Does Self-Selection Improve the Efficiency of Tournaments?

Tor Eriksson [a] Sabrina Teyssier[b] Marie-Claire Villeval [c]

July 21, 2005

Preliminary version

Abstract

Rank-order tournaments have incentive properties but their overall efficiency is reduced by a high variance in performance (Bull, Schotter and Weigelt, 1987). As emphasized by Lazear (1986, 2000) the efficiency of performance-related pay is attributable both to its incentive effect and to its sorting effect among employees. However, we know very little about the ex ante sorting effect of tournaments. This paper reports results from an experiment analyzing whether allowing subjects to self-select into different payment schemes helps in reducing the variability of performance in tournaments. We show that when the subjects choose to enter a tournament, the average effort is higher and the between-subject variance is substantially lower than when the same payment scheme is imposed. Sorting is efficiency-enhancing since it increases the homogeneity of the contestants. Our results suggest that the flexibility of the labor market is an important condition for a higher efficiency of relative performance pay.

JEL-Codes: M52, J33, J31, C81, C91.
Keywords**:** Tournament, Performance Pay, Incentives, Sorting, Experiment.

[a] Aarhus School of Business, Department of Economics and Center for Corporate Performance, Prismet, Silkeborgvej 2, 8000 Aarhus C, Denmark. Email: tor@asb.dk

[b] GATE (CNRS – University Lumière Lyon 2 – Ecole Normale Supérieure LSH), 93, chemin des Mouilles 69130 Ecully, France. Email : teyssier@gate.cnrs.fr

c GATE (CNRS – University Lumière Lyon 2 – Ecole Normale Supérieure LSH), 93, chemin des Mouilles 69130 Ecully, France, and Institute for the Study of Labor (IZA), Bonn, Germany. Email : villeval@gate.cnrs.fr

1. Introduction

While performance-pay systems have expanded significantly in many countries, the use of promotion tournaments is still fairly widespread especially in the higher ranks of firms and organizations. Why firms use payment schemes based on relative performance is not completely clear, however (Prendergast, 1999). The incentive property of tournaments has been studied extensively in the theoretical literature (Lazear and Rosen, 1981; Green and Stokey, 1983; Nalebuff and Stiglitz, 1983; O'Keeffe, Viscusi and Zeckhauser, 1984; for a survey see McLaughlin, 1988). The empirical studies are fewer, and many based on sports rather than business data, have confirmed that this efficiency depends on the spread between the winner's and the loser's prizes, the number of prizes at stake, the size of the tournament, and the degree of uncertainty faced by the employees (Bognanno, 2001; Ehrenberg and Bognanno, 1990a, 1990b; Eriksson, 1999; Knoeber and Thurman, 1994; Main, O'Reilly III and Wade, 1993). These predictions have also gained support from a series of experimental studies (Bull, Schotter and Weigelt, 1987; Harbring and Irlenbusch, 2003; Nalbantian and Schotter, 1997; Orrison, Schotter and Weigelt, 2004; Schotter and Weigelt, 1992; van Dijk, Sonnemans and van Winden, 2001).

However, both theoretical models and empirical studies also point to some factors that limit the incentive effect of tournaments. Since only relative performance matters, tournaments may stimulate collusion among employees. On the other hand, relative performance games may reduce cooperation and even encourage sabotage (see Lazear, 1989 for a theoretical analysis and Harbring and Irlenbusch, 2004 for some experimental evidence). While the studies confirm the importance of the structure of tournaments on their incentive effect, most laboratory experiments have provided evidence of tournaments being associated with a high variance in effort (see in particular Bull, Schotter and Weigelt, 1987 and Harbring and Irlenbusch, 2003; van Dijk, Sonnemans and van Winden, 2001). The variance of effort is found to be larger in symmetric tournaments than in an equivalent piece-rate scheme. This variability reduces the overall efficiency of tournaments.

Bull, Schotter and Weigelt, 1987 explain the variability observed by the game nature of the tournament, which requires the agents to elaborate a strategy that is more cognitively demanding than the maximizing behavior required by a piece-rate system. In addition to the stochastic technology of production, the agents have to cope with strategic uncertainty.[1] Vandegrift and Brown, 2003 show that the relationship between the difficulty of the task and the ability of the subjects explains the use of high-variance strategies. Typically in such experiments, all the subjects are exogenously imposed a competitive compensation. Therefore, very risk averse subjects may choose the minimum effort to kill both sources of uncertainty; at the opposite, some can choose the maximum effort to manage strategic uncertainty. Both strategies are clearly inefficient. Had the subjects been given the choice between various compensation schemes, very risk averse subjects would probably not have entered the competition. In real businesses and markets people are not always obliged to compete: they can shy away from competitive occupations or can choose not to apply for promotions. Employees prefer tournaments to individual pay if they expect their relative performance to be higher than that of the other employees. In contrast, very risk averse or underconfident employees avoid tournaments because they are not attractive to them.

[1] The variance is diminished when the subjects play against an automaton known to choose the number 37 (=e*) repeatedly. In this case, both conjectural and informational problems are eliminated. When more information is given to the subjects about the outcome of his human competitor only, variance is not reduced. When the subjects play against an automaton known to play repeatedly the same number but this number remaining secret, the variance remains high. The comparison between these treatments leads the authors to relating the observed variance to the strategic nature of the game.

