The effects of performance separability and contract type on agent effort

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\textbf{Abstract}

We report the results of an experiment on the influence of performance separability and contract type on the effort levels of subjects working in an environment characterized by team effects. We demonstrate that the principal can achieve improvements in productivity through the choice of incentive scheme and/or by increasing the degree of performance separability through monitoring activities. We consider competitive, individual, and cooperative incentive schemes and two levels of performance separability. Under both the competitive and individual schemes, effort levels increase as the degree of performance separability increases. Under the cooperative scheme, effort levels are not affected by changes in the degree of performance separability.

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This paper explores the behavior of agents in a situation characterized by a production externality where each agent chooses an effort level, unobserved by the principal, that stochastically affects his output. The presence of a production externality, which we will refer to as a team effect, creates an interdependency among the agents’ performance measures, which can result in an interdependency in compensation. A team effect is defined as a production process that is partially separable so that each agent’s observed output is a function of his and other agents’ effort levels (Drago & Turnbull, 1988). In such cases, agents’ performance measures are only partially separable due to a portion of one agent’s effort being allocated to another agent’s performance measure. Incentive problems can arise if agents are rewarded for less than the full amount of effort exerted or do not bear the full cost of shirking.

For instance, in manufacturing with shift-work, if periodic maintenance of equipment and improvements to machinery or the production process increase an employee’s output, it is also likely to increase the measured performance of employees in the same position on other shifts. Team effects could be present in a variety of non-production based situations, such as team audits, co-authored research, air traffic control, and in law and medical practices. While there is some empirical evidence of such incentive problems, according to Prendergast (1996), “A particular area of incentive provision that remains largely untested is the behavior of individuals within
teams.” In related research, Newhouse (1973) finds that in medical practice groups where costs are shared, overhead costs are higher and where profits are shared, doctors work less. Bailey (1970) finds similar results within medical practices and Leibowitz and Tollison (1980) find that cost control is poorer among large legal practices than among small practices.

In the presence of team effects, the principal can improve productivity through the choice of compensation scheme. Holmstrom (1982) demonstrates that with completely inseparable output and under certainty, cooperative schemes alone can remove incentive problems. His scheme requires penalties that waste output or bonuses that exceed output. The principal can also increase productivity through an increase in monitoring. In the presence of team effects, monitoring serves to uncover an individual’s productive inputs and hence provides a more separable performance measure on which to base compensation. Alchian and Demsetz (1972) argue that the necessity for monitoring created by the presence of team effects is a fundamental reason for the existence of firm, rather than strictly market, organization of production.

This research focuses on the behavioral implications, in terms of elicited effort, of simple incentive schemes and performance separability and how they interact to affect productivity in the presence of team effects. We demonstrate that the benefits of developing a more separable performance measure depend on how that measure is used in an employee’s compensation scheme. In particular, we test behavior across an individual scheme (individual piece-rate), a competitive scheme (rank-order tournament), and a joint performance evaluation scheme (joint piece-rate) across a high and low degree of performance separability.

We use a laboratory setting to test the behavioral predictions. The experimental task required subjects to make production decisions as managers of a hypothetical firm. Subjects were compensated under a tournament contract, an individual piece-rate or a joint piece-rate. In addition, we assigned subjects to conditions of either high or low performance separability. A novel feature of our experimental design is that we include performance separability as a parameter, which allows precise predictions.

We find that as the degree of performance separability decreases, effort levels decrease more under the rank-order tournament, than under an individual piece-rate. The use of a joint piece-rate results in the degree of performance separability having no influence on effort. Under the individual piece-rate we find evidence of social giving that is consistent with previous research on altruistic behavior. Under the tournament contract, we find evidence that differences in behavior across the two levels of separability result from strategic behavior.

