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Tournaments and Piece Rates Revisited: A Theoretical and Experimental Study of Premium Incentives

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Abstract

Tournaments represent an increasingly important component of organizational compensation systems. While prior research focused on fixed-prize tournaments, i.e., on tournaments where the prize or prize sum to be awarded is set in advance, we introduce a new type of tournament into the literature: premium incentives. While premium incentives, just like fixed-prize tournaments, are based on relative performance, the prize to be awarded is not set in advance but is a function of the firm's success: the prize is high if the firm is successful and low if it is not successful. Relying on a simple model of cost minimization, we are able to show that premium incentives outperform fixed-prize tournaments as well as piece rates. Our theoretical result is qualitatively confirmed by a controlled laboratory experiment and has important practical implications for the design of organizational incentive systems.

JEL Classification: C72, C91, J33

Keywords: Tournaments, Incentives, Economic experiments

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1 Introduction and Motivation

As documented by Orrison et al. (2004) or Bothner et al. (2007), tournament incentives have developed into an increasingly important component of compensation systems; they are ‘pervasive in organizations’ (Casas-Arce and Martínez-Jerez, 2009). Unlike piece rates, which are awarded according to absolute performance, tournament incentives are awarded according to relative performance. While the most prominent examples of tournament incentives in the organizational practice are standard promotion tournaments, any organizational incentive system awarding a (typically predetermined) prize to a predefined number of top performing employees actually qualifies as a tournament compensation system.

Unlike Ryvkin and Ortmann (2008), we focus on the incentive properties of tournament compensation systems and not on their predictive power. Starting with Lazear and Rosen (1981), the incentive properties of tournament compensation systems have repeatedly been analyzed in the literature (e.g., O’Keeffe et al., 1984; McLaughlin, 1988). However, the literature has so far principally focused on ‘fixed-prize’ tournament incentives in the sense that the prizes to be awarded are set in advance such that their actual size is not influenced by employee performance or firm success. A prominent exception to this are Japanese bonus tournaments (so-called J-tournaments; see Kräkel, 2003), where the size of the prize to be awarded to a single contestant depends on his/her relative performance (see, e.g., Endo, 1984). But as the size of the total wage sum or bonus bill is fixed in advance (e.g., Kanemoto and MacLeod, 1984), even in the J-tournament, the prize sum in a given year is predetermined and independent of the firm’s success in that year.

As long as firm performance can be easily assessed in advance, a system of predefined tournament prizes that have to be paid out even if the company does badly may not pose a severe problem. However, if firm performance cannot be assessed in advance (e.g., because the firm finds itself in an uncertain economic environment), a predetermined tournament prize sum may well exceed what the firm can actually afford to pay. Accordingly, in the

organizational practice, one should expect that the tournament prize sum depends on firm performance (as is, e.g., the case in any system of gain sharing). Besides the lack of ability to adequately forecast firm profitability, there is one further argument that speaks in favor of variable instead of predetermined tournament prizes: while fixed-prize tournaments carry the risk of horizontal collusion between the contestants, premium incentives clearly do not. If contestants decide for collusive behavior in a variable prize sum tournament, this will reduce the tournament prize and hence the attractiveness of collusive behavior.

In our study, we depart from the existing literature by studying tournaments that award a variable prize whose size is based on firm performance and refer to this incentive scheme as ‘premium incentives.’ Just as in a typical tournament, the premium incentive is only awarded to the top performer(s), but in contrast to the fixed prize in a typical tournament, its size is not predetermined but depends on firm performance. In order to study the comparative advantages of premium incentives, we allow for employee compensation to be composed of (a) a *piece rate* based on absolute performance, (b) a predetermined tournament prize awarded on the basis of relative performance (*fixed-prize tournament incentive*), and (c) a variable tournament prize awarded on the basis of relative performance, the size of which depends on firm success (*variable-prize tournament incentive* or ‘*premium incentive*’).

Theoretically, we rely on a simple cost-minimization approach in search of the optimal combination of the three incentive types studied. Our analysis shows that premium incentives are more cost-effective than piece rates and fixed-prize tournament incentives, the two types of incentives that have typically been studied in the literature so far.