The aim of this paper is to analyze whether the performance variability is reduced by the *ex ante* sorting effect of tournaments. More generally, the efficiency of performance pay schemes derives not only from their incentive effect but also from their selection effect, i.e. their ability to attract the best performers and to weed out the underdogs (for a theoretical model, see Lazear, 2004, 2000, 1986). [2] There are only a few empirical tests of sorting (Cadsby, Song and Tapon, 2004; Eriksson and Villeval, 2004 on sorting and abilities in the context of incentives; Lazear, Malmendier and Weber, 2005 on sorting in the context of social preferences; Camerer and Lovallo, 1999 on sorting and overconfidence in a market entry game; Bohnet and Kübler, 2004 on sorting and cooperation in a prisoner's dilemma game). These experimental studies point out the importance of sorting on economic behavior. It is thus essential to check the robustness of results previously obtained on behavior in tournaments to the introduction of a possibility for the subjects to decide to enter or not a competitive compensation scheme. The key hypothesis we examine is that self-selected entry into tournaments stimulates agents to exert a higher effort with lower variability. If this hypothesis is accepted, the *ex ante* sorting is efficiency-enhancing since it decreases the variance of performance and raises effort by making the pool of competitors more homogenous. Beyond this, and as suggested by Lazear, Malmendier and Weber, 2005, if the effect of sorting is confirmed, allowing subjects to self-select in the game they are willing to play increases the external validity of laboratory experiments since markets allow people to self-select.

[2] In the Safelite case study (Lazear, 2000), half of the productivity gains associated with the introduction of a variable pay scheme are attributable to its incentive effect and the other half to its sorting effect by retaining and attracting skilled employees.

Earlier, the sorting function of tournaments has mainly been documented with respect to their ability to select *ex post* the best performers by having individuals compete with one another.[3] However, the *ex ante* sorting effect is considerably less studied.[4] Ehrenberg and Bognanno, 1990a show that higher winners' prizes attract better players and Knoeber and Thurman, 1994 propose setting minimum standards to get rid of the poor performing competitors. Dohmen and Falk, 2005 compare tournaments to lump-sum compensation. Vandegrift, Yavas and Brown, 2004, Datta Gupta, Poulsen and Villeval, 2005, Niederle and Vesterlund, 2005 identify a gender effect in the sorting effect of tournaments. However, none of the previous studies have been concerned with the impact of sorting on the variability of performance.

Our laboratory experiment is designed to study the ex ante sorting effect of compensation schemes in the context of uncertainty and its impact on their incentive effect. We compare two treatments: a Benchmark and a Choice treatment, respectively. In the former, half of the subjects are exogenously imposed a piece-rate payment scheme and the other half enter the tournament. The task consists of choosing an effort level. The Choice Treatment is a two-stage game. In the first stage, the subjects have to choose between a piece-rate scheme and a tournament. Those who choose the tournament are paired together. In the second stage, the subjects decide on their level of effort.

In both treatments, the individual outcome depends on both the effort level and an *i.i.d.* random shock. The difference between the two payment schemes emanates from the strategic uncertainty associated with the tournament setting. In the tournament, we inform the subjects

[3] Regarding asymmetric tournaments, see e.g., Schotter and Weigelt, 1992; Harbring and Ruchala, 2003; Orrison, Schotter and Weigelt, 2004

[4] In the theoretical literature, Fullerton and McAfee, 1999 propose an auction design in order to limit the entry into tournaments to selected highly qualified contestants. Hvide and Kristiansen, 2003 show, however, that the selection efficiency of tournaments is not necessarily increased by improving the quality of the contestant pool. Krakel, 2004 draws the implications for self-selection of introducing an assumption of limited liability: in case of high risk, tournaments are dominated by piece-rate schemes despite their partial insurance effect.

about the difference between their own and the competitor's outcomes, but effort is not observable. The expected utility of both compensation schemes is the same, and hence, risk-neutral subjects should be indifferent between the two schemes. The equilibrium effort level is, however, higher in the tournament than under the piece-rate scheme. By comparing the subjects' behavior in the two treatments, we can identify precisely the impact of sorting on the average and the variance of effort. We also seek to identify determinants of self-selection. Risk aversion is a potential candidate. We measure the subjects' risk aversion by using the lottery procedure proposed by Holt and Laury, 2002.. The degree of risk aversion is then related to the choice of the compensation scheme and to the effort decision. In addition, we perform a cluster analysis to investigate further the behavior of the subjects.

In summary, we find, in line with earlier experiments, that in the Benchmark treatment, the variance of effort is vastly higher in the tournament than in the piece-rate payment scheme. The key novel finding is that the employees' choice of pay schemes contributes to a considerable reduction in the variance of effort among contestants in the tournament. Moreover, the average effort is higher when the subjects can select their payment scheme, like in most labor markets, which suggests that the sorting effect reinforces the incentive effect of both tournaments and variable pay schemes. The subjects self-select notably according to their degree of risk aversion. The cluster analysis identifies two groups of frequent contestants: motivated competitors characterized by a high eagerness to exert effort to win the competition and steady competitors who mainly rely on chance to win. Underconfident and hesitant subjects tend to shy away from competition. The resulting higher homogeneity of contestants improves the overall efficiency of tournaments.

The remainder of the paper is organized as follows. Section 2 presents the theoretical framework and the experimental design. Section 3 gives the experimental procedures. Section 4 describes and analyzes the experimental evidence. Section 5 discusses the results and concludes.

2. Theory and Experimental Design

2.1. The model

Consider an economy with identical, risk-neutral agents. Agent *i* has the following utility function, separable in payment and in effort:

$$U_i(e_i) = u(p_i) - c(e_i) \tag{1}$$

with $u(p_i)$ concave and $c(e_i)$ convex.

The production technology is stochastic and output is increasing in the agent's effort:

$$y_i = f(e_i) + \varepsilon_i \tag{2}$$

with $f(e_i) = e_i$ for the sake of simplicity and ε_i is an *i.i.d.* random shock distributed over the interval [$-z$, $+z$]. The individual random term could also be interpreted as an imperfection in the evaluation of individual performance. As a matter of fact, individual effort is observable by neither the principal nor the other agents. Only individual outcomes are observable.

The cost function is increasing and convex:

$$c(e_i) = \frac{e_i^2}{s} \tag{3}$$

with $s > 0$, $c(0) = 0$, $c'(e_i) > 0$ and $c''(e_i) > 0$.