Our experiment is designed to test theoretical predictions derived from the economic model. We find the theory to have significant explanatory power, however, there are important differences in predicted and actual behavior. Kachelmeier (1996) suggests, “…that the potential to add new insights through economic experimentation can be more fully tapped if the experimentalist considers both the economic incentives of a strategic model and the behavioral forces that might challenge these incentives.” In this spirit, we explore additional behavioral hypotheses in an attempt to explain the variance in behavior across treatments. We find this additional analysis helpful in explaining deviations from predicted behavior. Hence, in addition to demonstrating that the theory does reasonably well at predicting behavior, we investigate conditions in which those predictions may not be accurate. Note, however, that this additional analysis is based on observed rather than predicted deviations from the economic theory. In this sense, these results provide a baseline for the study of behavior in environments characterized by team effects. Future research

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2 In related research Choi (1993) derives optimal compensation when a production externality is present. He demonstrates that both joint performance evaluation and relative performance evaluation can be optimal depending on the relationship between a production externality and an informational externality. Arya, Fellingham and Glover (1997) develop a two-period model in a setting where only aggregate performance is measured and demonstrate that it can be optimal to condition both agents’ pay on a joint performance measure. Their result depends on the ability of managers to mutually monitor the first period action and punish deviant behavior in the second period.
needs to directly explore behavioral hypotheses as they relate to additional organizational aspects of teams.

1. Hypothesis development

Typically, studies on performance measures and alternative contracts assume that each agent's effort level has no direct effect on another agent's measured output. In this section we consider the effects of performance separability and contract type on agent's effort levels when team effects characterize the work environment. The contracts are a tournament, an individual piece-rate, and a joint piece-rate.

1.1. Agents' performance

We assume that agents $i$ and $j$ are identical and have the following utility function that is separable in compensation and effort level:

$$U(p, e) = u(p) - c(e)$$

where $e$ denotes the level of effort exerted and $p$ denotes the non-negative payment that the agent receives. The principal's observation of agent $i$'s performance is $Q_i$, which is a linear function of both his effort $e_i$, and the other agent's effort $e_j$, and a random shock $\mu_i$.

$$Q_i = (1 - \alpha)e_i + \alpha e_j + \mu_i$$

The individual random shocks, $\mu_i$ and $\mu_j$ are i.i.d. with zero mean, and finite variances. The parameter captures the degree of performance separability, which is inversely related to the team effect; therefore, lower values indicate a high degree of performance separability. The analysis is restricted to cases in which the performance of agents is partially separable, $0 < \alpha < 0.5$. When $\alpha = 0.5$ the observed output of the two agents is completely inseparable and when $\alpha = 0$, (2) simply reduces to $Q_i = e_i + \mu_i$, the case in which the performance measure is completely separable.

1.2. The tournament contract

Following Drago and Turnbull (1988), a tournament is analyzed in which greater effort by one agent increases the measured performance of another agent. In a situation in which agents are competing, increased effort by one agent can increase the expected reward of the other agent and hence, the equilibrium effort level is dependent on the degree of performance separability. Consider the following symmetric, two-agent tournament with the performance measure defined as above, that specifies the fixed reward $W$ for the agent that "wins" and the fixed reward $L$ for the agent that "loses" such that $W > L$. $P_i(e_i, e_j)$ is agent $i$'s probability of winning the tournament and is a function of both agents' effort levels. Hence, the expected utility of the contract to agent $i$ is

$$EU_i(e_i, e_j) = P_i(e_i, e_j)U(W)$$

$$+ (1 - P_i(e_i, e_j))U(L) - c(e_i)$$

Since $W > L$, the expected value of the tournament contract for an agent increases in both the probability of winning and the magnitude of the rewards.

To derive testable behavioral predictions a simple specification for agents' utility functions is given by

$$U(p, e) = p - \frac{e^2}{c}$$

In addition, the random shocks are assumed to be distributed uniformly on the interval $[-a, a]$.

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3 The random shock can be interpreted either as true randomness in the technology or as a measurement error associated with the principal's monitoring of output. See O'Keefe, Viscusi and Zeckhauser (1984). In the absence of random shocks, the tournament has no pure strategy Nash equilibrium (Bull, Schotter & Weigelt, 1987).

4 The analysis could alternatively be interpreted as holding the degree of the team effect constant while changing the degree of monitoring in the work environment.

5 Green and Stokey (1983) demonstrate that in general, in the absence of a common shock to workers' productivity a tournament will be dominated by an individualistic compensation scheme. Drago and Turnbull's (1988) result holds when a common error is added to the production function.