We also test our theoretical implications by confronting them with data from a controlled laboratory experiment.¹ Our data qualitatively supports the theoretical propositions:

¹For reasons of data availability, empirical studies on tournaments often rely either on laboratory evidence (see, e.g., Green and Stokey, 1983; Bull et al., 1987; Orrison et al., 2004) or on data from sports (e.g., Ehrernberg and Bognanno, 1990; Becker and Huselid, 1992; Bothner et al., 2007; Kaplan and Garstka, 2001).

despite agents not choosing the theoretically predicted effort level, premium incentives not only theoretically, but also empirically prove to be the profit maximizing type of incentive (as compared to the conventional alternatives), and accordingly, most principals decide in favor of premium incentives when designing an incentive system for their subordinates. In sum, our results suggest to foster the use of variable-prize tournaments or ‘premium incentives’ in the organizational practice as well as to encourage future research on the subject.

The remainder of this paper is organized as follows. In Section 2, we specify the model and derive its theoretical result. Section 3 presents the experimental design. The data is analyzed and discussed in Section 4. Section 5 concludes.

2 Theoretical Analysis

Assume two competing agents, 1 and 2, who may represent individual employees or teams in the same firm. Both agents $i = 1, 2$ must choose an effort level $x_i \geq \underline{x}$ with $\underline{x} \geq 0$. Each effort x_i generates output $y_i = x_i + \varepsilon_i$ subject to some noise term $\varepsilon_i \in [\underline{\varepsilon}, \bar{\varepsilon}]$ with $\underline{\varepsilon} < \bar{\varepsilon}$, $\underline{x} + \underline{\varepsilon} \geq 0$, and density $\varphi(\cdot)$ with all probability mass at interval $[\underline{\varepsilon}, \bar{\varepsilon}]$. According to such an iid-case, the noise levels ε_1 and ε_2 are stochastically independent and identically distributed and ensure the nonnegativity of the agents’ output. With $c_i(x_i)$ denoting the effort costs of the agents, the payoffs of $i = 1, 2$ with competitor $j \neq i$ can be defined as

$$u_i(x_i, x_j, \varepsilon_i, \varepsilon_j) = \begin{cases} \omega y_i - c_i(x_i) & \text{if } y_i = x_i + \varepsilon_i \leq y_j = x_j + \varepsilon_j \\ \omega y_i + \alpha + \beta(x_i + \varepsilon_i + x_j + \varepsilon_j) - c_i(x_i) & \text{otherwise,} \end{cases} \quad (1)$$

where $\omega \in \mathbb{R}_+$ is a piece rate, $\alpha \in \mathbb{R}_+$ is a fixed premium, and $\beta \in \mathbb{R}_+$ determines how sensitively the premium $\beta(x_i + \varepsilon_i + x_j + \varepsilon_j)$ depends on firm performance (represented by the sum of the two agents’ output levels $x_i + \varepsilon_i + x_j + \varepsilon_j$). After agents independently choose their effort levels, x_1 and x_2 , and nature has determined ε_1 and ε_2 (according to

the density $\varphi(\cdot)$, the ranking of the individual (observable) output levels $y_1 = x_1 + \varepsilon_1$ and $y_2 = x_2 + \varepsilon_2$ determines which agent receives $\alpha + \beta(y_1 + y_2)$.

To test the model experimentally we restrict ourselves to a specific form of $\varphi(\cdot)$ and $c_i(\cdot)$. In particular, we assume the noise terms ε_i to be uniformly distributed² on $[0, \varepsilon]$ and effort costs $c_i(x_i) = \frac{\gamma}{2}x_i^2$ to be quadratic with $\gamma > 0$ for $i = 1, 2$.

Finally, in our analysis we assume that the participants encounter the tournament repeatedly. Therefore, it makes sense to rely on common(ly known) risk neutrality, and the corresponding expected payoffs of agents $i \in \{1, 2\}$ are

$$Eu_i = \omega(x_i + \frac{\varepsilon}{2}) + \frac{1}{\varepsilon} \int_0^{\varepsilon} h(x_i, x_j, \varepsilon_j) d\varepsilon_j - \frac{\gamma}{2} x_i^2,$$

where

$$h(x_i, x_j, \varepsilon_j) = \begin{cases} 0 & \text{if } x_i \leq x_j + \varepsilon_j - \varepsilon, \\ \frac{1}{\varepsilon} \int_0^{\varepsilon} [\alpha + \beta(x_i + \varepsilon_i + x_j + \varepsilon_j)] d\varepsilon_i & \text{if } x_i \geq x_j + \varepsilon_j, \\ \frac{1}{\varepsilon} \int_{x_j + \varepsilon_j - x_i}^{\varepsilon} [\alpha + \beta(x_i + \varepsilon_i + x_j + \varepsilon_j)] d\varepsilon_i & \text{otherwise.} \end{cases}$$