In the labor market, some firms pay the agents a piece-rate compensation scheme and other firms use tournaments. If there is a perfect mobility in the labor market at no cost, in the first stage the agents choose their firm (i.e. their payment scheme) and, in the second stage, they decide on their level of effort. Let us first solve the equilibrium effort levels under each mode of payment.

In the piece-rate system, the agent's payment depends only on his own outcome. The payment consists of a fixed wage, denoted by *a*, corresponding to an input-based payment, and a linear piece-rate, denoted by *b,* corresponding to an output-based payment. Under this compensation scheme, the agent's utility function becomes:

$$U_i^{PR}(e_i) = a + b.y_i - \frac{e_i^2}{s} \tag{4}$$

The first order condition is:

$$\frac{\delta U_i^{PR}}{\delta e_i} = b - c'\left(e_i\right) = 0$$

Thus, the equilibrium effort of each agent under the piece-rate payment scheme depends positively on both the incentive, *b*, and the cost scaling factor, *s*:

$$e^{PR*} = \frac{b.s}{2} \tag{5}$$

In the firms practicing tournaments, the agents play a non-cooperative game with incomplete information like in Lazear and Rosen, 1981. In tournaments with two symmetric players, two prizes are distributed: *W* is the winner's prize allocated to the agent whose outcome is the highest and *L* is the loser's prize, allocated to the other agent, with *W* > *L*. The amount of the difference between the two outcomes does not enter into account in the determination of the winner of the tournament. The agent's utility is:

$$U_i^T\left(e_i,e_j\right)=\begin{cases} W-c\left(e_i\right) & if \quad y_i>y_j \\ L-c\left(e_i\right) & if \quad y_i<y_j \end{cases} \tag{6}$$

The agents being symmetric, the probability to win the tournament, $pr(e_i,e_j)$, reduces to the probability that the difference in individual random terms exceeds the difference between individual effort levels: $pr\left(e_i,e_j\right)=pr\left(\varepsilon_i-\varepsilon_j>e_j-e_i\right)$.

Agent *i*'s expected utility of the tournament is:

$$EU_i^T\left(e_i,e_j\right)=L+\left[pr\left(e_i,e_j\right).\left(W-L\right)\right]-\frac{e_i^2}{s} \tag{7}$$

We could write the symmetric expected utility for agent *j*. The maximization program yields the following first order condition:

$$\frac{\delta EU_i^T\left(e_i,e_j\right)}{\delta e_i}=\frac{\delta pr\left(e_i,e_j\right)}{\delta e_i}\left(W-L\right)-\frac{2e_i}{s}=0 \tag{8}$$

We obtain a pure symmetric Nash equilibrium, where effort increases with the prize spread and decreases with the cost of effort and with the size of the distribution of the random shock:

$$e_i^{T*}=e_j^{T*}=e^{T*}=\frac{\left(W-L\right).s}{4z} \tag{9}$$

Having determined the equilibrium effort level under each payment scheme, we now turn to the first stage problem. The agent chooses his firm by comparing his expected utility under each payment scheme. He is indifferent between the two schemes when:

$$0.5W+0.5L-\frac{\left[\dfrac{\left(W-L\right).s}{4z}\right]^2}{s}=a+b.\frac{b.s}{2}-\frac{\left(\dfrac{b.s}{2}\right)^2}{s} \tag{10}$$

2.2. The experimental design

The instructions have been kept as close as possible to Bull, Schotter and Weigelt, 1987 to facilitate comparisons (translated instructions from French to English are given in Appendix).

Treatments. The experiment consists of two treatments. In the Benchmark Treatment a single decision is made: the choice of the level of effort, knowing the cost function, the distribution of the random term and the compensation rule. An important difference from the set-up in Bull, Schotter and Weigelt, 1987, is that in a session, half of the subjects have been exogenously and randomly attributed a piece-rate payment scheme and the other half a tournament scheme, instead of organizing separate all-piece-rate sessions and all-tournaments sessions. The proportion was unknown to the subjects but the latter were aware of the coexistence of two modes of payment. This choice is motivated by the willingness to keep the social environment comparable with that of the Choice Treatment in which both schemes coexist in the same session in unknown proportions to the subjects. In order to provide the subjects with an opportunity to learn to play the game, they face the same payment scheme throughout the session.

The Choice Treatment is similar to the Benchmark Treatment except that in the first stage of each period, the subjects have to choose to be paid according to either a piece-rate scheme or a tournament scheme. Those who have opted for the tournament are pooled together and paired. In case of an uneven number of contestants, one subject is randomly chosen and paid according to a piece-rate scheme; he is informed of this before choosing his level of effort. The game is repeated 20 times and there is no mobility cost, i.e. the subjects are free to move to the other payment scheme as many times as they like.

Matching protocol. Unlike the conventional experiments on tournaments we do not implement a partner matching protocol but adopt a stranger matching protocol instead. An advantage of the latter protocol is that it allows us to check the stability of previous results in a slightly different environment. This choice results from the constraint of the Choice treatment: if we had used a partner matching protocol, a subject who would like to choose the tournament and who is paired with a subject who always chooses the piece-rate scheme, would then be prevented from competing throughout the game. A drawback is that we may reinforce the complexity of the tournament game due to conjectural variations since the subject has no indication about the past behavior of his opponent and its stability and thus it is harder for him to make inferences about his opponent's behavior.[5]

Choice of the parameters. Effort can take any integer value in the set: $e_i \in \{0,1,...,100\}$. In the cost function, s = 150, so that $c(e_i) = \frac{e_i^2}{150}$. The random shocks vary in the interval [-40,+40]. In the tournament, the winner's prize has been set at W = 96 and the loser's prize at L = 45. In the piece-rate scheme, the fixed wage, a, amounts to 45 and the piece-rate, b, is equal to .52, meaning that each unit of outcome gives .52 to the agent. These values have been selected so that the certain payment (either the fixed wage or the loser's prize) is the same under both payment schemes. Consequently, the difference between the payment schemes is only due to the strategic uncertainty associated with the tournament.