6 This is identical to the utility function used to study behavior in Bull et al. (1987) and Schotter and Weigelt (1992).
Substituting (4) into (3) yields the expected utility of the tournament as

\[ EU(e_i, e_j) = L + P(e_i, e_j)(W - L) - \frac{e_i^2}{c} \]  

(5)

In equilibrium, the following first order condition must be satisfied.

\[ \frac{\partial EU(e_i, e_j)}{\partial e_i} = \frac{\partial P(e_i, e_j)}{\partial e_i} (W - L) - \frac{2e_i}{c} = 0 \]  

(6)

This equates the marginal expected utility from increasing effort with the marginal cost of exerting greater effort. Given the distributional assumptions of the random shocks on the interval \([-a,a]\), (6) can be rewritten to yield the equilibrium effort level.7

\[ \frac{c(W - L)(1 - 2\alpha)}{4a} = e^* \]  

(7)

This provides testable implications. In particular, the equilibrium effort level increases with the spread between the prizes and with the degree of performance separability. Effort decreases with the width of the distribution of the random shock and the cost of effort. Our focus is on the effect of performance separability which leads to hypothesis one.

**Hypothesis 1.** Under the tournament contract, effort levels will be greater with a high degree of performance separability than with low degree of performance separability.

### 1.3. Linear piece-rate

Two versions of a linear piece-rate are analyzed, one based on individual output and one on joint output. Agents’ utility and performance measures are identical to the tournament case. Even when agents are compensated under an individual piece-rate, the equilibrium effort level increases as performance separability increases. However, when agents are compensated according to joint output, performance separability no longer influences the equilibrium effort level.

Agents’ utility functions and performance measures are again given by (2) and (4) respectively. Compensation is now given by

\[ p = wQ_i \]  

(8)

where \( w \) is a preset parameter. Substituting (2) into (8) and differentiating with respect to agent \( i \)'s effort yields the marginal benefit of exerting effort

\[ \frac{\partial p}{\partial e_i} = w(1 - \alpha) \]  

(9)

Equating the marginal benefit of exerting effort to the marginal cost of exerting effort yields the equilibrium effort level.

\[ \frac{we(1 - \alpha)}{2} = e^* \]  

(10)

As in the tournament case, the equilibrium effort level is an increasing function of the degree of performance separability which leads to hypothesis two.

**Hypothesis 2.** Under the individual piece-rate, effort levels will be greater with a high degree of performance separability than with a low degree of performance separability.

Next, consider the case in which agents’ compensation is based on joint output so that compensation is given by

\[ p = w(Q_i + Q_j) \]  

(11)

Substituting (2) into (11) for both agents and differentiating with respect to agent \( i \)'s effort yields the marginal benefit of exerting effort.

\[ \frac{\partial p(Q_i + Q_j)}{\partial e_i} = w \]  

(12)

The equilibrium effort level is found by equating marginal pay with the marginal cost of exerting effort.

\[ \frac{we}{2} = e^* \]  

(13)

Basing agents’ compensation on joint output eliminates the effects of performance separability. This leads to hypothesis three.

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7 Agent \( i \) wins when \( \mu_i > (1 - 2\alpha)(e_j - e_i) + \mu_j \). Therefore,

\[ (1 - 2\alpha) \frac{\partial P(e_i, e_j)}{\partial e_i} = \frac{(1 - 2\alpha)}{2\alpha} \]
Hypothesis 3. Under the joint piece-rate, effort levels will be the same with a high degree of performance separability as with a low degree of performance separability.

The first three hypotheses address effort levels as the degree of performance separability changes, holding the contact type constant. The hypotheses that follow are intended to compare the effect of performance separability across contact type.

Hypothesis 4. Effort levels decrease more under the individual piece-rate than under the joint piece-rate when performance separability decreases from high to low.

Comparisons among the tournament and piece-rates are not as straight forward since equilibrium effort levels depend on the selected values of the parameters, which are specific to the contract type. For instance, under the tournament contract effort level depends in part on the spread between the rewards, $W$ and $L$, while under a piece-rate effort level depends in part on the compensation parameter, $w$. In order to develop hypotheses five and six, parameters are chosen so that with high performance separability, the equilibrium effort levels are identical under the tournament and the individual piece-rate. This allows comparisons between behavior under the alternative contacts as the degree of performance separability decreases. This leads to hypotheses five and six.

Hypothesis 5. Effort levels decrease more under the tournament than under the individual piece-rate when performance separability decreases from high to low.

Hypothesis 6. Effort levels decrease more under the tournament than under the joint piece-rate when performance separability decreases from high to low.