For $\beta \geq \frac{\gamma\varepsilon}{2}$ there is no finite best reply x_i to x_j . For the case $\beta < \frac{\gamma\varepsilon}{2}$ the unique equilibrium efforts (in the sense of mutually best replies) are

$$x_i = \frac{2\alpha + \varepsilon(3\beta + 2\omega)}{2\gamma\varepsilon - 4\beta} \quad \text{for } i \in \{1, 2\}. \quad (2)$$

Since the principal can implement a three-dimensional incentive scheme (α, β, ω) , the natural problem of cost minimization arises, i.e., finding the cheapest incentive scheme

²Some tournament models (e.g., Lazear and Rosen, 1981) rely on normally distributed noise ε_i for the sake of mathematical convenience. This violation of economic nonnegativity constraints is easily sustainable in theory. However, it is difficult to test such models experimentally without deception.

that yields a given positive (expected) output $y = y_1 + y_2$. Formally, this is equivalent to finding a combination (α, β, ω) that minimizes the linear costs of the principal

$$C_{\alpha, \beta, \omega}(y) = \alpha + (\beta + \omega)y,$$

with $y = \frac{2\alpha + \varepsilon(3\beta + 2\omega)}{\gamma\varepsilon - 2\beta} + \varepsilon$.

Considering the linearity of the problem, it suffices to compare the costs of the three ‘corner’ incentive schemes:

$$(\alpha, \beta, \omega) = \begin{cases} \left(\frac{\gamma\xi\varepsilon}{2}, 0, 0 \right) \\ \left(0, \frac{\gamma\xi\varepsilon}{2\xi + 3\varepsilon}, 0 \right) \\ \left(0, 0, \frac{\gamma\xi}{2} \right), \end{cases}$$

where $\xi = y - \varepsilon$. The corresponding costs are

$$C_\alpha = \frac{\gamma\xi\varepsilon}{2}, \quad C_\beta = \frac{(\xi + \varepsilon)\gamma\xi\varepsilon}{2\xi + 3\varepsilon}, \quad \text{and} \quad C_\omega = \frac{\gamma\xi(\xi + \varepsilon)}{2}.$$

One can easily see that for all nonnegative ξ , ε , and γ , it holds that $C_\beta \leq C_\alpha \leq C_\omega$. Thus, from the principal’s point of view, the premium incentive β is superior to both the piece rate ω and the fixed-prize tournament α .

Proposition 1 *The premium incentive β is more cost-effective than the fixed prize α which, in turn, is more cost-effective than the piece rate ω .*

The result is by no means obvious. When individual output $y_i = x_i + \varepsilon_i$ is assumed to be readily observable and agents are assumed to be risk neutral, one would typically expect piece rate incentives only, which would avoid strategic interaction of agents. Our analysis shows, however, that an employer can gain by implementing tournament competition, and most preferably by using premium incentives – even in those cases where there is no potential for economizing on measurement costs (output is readily observable) and where there is no benefit to eliminating common shocks (risk neutral agents).

While our theoretical analysis neglects the potential of collusive behavior by agents (collusion is most likely for α incentives as agents can share α even when investing very little effort) as well as the fact that competition may endanger feelings of corporate identity (which would seem to be least endangered by ω as agents do not strategically interact at all), both effects may play a role in the experiment.

3 Experimental Design

The experiment was run at the computer laboratory of the Max Planck Institute of Economics with 112 participants, mostly undergraduates of the University of Jena, enrolled in different fields. Each of the four computerized experimental sessions (28 participants per session) lasted about 100 minutes. Earnings, including a show-up fee of € 2.50, ranged from € 4.60 to € 17.44. Upon arrival, each participant was seated in a visually isolated cubicle. Detailed written and oral instructions (to establish common knowledge) explained the rules and payoffs of the game and were followed by a control questionnaire. After the experiment, participants were paid individually and left the laboratory separately. In each session the 28 participants were randomly partitioned into four 7-person groups. In each group, one participant was assigned the role of ‘principal’ and 6 were assigned to be ‘agents’. The 7-person groups remained constant throughout the experiment, and this was made known to the participants. However, they did not know which of the other participants was in their group. Each session was divided into three phases with 10 rounds each.