Given these values, and assuming the agents to be risk neutral and rational, those who are paid according to a piece-rate system should provide the effort e_i^{PR*} = 39, according to equation (5);

[5] Bull, Schotter and Weigelt, 1987, show that, in fixed pairs, providing the subjects with a feedback on the effort chosen by the opponent (not only the rank or the outcome) does not reduce the variance of effort. This tends to reject the errors in inference explanation of the variance. Moreover, it indicates that our use of a stranger protocol is not a major problem since information about past behavior does not facilitate the task of the subjects.

those who enter the tournament should provide the effort e_i^{T*} = 48, according to the pure strategy Nash equilibrium in equation (9). No player has an incentive to work harder since her cost increases in the level of effort. The players should be indifferent between the two payment schemes since $EU_i^{PR} = EU_i^{T} = 55$ but by choosing the tournament they have to work harder than in the piece-rate scheme.

Elicitation of risk aversion. One would expect that risk aversion to play a role in the effort decision in the Benchmark treatment and in the selection of the payment scheme in the Choice Treatment. Risk averse subjects tend to reduce their effort level under each mode of payment; they are also more likely to prefer a piece-rate scheme since they avoid the strategic uncertainty linked to the tournament (Lazear and Rosen, 1981). To elicit the risk aversion of our subjects, we used the lottery procedure proposed by Holt and Laury, 2002.

At the end of the session, the subjects had to fill out a questionnaire with 10 decisions (see the instructions taken from Holt and Laury in Appendix). Each decision consists of a choice between two paired lotteries, “option A” and “option B”. The payoffs for options A are either €2 or €1.6, while the riskier options B pay either €3.85 or €0.1. In the first decision, the probability of the high payoff for both options is 1/10. Only a very risk loving subject should choose option B. In the second decision the probability increases to 2/10. Similarly, the chances of receiving the high payoff for each decision increases as the number of the decision increases. When the probability of the high payoff is high enough, subjects should cross over from option A to option B. Risk neutrality corresponds to a shift at the fifth decision, while the risk loving subjects are expected to move earlier and the risk averse subjects as from the sixth decision. The subjects had to make 10 decisions but only one decision was selected at random for payment.

3. Experimental Procedures

The experiments have been conducted at the GATE (Groupe d'Analyse et de Theorie Economique) laboratory, Lyon, France. The experiment was computerized, using the Regate software (Zeiliger, 2000). We recruited 120 under-graduate students from three local business or engineering schools, trying to guarantee a fair gender distribution of participants in each session (we had in fact 46% of male participants in total). No subject participated in more than one session. Six sessions with 20 subjects in each have been organized; 3 for the Benchmark Treatment and 3 for the Choice Treatment. Thanks to the 20 repetitions of the game, we thus collected a total of 2400 observations.

Upon arrival, each subject was randomly assigned a computer. Instructions, written in the same neutral terms as Bull, Schotter and Weigelt's, were distributed and read aloud. Attached to the instructions was a sheet displaying the decision costs associated with each possible effort from 0 to 100. Questions were answered in private. To make sure that the participants had understood the instructions, they had to answer a series of questions about the computation of payoffs under each payment scheme. The experiment started once all the participants answered correctly. No communication was allowed.

In the Benchmark Treatment, at the beginning of the session and for its whole duration 10 subjects were attributed the piece-rate payment scheme and 10 the tournament scheme. In the Choice Treatment, in each period they had to tick either the "*mode X*" (piece-rate) box or the "*mode Y*" (tournament) box to choose their payment scheme for the current period. In both treatments, they selected their effort ("*their decision number*") by means of a scrollbar on their computer screen. This being done, they had to click a button to generate their "*personal random number*" that was added to their effort choice to constitute their individual outcome (‘*their result*”). Under the tournament pay scheme, the computer program compared the outcomes of the two contestants in each pair and determined who was to receive the winner’s prize (“*the fixed payment M*”) and who to get the loser’s prize (“*the fixed payment L*”). In case of a tie, a fair random draw determined the allocation of prizes among the pair members. At the end of the period, each subject received a feedback on his payoff and in case of a tournament, on the difference between his outcome and his competitor’s outcome. In each new period, the pairs involved in a tournament were randomly reconstituted.

After the completion of the 20 periods, the risk aversion post-experimental questionnaire was distributed and read aloud. Subjects noted on their sheet of paper the option they chose for each of the 10 lottery decisions. After all participants had made their decisions, they were asked to enter one at a time into a separate room. Then, they had to throw a ten-sided die twice: once to select the decision to be considered and a second time to determine the payoff for the option chosen, A or B.

All the transactions, except the lottery, were conducted in points, with conversion into Euros at a rate of 80 points = €1. Payment consisted of the sum of payoffs during each period plus the lottery payment and a €3 show-up fee. On average, the subjects earned €17.4. The sessions lasted approximately 60 minutes, excluding the lottery draw and payment that were made in private in separate room for confidentiality.

4. Experimental Results

4.1. Mean and Variance of Effort

First, we need to check whether we observe in our Benchmark treatment, like in the previous experiments, both a higher mean and a greater variance of effort under the tournament than under the piece-rate pay scheme.

Table 1.
Summary statistics on average level and variance of effort

	Average effort					Mean variance of effort				
Periods	All	1	20	1-10	11-20	All	1	20	1-10	11-20
Piece-rate										
Benchmark Tr.	46.48	55.73	45.37	48.92	44.04	368.88	388.06	364.79	380.29	354.84
Choice Tr.	50.45	47.63	48.53	51.33	49.66	227.87	192.37	177.83	221.86	231.72
Tournament										
Benchmark Tr.	53.28	60.03	46.70	55.62	50.94	652.26	663.76	627.32	674.42	633.46
Choice Tr.	61.57	65.75	56.92	63.35	59.75	258.19	319.38	394.95	238.44	259.73

Table 1 displays summary statistics about the mean and the distribution of effort by payment scheme and by treatment. In the Benchmark treatment, we observe that the average effort is 46.5 under the piece-rate scheme and 53.3 in the tournaments. These numbers are significantly above the equilibrium effort levels (39 and 48, respectively; t-test, p=0.000). As predicted, if we consider all observations as independent, the agents exert more effort in a competitive setting (Mann-Whitney U test, p=0.000). As regards the variance of effort in tournaments, our results corroborate those of previous experiments. Averaging over all the periods of the game, the total variance is 369 under the piece-rate scheme and 652 in tournaments. Thus, also in our experiment, the variability of effort is clearly higher under the competitive pay scheme. Note, moreover, that the use of a stranger matching protocol, although reinforcing the complexity due to strategic variability, does not seem to have a significant impact on the magnitude of the variance.