The experiment, discussed in the next section, was designed to test the predictions developed from economic theory. The predictions concern one-shot rather than repeated interactions. Repeated interaction could potentially confound results and remains an interesting question for future research. In addition to tests of the validity of the economic theory we investigate alternative perspectives that acknowledge both economic and social aspects of organizations. In some cases the theories from that literature support the economic theories and oppose them in others. For instance, under both the individual and joint piece-rates altruistic behavior can result in effort levels that are greater than those predicted. Previous research has studied incentives to help others in an organizational context (Young, Fisher & Lindquist, 1993; Ravenscroft & Haka, 1996). Our data allows us to directly test if the amount of effort allocated to another agent is related to the cost or sacrifice that it imposes on the helping agent’s own compensation. Also, since tournament contracts represent a strategic game behavior can be influenced by strategic considerations. Previous research has explored how competitive contracts can influence behavior (Bull et al., 1987; Drago & Heywood, 1989; Merlo & Schotter, 1992). Our data allows us to investigate the effects of strategic considerations on behavior.

2. Experimental method

The experimental design employed a $2 \times 3$ factorial design obtained by crossing two levels of performance separability (high and low) and three types of contracts (tournament, individual piece-rate and joint piece-rate). Both factors were manipulated between subjects; therefore, there was an experimental session for each condition. Subjects were recruited from advanced business classes and were randomly assigned to experimental treatments. Either 14 or 20 subjects participated in each of the six experimental treatments. Table 1 summarizes the experimental design.8

2.1. Experimental task

Subjects were asked to assume a manufacturing company had hired them for management positions. The company has many identical production lines and each production line contains two interrelated

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8 Preparations were made to conduct the experiments with a minimum of 14 and a maximum of 20 subjects.
production shifts. The company assigns two managers to each production line and hence, one manager to each of the two production shifts contained in a production line. At the beginning of each production cycle a manager decides how many units of output to produce. The actual number of units produced is determined by the number of units that the manager decides to produce, the number of units that the other manager, assigned to the same production line, decides to produce, and a random shock.

2.2. Effort preferences

Consistent with agency theory (Baiman 1982; Namazi 1985), effort is any action that satisfies three conditions: (1) the agent controls the action, (2) an increase in the action results in a rightward shift of the distribution of output, and (3) the agent receives disutility from exerting effort. According to agency theory, physical exertion is not a requirement for an action to be regarded as effort. In the experiment effort is measured as the total number of units that a subject decides to produce as a manager of a hypothetical firm. This measure is compatible with the definition from agency theory in that each subject completely controls the number of units he or she chooses to produce and subjects can increase the expected number of actual units produced by increasing the production decision. The actual number of units produced is a function of both subjects' production decisions and a random shock.

Agency theory also assumes that agents' utility functions are additively separable in compensation received and in effort exerted (Holmstrom, 1982). In the tournament treatments, the subjects' probabilities of receiving the largest fixed payment increased with their production choice and under the piece-rate treatments subjects were paid a fixed amount for each unit produced using either individual or joint output. Disutility from exerting effort was induced by implementing the cost function $c(e) = e_i^2 / 10,000$ for production decisions, where $e_i$ denotes the production decision. This cost was deducted from compensation.

2.3. Administration of the experiment

The experiment involved 102 undergraduate students from business courses at a large university. Experiments were conducted as follows. A group of subjects was recruited. They reported to a room where they were randomly assigned subject numbers and seating assignments. Instructions were distributed to the subjects. The instructions explained the company's production process, the subjects' tasks within the company, how production shifts are assigned and the interrelated nature of production decisions. They were also informed of how the amount of money that they could earn depended on their decisions and the decisions of the other participants in the experiment. After the instructions, but before the actual decision rounds began, the subjects filled out a questionnaire to insure that they understood how to compute actual output and payoffs for themselves and other participants.

The random shock was operationalized by explaining to subjects that the choice of the number of units to produce is based on the average number of hours that the automated equipment is productive. The actual number of productive hours and hence the actual number of units produced, depends on the actual number of productive machine hours for the production cycle. The actual number of productive machine hours on a given shift, therefore, can be more or less than the average.