Each of the three phases began with principals selecting one of 15 available combinations of the three incentives α , β , and ω (displayed in Table 1). This choice set the stage for the interactions of ‘their’ three pairs of agents in the following ten rounds (phase). The principal’s payoff from each agent-pair-interaction was $u_p(x_1, x_2, \varepsilon_1, \varepsilon_2) = (20 - \omega - \beta)(x_1 + \varepsilon_1 + x_2 + \varepsilon_2) - \alpha$, based on the interpretation that principals can sell whatever ‘their’ agents produce at a constant price of 20 per unit and that they must reward the agents according

Contract			Equilibrium			Empirical		
α	β	ω	A-effort	P-profit	A-profit	Frequency	A-effort	P-profit
0	8	0	20	960	320	16	18.08	910
200	6	0	20	920	340	7	18.95	877
400	4	0	20	880	360	5	19.20	872
600	2	0	20	840	380	1	16.27	784
800	0	0	20	800	400	1	16.05	656
0	6	5	20	720	440	6	18.16	690
200	4	5	20	680	460	4	21.44	696
400	2	5	20	640	480	1	19.18	606
600	0	5	20	600	500	0	—	—
0	4	10	20	480	560	3	21.66	500
200	2	10	20	440	580	3	21.80	489
400	0	10	20	400	600	0	—	—
0	2	15	20	240	680	1	23.35	273
200	0	15	20	200	700	0	—	—
0	0	20	20	0	800	0	—	—

Table 1: Available contracts – equilibrium predictions and empirical results

to the chosen contract.

After learning which incentive scheme (α, β, ω) had been implemented by the principal, each agent was randomly paired, in each round, with one of the other five agents in the same group. Agents were not told with whom they were randomly paired. Agent $i \in \{1, 2\}$ could choose the effort level $x_i \in [0, 30]$, knowing that the random variable ε_i takes values $\varepsilon_i \in [0, 40]$ according to the constant density having all probability mass at interval $[0, 40]$ and that both cost functions $c_i(x_i)$, $i \in \{1, 2\}$ are given by $\frac{x_i^2}{2}$, i.e., $\gamma = 1$.

After each round, principals were informed about the production (y_i) of each agent, the joint revenue $(20(y_1 + y_2))$, their cost $((\omega + \beta)(y_i + y_2) + \alpha)$, and their profit (u_p) . This information remained on the principal's screen, and information from the next round was appended to it. Thus, after each phase of 10 successive rounds, the principal had information about all tournaments (three pairs of agents in ten rounds). Additionally, after

each of the three phases, principals received feedback information on average production, revenues, costs, and profits across all thirty tournaments that took place in the phase.

To capture the fact that the organizational structure of a firm is rarely re-designed, and that such changes, when they are made, are mostly made in the light of much experience with a status quo structure, the principals in the experiment could change the incentive scheme only twice. In both cases they completed thirty tournaments before they were allowed to re-structure the incentive scheme.

After each round, agents were informed about both production levels (y_1, y_2) and the α , β and ω components of their earnings before they were randomly rematched with another agent of the same group except for the last round of the phase when they knew that the principal could change the incentive scheme.

All fifteen available contracts yield the same individual equilibrium effort of twenty. If both agents play optimally, i.e., both choose twenty, they suffer when the principal switches to a superior contract from her point of view. In view of such conflicting interests agents may be inclined to collude rather than to compete. Obviously, the strongest incentive for collusion by agents is offered by the pure α -scheme: since the α -component does not depend at all on output, agents can collect α even when effort levels are very low. Such collusion, however, is rather unlikely, since agents are randomly rematched with one out of five possible partners in each period. Similarly, one may ask whether a group consisting of one principal and six agents, rematched to three work teams in each period, might develop something like a ‘corporate identity’ and aim at group efficiency. Such potential efficiency seeking, however, is unproblematic since equilibrium efforts are also efficient due to rent dissipation (Tullock, 1980).³

³In the sense of symmetric efforts maximizing the firm’s expected surplus $p(y_1 + y_2) - \frac{\gamma}{2}(x_1^2 + x_2^2)$.