Next, we turn to consider the influence of the possibility given to the subjects to choose their payment scheme. Table 1 and Figure 1 reveal a dramatic increase of the average effort in the tournaments when we compare the Choice Treatment with the Benchmark Treatment; average effort amounts to 61.6 in the former and to 53.3 in the Benchmark Treatment. Interestingly, average effort also increases from 46.5 in the benchmark to 50.4 for the agents who choose to be paid a piece-rate. As a consequence, the differences relative to the equilibrium effort values are even larger when agents self-select. As for the tournaments, we may note that while the subjects on average play the equilibrium effort in the last four periods in the Benchmark Treatment, this kind of behavior cannot be observed in the Choice Treatment although there is a slight decline in effort over time. The choice of the payment scheme tends to slow down the convergence to the equilibrium.

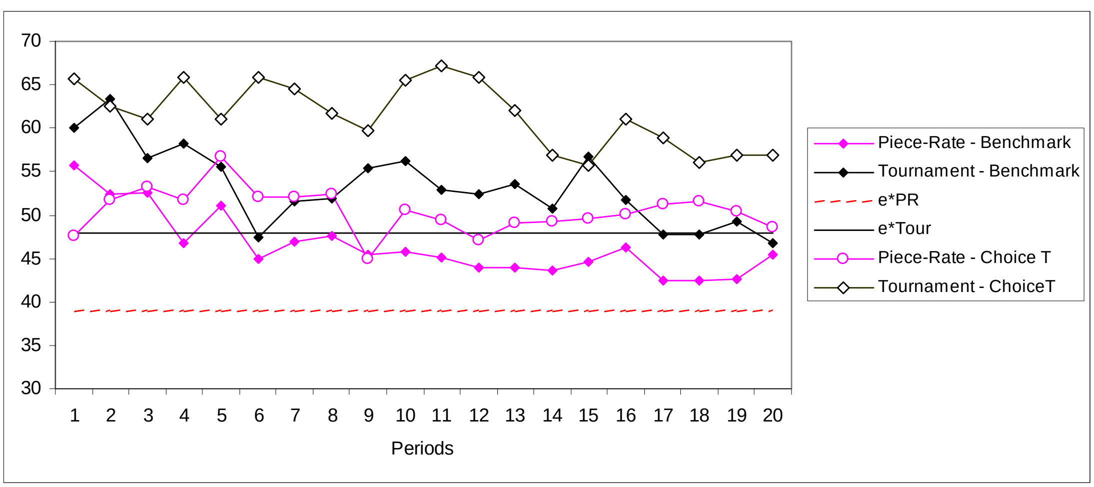

Fig.1. Evolution of the effort decisions by treatment and by mode of payment over time

Table 1 and Figure 2 show a dramatic change in the variability of effort when agents self-select. Comparing the Benchmark to the Choice Treatment, we find that the variance under the piece-rate diminishes from 368.9 to 227.9 (-38.2%) and the variance in the tournament decreases from 652.3 to 258.2 (-60.4%). The variability of effort is not only lower when agents self-select but now the tournament cannot be considered as more unstable than the piece-rate. Considering observations as independent, Levene's robust test statistics reject the hypothesis of equality of variance between the tournament and the piece-rate in the Benchmark Treatment (z=48.93, p<0.000) but accepts it in the Choice Treatment (z=.135).