Each decision round, subjects made a production decision and recorded it on both a record sheet and a reporting sheet. There was no time limit for subjects' decisions. After all subjects made a choice for a round, an experimenter collected the reporting sheets. At the front of the room subjects were randomly and anonymously paired by subject numbers according to a table of random matches. All random numbers and matches were generated with a C++ computer program. In addition, the random shocks were independent across subjects and rounds and were assigned according to a table of random numbers.10

9 Bull et al. (1987) and Frederickson (1992) use similar measures of effort.

10 The procedure for calculating both the random shocks and the random pairs was explained in the instructions. Further, subjects were told that they would be allowed to view either table at the conclusion of the experiment.
Using the tables, an experimenter filled in the random shock on each subject’s reporting sheet and filled in the information concerning the other manager’s total production choice and random shock. Next, reporting sheets were returned to subjects and they filled in the relevant information on their record sheets and calculated their compensation for the period. This process was repeated for ten rounds.

2.4. Experimental parameters

For the tournament case the choice of parameters is restricted by Eq. (7). An effort was made to make as few changes as possible to the parameters in order to enhance comparability across treatments. The focus is on the effects of performance separability on effort levels across the different contract types. For the tournament treatments, the prizes are $1.40 and $0.80, the range of the random shock is $-20$ to $+20$, and the cost of effort is given by $e^2/10,000$. Using these parameter values, the equilibrium effort level with the low degree of performance separability, $\alpha = 0.4$ is $e_i = 15$, and under a high degree of performance separability, $\alpha = 0.1$, the equilibrium effort level is $e_i = 60$.

For comparability, the parameters for the linear piece-rates were chosen so that with the high degree of performance separability, the equilibrium effort level is equal to the equilibrium effort level under the tournament contract with the high degree of performance separability, $e_i = 60$. This provides a baseline and was achieved by setting $w = $0.0133 in Eqs. (8) and (11). The other parameters were unchanged. With the low degree of performance separability the equilibrium effort level decreases to $e_i = 40$. Finally, under the joint piece-rate pay is based on joint output and the equilibrium effort level is $e_i = 66.5$ regardless of the degree of separability. The experiment replicated the analytical model from Section 2. The production decision corresponds to effort, the random number to the random productivity shock, and the production cost to the disutility of exerting effort. Table 2 summarizes the parameter values used in all six treatments of the experiment.

### Table 1
Experimental design

<table>
<thead>
<tr>
<th>Degree of separability</th>
<th>Contract type</th>
<th>High</th>
<th>Low</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tournament</td>
<td>20</td>
<td>14</td>
<td></td>
</tr>
<tr>
<td>Individual piece-rate</td>
<td>20</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>Joint piece-rate</td>
<td>14</td>
<td>20</td>
<td></td>
</tr>
</tbody>
</table>

Using the tables, an experimenter filled in the random shock on each subject’s reporting sheet and filled in the information concerning the other manager’s total production choice and random shock. Next, reporting sheets were returned to subjects and they filled in the relevant information on their record sheets and calculated their compensation for the period. This process was repeated for ten rounds.

### Table 2
Experimental parameters

<table>
<thead>
<tr>
<th>Experimental treatment</th>
<th>Range of effort choices</th>
<th>Effort cost function</th>
<th>Degree of separability ($\alpha$)</th>
<th>Compensation</th>
<th>Range of random shock</th>
<th>Optimal effort level</th>
<th>Output used for compensation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tournament with high separability</td>
<td>$e_i=(0,1,...,100)$</td>
<td>$e^2/10,000$</td>
<td>$\alpha = 0.1$</td>
<td>$W=1.4L=$0.80</td>
<td>$\mu = (-20,...,20)$</td>
<td>$e_i=60, i=1.2$</td>
<td>$Q_i$</td>
</tr>
<tr>
<td>Tournament with low separability</td>
<td>$e_i=(0,1,...,100)$</td>
<td>$e^2/10,000$</td>
<td>$\alpha = 0.4$</td>
<td>$W=1.4L=$0.80</td>
<td>$\mu = (-20,...,20)$</td>
<td>$e_i=15, i=1.2$</td>
<td>$Q_i$</td>
</tr>
<tr>
<td>Individual piece-rate with high separability</td>
<td>$e_i=(0,1,...,100)$</td>
<td>$e^2/10,000$</td>
<td>$\alpha = 0.1$</td>
<td>$0.0133 \times Q_i$</td>
<td>$\mu = (-20,...,20)$</td>
<td>$e_i=60, i=1.2$</td>
<td>$Q_i$</td>
</tr>
<tr>
<td>Individual piece-rate with low separability</td>
<td>$e_i=(0,1,...,100)$</td>
<td>$e^2/10,000$</td>
<td>$\alpha = 0.4$</td>
<td>$0.0133 \times Q_i$</td>
<td>$\mu = (-20,...,20)$</td>
<td>$e_i=40, i=1.2$</td>
<td>$Q_i$</td>
</tr>
<tr>
<td>Joint piece-rate with high separability</td>
<td>$e_i=(0,1,...,100)$</td>
<td>$e^2/10,000$</td>
<td>$\alpha = 0.1$</td>
<td>$0.0133 \times (Q_i+Q_j)$</td>
<td>$\mu = (-20,...,20)$</td>
<td>$e_i=66.5, i=1.2$</td>
<td>$Q_i+Q_j$</td>
</tr>
<tr>
<td>Joint piece-rate with low separability</td>
<td>$e_i=(0,1,...,100)$</td>
<td>$e^2/10,000$</td>
<td>$\alpha = 0.4$</td>
<td>$0.0133 \times (Q_i+Q_j)$</td>
<td>$\mu = (-20,...,20)$</td>
<td>$e_i=66.5, i=1.2$</td>
<td>$Q_i+Q_j$</td>
</tr>
</tbody>
</table>