4 Results

4.1 Agents' Choice of Effort

The first part of our analysis examines agents' efforts whose dynamics of group averages are graphically illustrated in Figure 1 of the Appendix. Since the equilibrium effort is always twenty, regardless of the contract installed by the principal, we first check whether agents' efforts are indeed identical across all chosen contracts. For this we check whether the contract, characterized by the principals' equilibrium profit, or by the *level*⁴ of each contract component (α, β, ω) associated with it, is a good predictor of the effort invested by agents. We use Tobit regressions, taking into account that only observations across groups are independent, with the agents' efforts as a dependent censored variable.⁵ The result is that agents systematically deviate from their equilibrium effort of twenty; when we use the principals' theoretical profit as a predictor, the coefficient is -0.00744 ($Z = -4.05$, $p < 0.0005$). The small value of the coefficient is somewhat misleading and results from the difference in scales between the theoretical payoffs (0 to 960) and the effort level intervals agents could choose from (0 to 30). The interpretation of the coefficient is straightforward; the more profitable a contract is for the principal, the lower the effort invested by agents. Specifically, an increase of 100 points in the principal's theoretical payoff results in a decrease of 0.744 in the agents' effort. Considering the 960-point difference between the minimal and maximal theoretical payoffs, the effect on the agents'

⁴For the purpose of the this and the following analyses we use the *level* of each contract component rather than the absolute value. For example, while the possible values of the α component are 0, 200, 400, 600, and 800, the variable included in the analyses has corresponding possible values of 0, 1, 2, 3, and 4. The same holds for the β and ω components.

⁵Each of these Tobit regressions uses only one explanatory variable (the principal's equilibrium profit, the level of the α component, the level of the β component, or the level of the ω component). It is not possible to include all of these as explanatory variables in the same regression model because they are not really distinct from each other; the level of each contract component can be determined by the other two, and it follows that the principals' equilibrium profit can also be determined by the levels of any pair of components.

efforts could be substantial.

When we use the level of each of the contract components, rather than the principal's theoretical profit, as explanatory variables, additional Tobit regressions reveal that agents react differently to each component. Figure 2 in the Appendix, which should be self-explanatory, visualizes the dependency of mean effort separately on α , β , ω and the equilibrium profit of the principal, depending on contract choice. The coefficient on the level of the ω component is 1.78 ($Z = 3.83$, $p < 0.0005$), indicating a rather strong and positive relation between the level of ω and the agents' efforts. For the β component the coefficient is -0.78 and only marginally significant ($Z = -1.57$, $p = 0.116$), indicating that agents possibly exert less effort the higher the level of the β component. Most strikingly, agents were not sensitive at all to the α component of the contracts (coefficient: -0.18 , $Z = -0.30$, $p = 0.763$), the main incentive component in nearly all the tournament literature.

Given the negative relation between the principal's equilibrium profit and the agents' effort, principals' (empirical) profits are clearly higher than the equilibrium profit for the relatively inferior (from the principals' point of view) contracts and lower for the relatively superior contracts. Possibly, such a pattern could lead to a situation, where theoretically superior contracts are empirically inferior (and vice versa). However, this is not the case; using principals' theoretical profit to predict their actual profit in a linear regression (taking into account that only observations across groups are independent) reveals a very strong and positive relation. The coefficient of the theoretical profit is 0.67 ($t = 5.47$, $p < 0.0005$), indicating that an increase of 1 point in the theoretical profit was accompanied by an increase of 0.67 points in the actual profit. The data in Table 1 also makes it clear that the principal's theoretical and actual profits are closely linked and that, despite the pattern of agents' deviations from their equilibrium effort of twenty, principals enjoyed higher profits when they chose the theoretically superior contracts.

Agents' efforts may, of course, adjust during the ten rounds of each phase. However, including the period number as an explanatory variable along with the principals' equilibrium

profit in a Tobit regression yields an insignificant coefficient of -0.10 ($Z = -0.94$, $p = 0.345$). To exclude effects of experience from previous phases we ran the same regression for first-phase decisions only, which also yielded an insignificant result (coefficient: -0.014 , $Z = -0.07$, $p = 0.940$), leading us to conclude that effort choices do not reveal any systematic dynamics during phases with constant contracts.