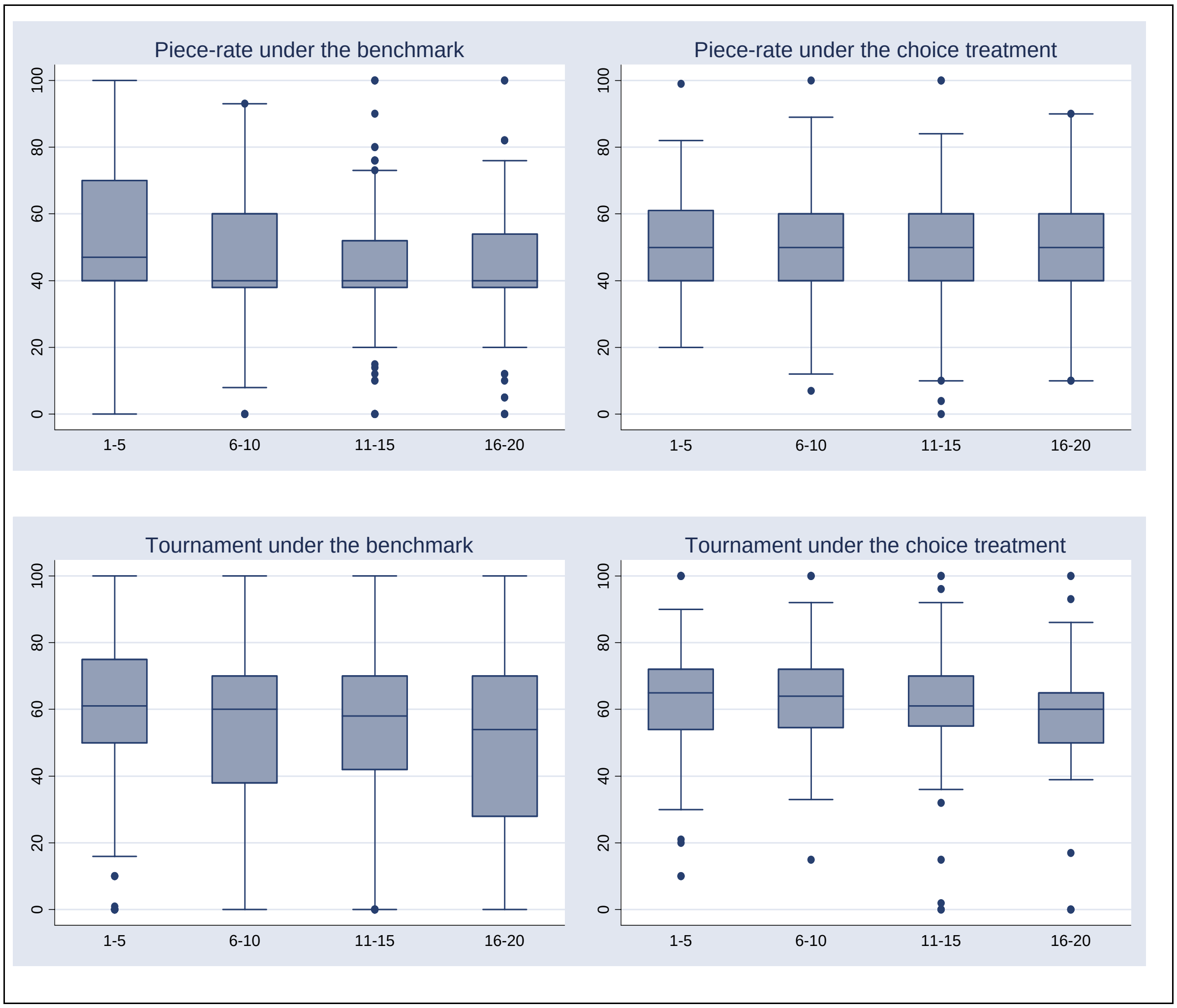

Fig.2. Dispersion of effort by treatment, mode of payment and category of periods

Figure 2 gives for each treatment and each mode of payment, the median (indicated by the horizontal line), the quartiles (the grey bars), the adjacent values (the vertical lines) and the outliers (the dots). In the Choice Treatment, whatever the payment scheme, the median is higher than in the benchmark. The distance between the first quartile and the median is almost the same as the distance between the fourth quartile and the median. On the other hand, in the Benchmark Treatment, effort is more dispersed above the median in the piece-rate and more dispersed below the median in the tournament. In addition, regarding the tournament, the distribution of effort is more concentrated around the median when agents can self-select. The adjacent values are also closer to the median, meaning that fewer contestants choose a zero or a maximum effort than in the benchmark. This figure indicates a greater stability of behavior when ex ante sorting is possible.

In Table 2 we decompose the variance into its within and between dimensions in order to show the sorting effect due to the possibility to choose one's payment scheme. From this, we can see that in the Benchmark Treatment the between-subject variance of effort in the tournament accounts for 66.6 % of the total variance; in the Choice Treatment, its value is 75.6% smaller and it does not make up more than 39.4% of the total variance.[6] Consequently, the population of voluntary contestants is more homogeneous in terms of exerted effort.

The within-subject variance of effort in the tournament is also lower in the Choice Treatment but the difference is smaller (-28.4%): although the tournament is played less frequently, the within-subject variability of effort is lower than in the Benchmark Treatment. A similar difference is observed for the piece-rate scheme: both the between-subject and the within-subject variances are lower in the Choice Treatment than in the Benchmark Treatment in almost same proportions (-38.0% and –38.4%, respectively).

[6] If we remove the outliers playing either 0 or 100, the between-subject variance in the tournament still represents 64.4% (270.6/419.9) of the total variance in the Benchmark treatment. Its value is reduced by 71.9% in the Choice Treatment, in which it only represents 42.0% (75.1/181.0) of the total variance. Thus the structure of the variance remains the same as when we include all the contestants in the analysis.

Table 2.
Decomposition of the variance of effort

Variance	Between-subject	Within-subject	Total
Benchmark Treatment			
- Piece-rate	193.69 (52.51)	175.19 (47.49)	368.88 (100)
- Tournament	434.55 (66.62)	217.71 (33.38)	652.26 (100)
Choice Treatment			
- Piece-rate	120.01 (52.66)	107.86 (47.34)	227.87 (100)
- Tournament	101.79 (39.42)	156.41 (60.58)	258.19 (100)

Note: Percentages of the total variance in parentheses.

The descriptive statistics shown above refer to averages. Next, we account for some individual characteristics. In Table 3, regressions (1) and (2) give the results of OLS regressions of the effort decisions in each treatment, with robust standard errors and accounting for clustering of the individuals; regressions (3) and (4) use panel data analysis with fixed effects. As explanatory variables we include a time trend, the mode of payment, the random shock in the previous period and a series of individual characteristics such as gender, age, experience of experiments, and the degree of risk aversion. The “risk aversion” variable (coded from 1 to 10) corresponds to the number of the lottery decision where the subject crosses over from the safer to the riskier option in the post-experimental test: the higher this number, the more risk averse the subject.

The main differences between the two treatments are related to the influence of the mode of payment and risk aversion. In tournaments the subjects exert a higher effort than under a piece-rate scheme. However, in the Benchmark Treatment, the difference is not significant when we include robust standard errors and cluster on individuals; in contrast, competition stimulates performance when the subjects can self-select. Risk aversion has a significant negative impact on effort when the subjects are imposed their payment scheme: considering the uncertainty of the environment, risk averse subjects decrease their effort to minimize their cost. This variable is not significant in the Choice Treatment, suggesting that risk aversion plays a role in the sorting process but not once the choice has been made.

In both treatments effort declines over time but this tendency is less pronounced when the subjects are allowed to choose their scheme. Although the periods are independent, the subjects in both treatments adjust their effort downwards (upwards) when they have got a positive (negative) random shock in the previous period.