3. Results

The results are reported in three sections. The first section summarizes the experimental data, the second section reports statistical tests of the six hypotheses.
derived from the economic theory, and the third section explores deviations and variations in behavior that are not predicted by the economic theory.

3.1. Descriptive analysis

The results for the six experimental treatments are summarized in Figs. 1 and 2 and Table 3. The figures display the mean effort levels by decision round. The horizontal lines on the graphs correspond to the equilibrium effort levels. In general, actual subject behavior was similar to the predicted behavior. The mean effort level in the treatments using an individual piece-rate was closer to predicted behavior than the mean effort levels under the tournament contract. This was the case with a low and high degree of performance separability. One explanation for the difference is that tournaments represent strategic games between subjects and, therefore, are behaviorally more complex. This is discussed further below. Table 3 reports the summary statistics for the six experimental treatments and reports the percentage decrease in the mean effort level, as the degree of performance separability changes from high to low across the three contract types.

3.2. Tests of hypotheses

The hypotheses address the changes in effort levels resulting from changes in the degree of performance separability and the contract type. The dependent variable is the mean effort level of subjects over all ten rounds of the experiment.\textsuperscript{11} Table 4, panel A reports the results of a generalized lin-

\textsuperscript{11} We performed the statistical analysis separately on data from the first five and last five decision rounds. The results for each subsample were qualitatively the same and the same as the reported results.
Fig 2. Effort levels with high separability. The horizontal line at 66.5 represents the point prediction under the joint-piece rate. The horizontal line at 60 represents the point prediction under the individual piece-rate and the tournament.

Table 3
Summary of results

<table>
<thead>
<tr>
<th>Degree of separability</th>
<th>High</th>
<th>Low</th>
<th>% Decrease in effort level from high to low separability</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean S.D.</td>
<td>Mean S.D.</td>
<td></td>
</tr>
<tr>
<td></td>
<td># of subjects</td>
<td># of subjects</td>
<td></td>
</tr>
<tr>
<td>Tournament</td>
<td>52.360</td>
<td>37.000</td>
<td>29.3%</td>
</tr>
<tr>
<td></td>
<td>16.016</td>
<td>24.279</td>
<td></td>
</tr>
<tr>
<td></td>
<td>N = 20</td>
<td>N = 14</td>
<td></td>
</tr>
<tr>
<td>Individual piece-rate</td>
<td>59.185</td>
<td>50.995</td>
<td>13.8%</td>
</tr>
<tr>
<td></td>
<td>16.715</td>
<td>13.587</td>
<td></td>
</tr>
<tr>
<td></td>
<td>N = 20</td>
<td>N = 20</td>
<td></td>
</tr>
<tr>
<td>Joint piece-rate</td>
<td>69.136</td>
<td>65.690</td>
<td>4.9%</td>
</tr>
<tr>
<td></td>
<td>25.074</td>
<td>22.771</td>
<td></td>
</tr>
<tr>
<td></td>
<td>N = 14</td>
<td>N = 20</td>
<td></td>
</tr>
</tbody>
</table>
ear model (GLM) that was fit to the data.12 Contract type, performance separability, and their interaction are all statistically significant. This indicates that subjects do respond to both the degree of separability in their performance measures and how those measures are used for purposes of compensation.