Result 1 *Agents systematically deviate from the equilibrium effort of twenty; the better a contract is for the principal (in equilibrium), the less effort agents choose to invest. Efforts are positively related with ω , negatively with β , and are not related at all with α . However, agents' actual efforts do not question the theoretical ranking of contracts from the principal's point of view. Effort choices during all ten-period phases are rather stable.*

4.2 Principals' Choice of Incentive Scheme

The second part of our analysis examines the contract choice by principals. In Figure 3 in the Appendix, we visualize separately for α , β , ω , and the principal's equilibrium profit how the frequency of contract choices depends on each of them. Since the contracts are clearly ranked in terms of the equilibrium profit of the principal, and especially since the empirical profits closely preserve this ranking, we checked if principals indeed chose contracts that were more profitable to them, namely, contracts with a high β (and α) component and a low ω component. The data in Table 1 makes it clear that this is mostly the case. Both the contracts' theoretical and empirical profits are highly correlated with the frequency with which they were chosen ($r = 0.61$, $p = 0.0161$; $r = 0.60$, $p = 0.049$, respectively). Principals display a very strong tendency to choose contracts with high β levels ($r = 0.90$, $p < 0.0001$), and a weaker tendency to rely on contracts with low ω levels ($r = -0.50$, $p < 0.0594$). The correlation between the level of the α component and the contracts' frequency is negative and marginally significant ($r = -0.4056$, $p < 0.1337$).

Do principals change their contract choices in a systematic way during the experiment? Although principals have only two opportunities to adapt the contract – once after the first

Comparison	Equilibrium profit		Empirical profit	
	S	p	S	p
Phase one – phase two	-14.5	0.2622	-5	0.8209
Phase one – phase three	-6.0	0.6338	-11	0.5966
Phase two – phase three	10.5	0.4033	5	0.8209

Table 2: Principals' contract design dynamics. S – Wilcoxon signed rank sum test statistic; p – significance level

phase and once after the second – they do receive a great deal of feedback information (thirty tournaments per phase), making it reasonable to expect that they will choose more favorable contracts as the experiment progresses, e.g., due to the 'law of effect,' as propagated by reinforcement learning.

To check for systematic changes in principals' contract choices across phases, we compared for each principal her theoretical profits of the contracts chosen in the first and second phase. Similarly, we compared 'first phase – third phase' and 'second phase – third phase.' We conducted equivalent comparisons for the empirical profits. Wilcoxon signed rank sum tests, however, do not reveal any systematic differences (Table 2).

It should be noted that the lack of noticeable dynamics in principals' contract choices may, at least partly, be due to the fact that in many cases principals already started out by relying heavily on premium incentives (β) and that any contract dynamics therefore would have meant adopting worse contract schemes.

Result 2 *Principals chose the superior contracts. They were primarily sensitive to the β component of their contract choices.*

5 Discussion and Conclusions

Tournaments are often used by firms and organizations to inspire their agents' performance and supplement the usual reward schemes for employees, like salaries or piece rates. The general reward scheme and the specific rules of such tournaments do not only inspire higher efforts but also have many quite diverse side effects, e.g., crowding out of intrinsic motivation (e.g., Frey and Jegen, 2001) or fostering of collusive behavior – both of which we excluded from our theoretical and experimental analysis.

Nonetheless, we derived an important and – to the best of our knowledge – new result: tournament compensation systems, especially if they come in the form of premium incentives, *outperform* piece rates even in cases where individual output is readily observable and agents are risk neutral. In the organizational practice the comparative advantage of premium incentives as opposed to piece rates is further supported by the former's ability to economize on monitoring and measurement costs (a tournament requires only ordinal information on individual performance) and to reduce agents' risk exposure by eliminating common shocks. While the latter two arguments apply to traditional fixed-prize tournaments and premium incentives alike, premium incentives have the additional advantage that they bear less potential for the collusion of agents since collusion will result in lower firm performance and hence lower the tournament prize. However, when compared to traditional fixed-prize tournaments, premium incentives have the disadvantage of additionally exposing agents to the risks inherent in the production process: not only is the probability of winning the tournament affected by the amount of idiosyncratic risk but also the size of what is at stake. While in real-life tournaments with risk averse agents this effect may overcompensate the cost advantage of premium incentives such that traditional fixed-prize tournaments are superior, our laboratory findings for the (usually risk averse) student participants do not suggest that this is the case.

