_{22} = e^*_{TB}$. The marginal probability of winning for each member in each team, then, is $\frac{1}{3q}$.

Notice that the probability that team 1 wins when $E_1 - E_2 \leq 0$ is equal to 1 minus the probability that team 2 wins when $E_1 - E_2 \leq 0$. Since the two teams are symmetric, the probability that team 2 wins when $E_1 - E_2 \leq 0$ is exactly given by (A3) by switching E_1 and E_2. Hence, it is straightforward to see that the marginal probability of winning for each member in each team in this case is $\frac{1}{3q}$ as well.

Appendix 3: Experimental Instructions for Team-Based Contest in Social Condition B

1. Introduction

This is an experiment in decision-making. The instructions are simple, if you follow them carefully and make good decisions, you could earn a considerable amount of money, which will be paid to you in cash immediately and privately after the experiment. What you earn today partly depends on your decisions, partly on the decisions of others, and partly on chance. Do not look at the decisions of others, talk, laugh, or engage in any activities unrelated to the experiment. You will be warned if you violate this rule the first time. If you violate this rule twice, we will cancel the experiment immediately and your earnings will be $0.

2. Decision Steps

At the start of the experiment, each participant will be assigned to a group of 4 and the composition of each group will remain unchanged throughout the experiment. There are a total of 15 decision rounds in this study.

In the first round, you will be randomly and anonymously matched with another participant from your group to form a team. This individual will remain your teammate for 5 rounds. Your team will be randomly and anonymously matched with another team (that also has 2 participants) from another group. This team will remain your competitor for 5 rounds. In other words, both your teammate and your competitor remain the same for 5 rounds. In the sixth round, you will be randomly and anonymously re-matched with another participant from your group (who will be your teammate) and another team that is made up of two participants from the other groups (who will be your competitor). You will proceed for another 5 rounds in this format and then the same process will occur in the eleventh round. The experiment will come to a completion after 15 rounds.

Please refer to the "Decision Cost Table" now. Your task in every round is to select a Decision Number, which ranges from 0 to 75. Associated with each decision number is a Decision Cost, which is listed on the same row in the next column. After you have selected your Decision Number, the computer will generate your Random Number.

This Random Number ranges from –60 to 60. Each number in this range has an equal chance of being drawn.

After this, the computer will generate your Final Number, which is calculated as follows:

Final Number = Your Decision Number + Your Random Number

Note that if you choose a higher Decision Number, your Final Number will be higher. However, choosing a higher Decision Number also means that you will have to pay a higher Decision Cost. The Final Numbers of the other participant in your team and those in the other team are determined in exactly the same manner.

The computer will then generate your Team's Final Number as follows:

Team's Final Number = Your Final Number + the Final Number of the Other Participant in Your Team

The Team's Final Number of the other team that your team is matched with is also determined in the same manner.

The computer will rank the Team's Final Numbers of the 2 matched-up teams from high (1^{st}) to low (2^{nd}).

If your team is ranked 1^{st}, your team will receive a Fixed Payment of **13** points which will be equally split between you and your teammate. If your team is ranked 2^{nd}, your team will receive a Fixed Payment of **2** points which will be equally split between you and your teammate.

3. Determining Your Point Earnings and Cash Earnings

Your point earnings in each round will be:

a. **6.5 points minus Your Decision Cost,** if your team is ranked 1^{st}.

b. **1 point minus Your Decision Cost,** if your team is ranked 2^{nd}.

We will repeat the same procedure in every round. In each round, you will choose a Decision Number (you may pick the same one or a different one). The computer will generate your Random Number, calculate the Final Number and the Team's Final Number, rank the Team Final Numbers for the 2 teams, and then compute your payoff for that round. Recall that the identities of the participants you are matched with in the same team and in the other team remain the same for 5 rounds and then change. Your **Total Point Earnings** will be the sum of your point earnings across the 15 rounds. Also, note that the computer will generate a random number separately in every round and that the values of random numbers that have been drawn do not affect the values of future numbers that will be drawn.

Your **Cash Earnings** will be your Total Point Earnings multiplied by **0.2**. The more points you earn, the more money you will make. We will pay everyone privately after all the participants have completed the experiment.

Before we begin the experiment, we will also go through 3 practice rounds to familiarize you with the procedure. In these practice rounds, you will be playing against the computer (and not the other participants) and there will be no monetary payoffs. Are there any questions?