Since hypotheses 1–3 are contract-specific, the data are partitioned by contract type. Hypotheses 4–6 compare the effects of performance separability across contract type. Since we specify the functional form of the relationship among cell means we perform linear contrasts to test the six maintained hypotheses. Table 4, panel B reports the results of the contrasts.

Hypothesis 1 maintains that under the tournament contract, effort levels will be greater with high performance separability than with low performance separability. The null hypothesis that under the individual piece-rate, the mean effort level of 59.2 with high performance separability is equal to the mean effort level of 50.9 with low performance separability is rejected ($p = 0.0002$, one-tail). Hypothesis 3 maintains that under the joint piece-rate, effort levels will be the same with high and low performance separability. The null hypothesis that under the joint piece-rate, the mean effort level of 69.2 with high performance separability is equal to the mean effort level of 65.6 with low performance separability cannot be rejected ($p = 0.1888$, two-tail). Support for hypotheses 1–3 implies that subjects do respond to how their effort affects their measured performance. The next three hypotheses compare how the use of these measures in alternative compensation schemes affects effort.

Hypothesis 4 maintains that effort levels decrease more under the individual piece-rate than under the joint piece-rate when performance separability decreases. The decrease of 8.2 under

<table>
<thead>
<tr>
<th>Table 4</th>
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<tbody>
<tr>
<td>Statistical analysis</td>
</tr>
<tr>
<td>Panel A: GLM analysis</td>
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<tr>
<td><strong>Between subjects</strong></td>
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<td>Factor</td>
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<td>Separability</td>
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<td>Contract</td>
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<td>Separability by contract</td>
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<td>Panel B: linear contrasts</td>
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<tr>
<td><strong>Contrast</strong></td>
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<td>H1: Tournament/low vs tournament/high</td>
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<td>H2: Ind. piece-rate/low vs ind. piece-rate/high</td>
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<td>H3: Joint piece-rate/low vs joint piece-rate/high</td>
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<td>H4: Joint piece-rate vs ind piece-rate</td>
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<td>H5: Ind piece-rate vs tournament</td>
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<td>H6: Joint piece-rate vs tournament</td>
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12 This procedure is similar to ANOVA except that it adjusts for an unbalanced design.

13 The analysis of variance procedure yields $F$ statistics that have 1 degree of freedom in the numerator. Where appropriate, these are converted into $t$ statistics by taking the square root of the $F$ ratio and used to compute one-tailed significance levels.

14 Failing to reject the null hypothesis is consistent with the prediction. However, this informs us that either the null hypothesis is indeed true, or that the experimental design lacked the statistical power to detect any differences.
the individual piece-rate is significantly greater than the decrease of 3.5 under the joint piece-rate (\( p = 0.0002 \), one-tail).

Hypothesis 5 maintains that effort levels decrease more under the tournament than under the individual piece-rate when performance separability decreases. The decrease of 15.4 under the tournament is significantly greater than the decrease of 8.2 under the individual piece-rate (\( p = 0.0002 \), one-tail). Hypothesis 6 maintains that effort levels decrease more under the tournament than under the joint piece-rate when performance separability decreases from high to low. The decrease of 15.4 under the tournament is significantly greater than the decrease of 3.5 under the joint piece-rate (\( p = 0.0002 \), one-tail).

These results provide evidence of some of the tradeoffs involved in the choice between compensation schemes and expending resources to develop more separable measures of individual productivity. In the next section we explore how factors that counter the equilibrium predictions affect behavior.

3.3. Investigation of deviations from predicted behavior

This section reports the results of period-by-period tests of the point predictions and explores deviations from predicted behavior to see if those deviations are consistent with the issues raised in the hypothesis development section. In the individual piece-rate with low separability and the tournament with low separability treatments we can reject that the results are consistent with the point predictions for all ten periods. These treatments are discussed below. With the exception of period three in the joint piece-rate with high separability treatment, we cannot reject that the results are consistent with the point predictions for all periods of the remaining treatments.