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Appendix

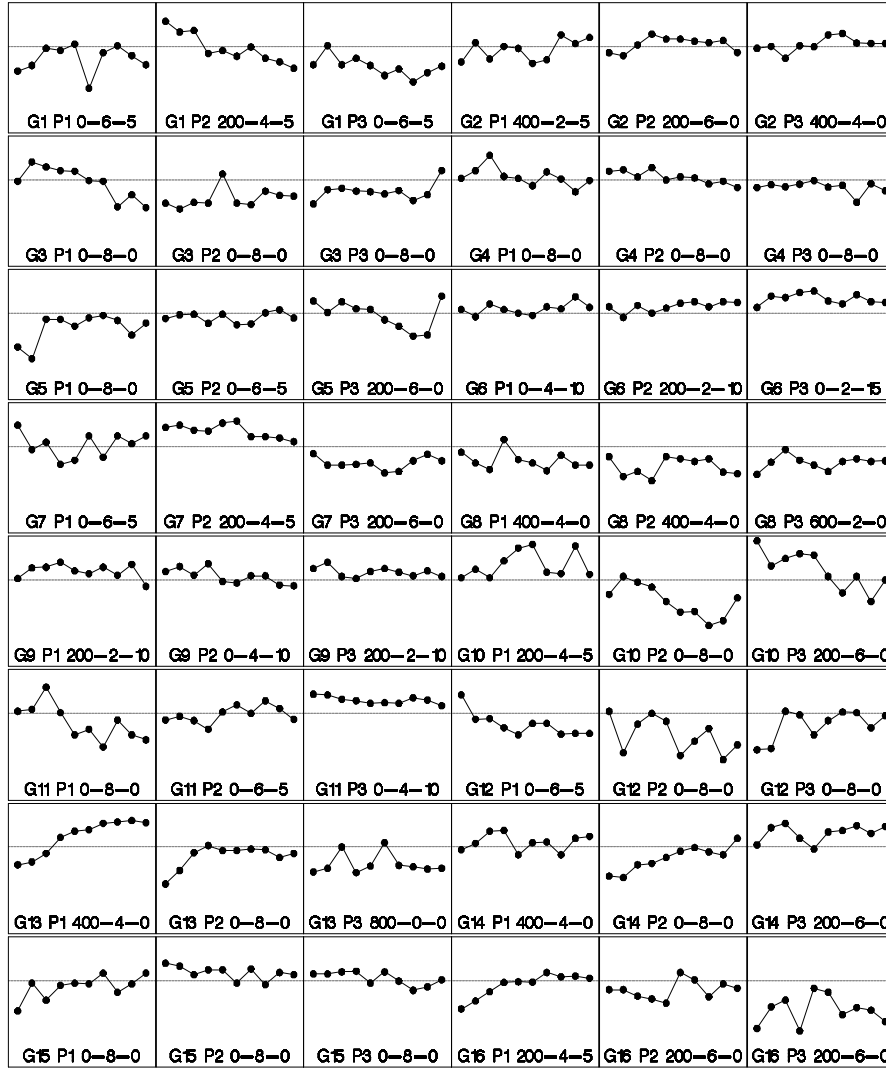


Figure 1: **Mean group efforts – all observations.** Each of the 48 (16 groups $\times$ 3 phases) plots describes average efforts for a specific group in one (10-round) phase. The horizontal axis in each plot is the ‘round’ axis, going from 1 (left) to 10 (right), and the vertical axis is the effort axis, going from 0 (bottom) to 30 (top). The horizontal line in each plot marks the equilibrium effort of 20. Each plot is labeled with information regarding the group, phase, and the contract that was in effect. The group number (1-16) is prefixed by ‘G’, the phase number (1-3) by ‘S’; the 3 numbers separated by dashes pertain to the α , β , and ω components of the contract that was chosen by the principal for the phase. For example, the top left graph is labeled ‘G1 P1 0-6-5’. This means that the data pertains to average efforts of group number one during the first phase, and that the principal chose $\alpha = 0$, $\beta = 6$, and $\omega = 5$.