Table 3.
Determinants of the effort decision

	Regressions with robust standard errors		Panel data analysis with fixed effects	
	Benchmark Treatment (1)	Choice Treatment (2)	Benchmark Treatment (3)	Choice Treatment (4)
Periods	-.4888*** (.1342)	-.3049*** (.0953)	-.4822*** (.0728)	-.2958*** (.0689)
Tournament	5.1846 (4.7936)	10.3899*** (1.4860)	-	11.8411*** (.8753)
Lagged random number	-.0743*** (.0252)	-.0399** (.0166)	-.0393** (.0171)	-.0294* (.0162)
Risk aversion	-2.4814** (1.1169)	-0.1011 (.8539)	-	-
Gender (male=1)	-5.4184 (4.8132)	-6.5433*** (2.2455)	-	-
Age	-3.1068 (1.8634)	.3910 (0.4398)	-	-
Experience	4.0601 (8.0158)	-.3474 (2.9161)	-	-
Nb obs.	1140	1140	1140	1140
F (7,59);(7,59);(2,1078);(3,1077)	4.88	10.06	23.95	72.20
Prob>F	0.000	0.000	0.000	0.000
R^2	0.1088	0.1630	0.0167	0.1198

Note: standard errors in parentheses; *** significant at 1% level, ** at 5% level, * at the 10% level.

The third and fourth columns of Table 3 display the estimations accounting for the longitudinal character of the data and including individual fixed effects. We may note that the coefficients to the lagged random number are reduced but continue to differ from zero, whereas the other coefficients do not change much. In particular, it is worth remarking that the estimate to the tournaments dummy in the choice treatment is larger, not smaller, when fixed effects are entered.[7]

These estimations show that behavior in the Choice Treatment clearly differs from behavior in the Benchmark Treatment. It is therefore important to understanding what determines sorting.

4.2. Sorting

In the Choice Treatment, the competitive scheme is chosen in 50% of the observations. Its relative frequency declines slightly over time, from 52.7% in the first ten periods to 47.3 in the subsequent ten periods (see Figure 3). This almost corresponds to the proportion predicted by theory since we have chosen the parameters so that the expected utility in the tournament and the piece-rate scheme is the same. Does it mean that subjects choose at random or can we identify characteristics of the subjects that predict their behavior? Some inertia can be noted: 66% of the subjects choose the same payment scheme in the current period than in the previous one.

[7] This is interesting because the fixed effects, in addition to the individual characteristics included in columns 1 and 2, are also picking up the impact of time-invariant unobservables. In the next of the paper we will address the issue of endogeneity of the payment scheme indicator in the choice treatment.

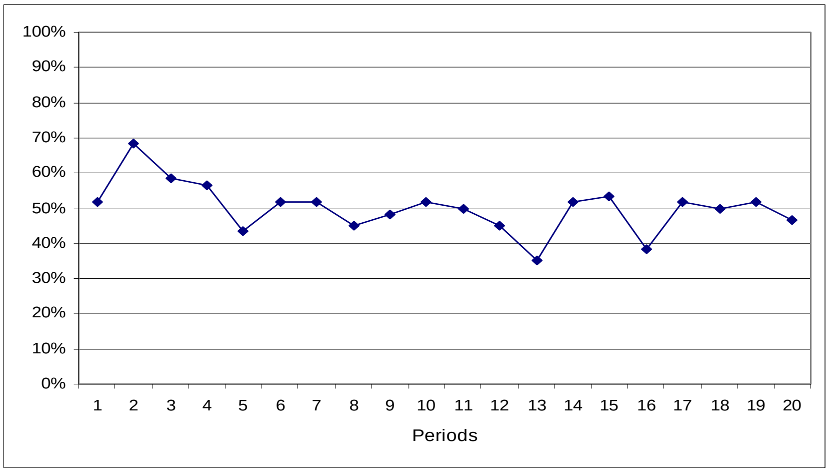

Fig.3. Evolution of the proportion of chosen tournaments over time

Risk aversion. A first candidate for a determinant of sorting is risk aversion. Table 4 compares the distribution of our subjects in terms of risk aversion to the results in Holt and Laury, 2002.

Table 4.
Distribution of risk aversion

# safe choices	Risk Preference Classification (Holt and Laury)	Holt and Laury's experiment	Our experiment	
			Benchmark T.	Choice T.
0-1	Highly Risk Lover	0.01	0.05	0.00
2	Very Risk Lover	0.01	0.00	0.02
3	Risk Lover	0.06	0.05	0.10
4	Risk Neutral	0.26	0.18	0.22
5	Slightly Risk Averse	0.26	0.18	0.15
6	Risk Averse	0.23	0.32	0.30
7	Very Risk Averse	0.13	0.17	0.17
8	Highly Risk Averse	0.03	0.03	0.03
9-10	Stay in Bed	0.01	0.02	0.02

Note: The number of safe choices corresponds to the number of the decisions with the "safe" option A, and thus corresponds to the "risk aversion" variable in our econometric analysis.

The distribution of our subjects is less concentrated in the categories "risk neutral" and "slightly risk averse" than in Holt and Laury's pool of subjects. We observe higher proportions of risk lovers and more than slightly risk averse subjects. The differences are small, however. A Kolmogorov-Smirnov exact test does not reject the hypothesis of equality of distribution functions between our Benchmark and Choice Treatments.

Next, we look at how the degree of our subjects' risk aversion is related to the frequency of their tournament choices. We have grouped the contestants into three categories: subjects who choose the tournament in at least 14 periods out of 20 ("*tournament* +" in Figure 4), subjects who choose the tournament in 6 periods or less ("*tournament* –"), and an intermediate category ("*tournament* ="). Figure 4 displays the proportion of safe choices in the ten decisions of the lottery task. The dashed line corresponds to the behavior of a risk neutral agent switching from option A to option B at decision 5.