Andreoni and Miller (1998) note that, “Economists know very little about the nature of altruism, nor do we have a constructive notion of what a rational preference for altruism may look like.” In an experimental study, Andreoni and Miller varied the cost of giving money to others. Results from their research provide evidence that altruistic behavior or social gift giving is more likely when giving away money is relatively inexpensive. Recent research has studied incentives to help others in an organizational context (Ravenscroft and Haka, 1996; Young et al., 1993). Our data allows us to directly test if the amounts of effort allocated to another agent is related to the cost or sacrifice that it imposes on the altruistic agent. In the individual piece-rate treatments it is relatively cheaper to “help” the other subject under low performance separability than under high performance separability.\(^{15}\) Hence, if subjects’ behavior is consistent with Andreoni and Miller’s findings, we should expect a higher level of altruistic behavior with low separability than with high separability. The results of a period-by-period test found that effort levels were significantly higher than the equilibrium prediction every period with low performance separability. With high performance separability we cannot reject that mean effort levels are equal to the equilibrium prediction for any period.

Previous research on tournament compensation schemes attributes a large portion of variance in behavior to the fact that a tournament is a game and so requires strategic rather than only maximizing behavior (Bull et al., 1987). Concerns with winning and losing could affect behavior differently depending on the degree of performance separability. In particular, it takes much larger increases (decreases) in effort under low separability to increase (decrease) the probability of winning than it does under high separability. Hence, to achieve the same change in the probability of winning requires a larger change in effort choice under low separability. This implies that the variance in effort should be greater for the low separability treatment than for the high separability treatment. We find the variance under low separability to be significantly higher than under high separability (\( p = 0.0000 \)). Also, the results of a period-by-period test found that effort levels were significantly higher than the equilibrium prediction every period with low performance separability.

\(^{15}\) For instance, for an effort increase of five units above the equilibrium level with high separability, a transfer of 0.00665 to another subject reduces a subject’s payoff by 0.00265 and with low separability a transfer of 0.0266 to another subject reduces a subject’s payoff by 0.0026.
Though not borne out in the analysis, under all three contract types the unique equilibrium effort levels are not the efficient outcomes from the agents’ perspective. Under the tournament contract agents could collude on the efficient outcome in which both agents provide zero effort. Under both forms of the piece-rate, there are more efficient outcomes at effort levels above the Nash equilibrium effort levels and hence, these are also better outcomes from the principal’s perspective. The experiment was designed to test the one-shot theory and, therefore, we randomly rematched subjects each period. This makes convergence to cooperative outcomes difficult and we observe little indication of actual convergence. Aspects of organizations such as repeated interaction, communication, mutual monitoring and other methods to enhance cooperation could result in these cooperative outcomes.

4. Conclusion

This study explores, in terms of effort levels elicited, the degree of separability in performance measures and how a management control system uses that measure in compensating employees. Prendergast (1996) notes, “Firms spend considerable time and resources identifying how best to monitor workers, but at an empirical level economists have done little to understand the costs and benefits of various forms of evaluation.” While not a cost/benefit analysis, the results provide evidence of some of the tradeoffs involved in the choice between compensation schemes and expending resources to develop more separable measures of individual productivity.

Our results imply that in environments in which developing separable performance measures is prohibitively expensive, firms should avoid competitive contracts in favor of more aggregate measures of performance. Likewise, in situations where competitive schemes are difficult to avoid such as promotions, the gains from obtaining a more informative measure should be substantial. In this sense, these treatments of our experiment represent out-of-equilibrium behavior. In other words, when firms are acting optimally we should not observe these situations in the field. Also, we have investigated behavior that deviates from that predicted by the economic model. We find this behavior to be consistent with behavioral explanations; however, our analysis was post hoc. Future researchers need to carefully design studies to specifically address alternative behavioral theories and thus capture additional organizational features of firms. See Moser (1998) and Kachelmeier (1996) for a discussion of this approach.

The presence of team effects among agents or divisions can further complicate the observability of agents’ productivity and may hinder intrafirm coordination efforts. As firms become more complex, interdependencies within organizations create the need for better management control systems. In general, agency theory has focused too narrowly on single-agent environments (Baiman, 1982; Demski & Kreps, 1982). According to Frederickson (1992), “Additional analytical and empirical research that examines multi-agent environments appears to be a more relevant and fruitful approach for studying motivation than focusing on single-agent environments.” More research is needed focusing on behavior, evaluation, and compensation in multi-agent environments in which, in addition to principal-agent interaction, interactions among agents are taken into account and environmental variables are considered.

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References