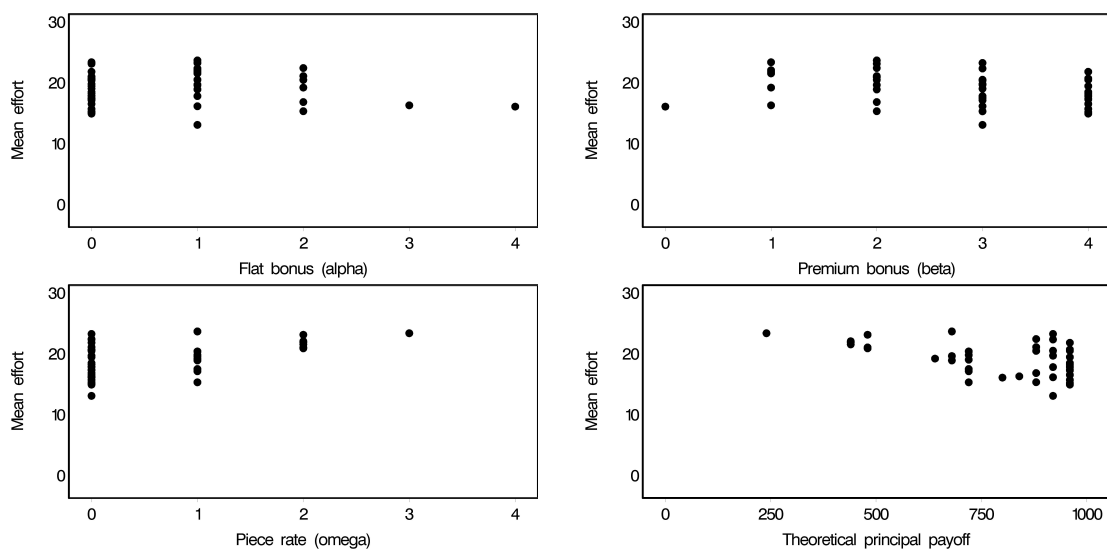


Figure 2: Mean efforts of agents as a function of the level of each contract component and of the theoretical principal payoff. Each dot represents the average efforts of members of a single group in one phase.

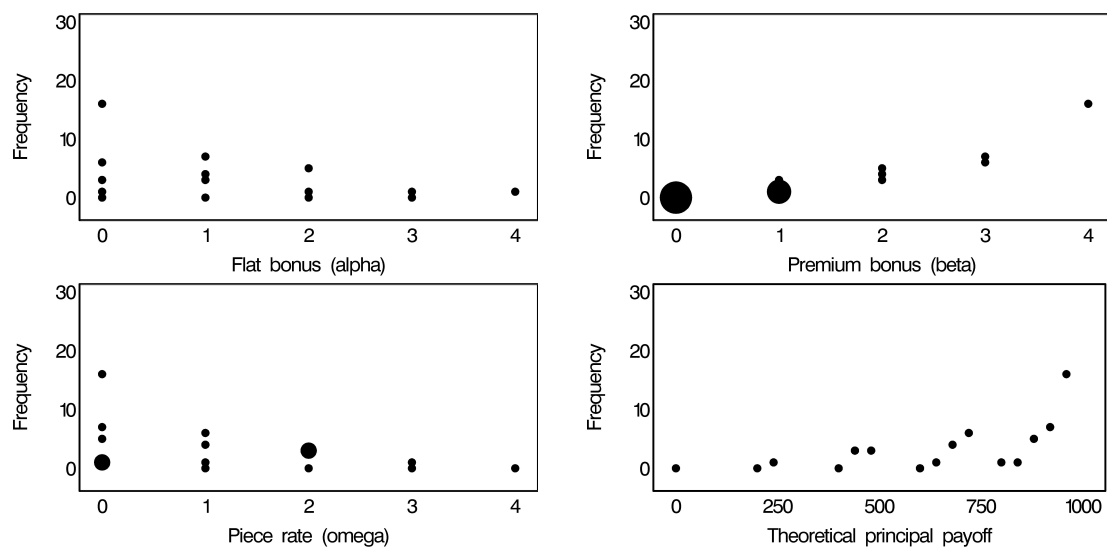


Figure 3: Frequency of contract choices as a function of the level of each contract component and of the theoretical principal payoff. Each small dot represents one of the 15 available contracts. Larger dots indicate that multiple contracts share the same frequency and horizontal-axis value.