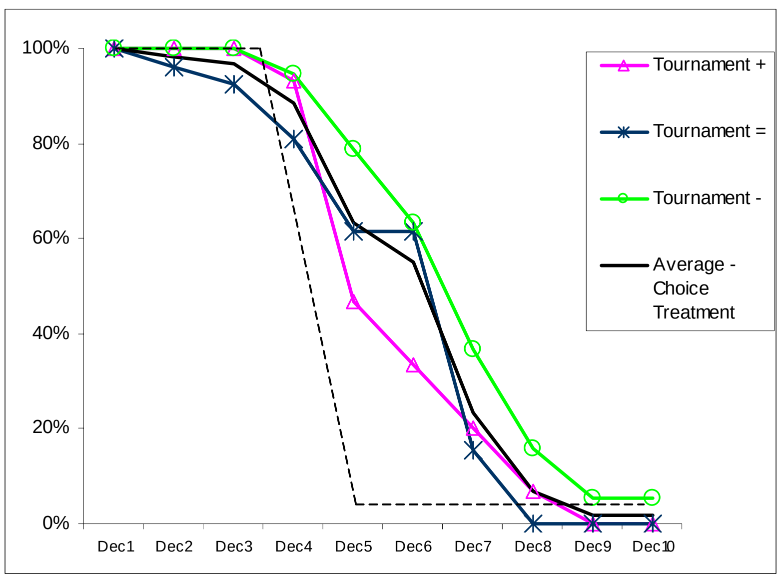

Fig.4. Proportion of safe choices in each decision according to the frequency of the tournament choices

Clearly, the subjects who choose the tournament less frequently are more risk averse than the other categories. All categories of risk-averse subjects considered together choose the tournament in 45.5% of the periods, whereas the corresponding proportions are 60.4% for the risk neutral subjects and 56.4% for the risk lovers.

Regression analysis. Table 5 contains regression (1) that estimates a panel probit model with random effects, and regression (2) based on a panel logit model with fixed effects. The dependent variable is the choice of the tournament payment scheme.

Table 5.
Determinants of the tournament choice

	Panel Probit model, with random effects (1)	Panel Logit model with fixed effects (2)
Periods	-.0173** (.0074)	-.0295** (.0125)
Lagged random number	-.0030* (.0017)	-.0051* (.0029)
Risk aversion	-.1461** (.0745)	
Gender (male=1)	-.0227 (.2176)	
Age	-.0349 (.0355)	
Experience	-.0923 (.2564)	
Constant	1.7981** (.8511)	
Nb observations	1140	1102
Wald χ^2 / LR χ^2	14.61	8.60
Prob>χ^2	0.023	0.014
Log Likelihood	-691.0045	-517.0653

Note: standard errors in parentheses; ** significant at 5% level, * at 10% level.

Both specifications tell the same story. The tournament choice declines over time. The most important determinant of the choice of the competitive scheme is the degree of risk aversion: in the risk aversion test, crossing over from the safe option to the riskier option later diminishes the probability to choose the tournament. Although periods are independent and this is common knowledge, a bad (good) luck in the previous period increases (diminishes) the probability to enter the competition. This could be explained by a gambler's fallacy ("*bad luck cannot continue*"). Lastly, demographic characteristics such as gender, age and experience do not influence the choice.

4.3 Heterogeneity of Behavior in Tournaments

We adopt a cluster analysis to identify homogenous groups of players following the same type of behaviour when entering a tournament. In order to partition the sample, in the Choice Treatment we retain three variables that summarize each individual's decisions: the frequency of choices of the tournament by the subject, his mean effort in the tournament, the standard deviation of his effort in the tournament. In the Benchmark treatment, we only consider the last two variables. We apply the hierarchical Wald method based on the minimization of the intra-group variance ($\sum_{k=1}^{p}\left(x_{ki}-x_{kj}\right)^2$) to identify the clusters that sum up the participants' strategies. We have grouped the clusters so that each cluster includes at least 10% of the subjects. Table 6 summarizes the statistics that help to characterize the main strategies in each treatment. The last two columns correspond respectively to the minimum and maximum mean efforts in each cluster and to the between-subject standard deviation. The other columns correspond to average individual characteristics.

The cluster analysis identifies four main categories of subjects. In both treatments, these four categories display similar characteristics; therefore we use the same denomination of clusters. We classify as "*underconfident competitors*" the subjects who exert an excessively high level of effort (more than 50% above the equilibrium), with a relatively low standard deviation. We classify as "*motivated competitors*" subjects who exert a level of effort still higher than the equilibrium but closer to it. "*Hesitant competitors*" group subjects who alternate levels of effort below and above the equilibrium; they are characterized by the highest standard deviation of effort in the population. Lastly, we classify as "*steady competitors*" subjects who follow a stable strategy based on the choice of a low level of effort. Notably, it includes a few subjects who even exert a minimum effort all along the game, just to make sure to win at least the loser's prize without incurring any cost of effort; this strategy clearly reflects a lack of ambition.

Table 6.
Strategies in tournaments

Benchmark Treatment – Tournament is imposed

	Share in the population	Mean effort	SD Within	Min/ Max Mean effort	SD Between
Underconfident Competitors	30.0	74.48	6.35	70/ 82	4.2
Motivated Competitors	30.0	59.93	10.78	53 / 68	5.4
Hesitant Competitors	30.0	40.65	20.48	28/52	7.1
Steady Competitors	10.0	7.6	9.9	1/15	7.1

Choice Treatment – Tournament is chosen

	Share	Relative frequency	Mean effort	SD Within	Min/ Max Mean effort	SD Between
Frequent competitors						
Motivated Competitors	40.0	57.9	61.87	9.45	56 / 69	3.7
Steady Competitors	18.3	50.9	44.55	7.60	0 / 54	15.6
Occasional competitors						
Hesitant Competitors	10.0	35.8	53.06	32.61	40 / 57	6.5
Underconfident Competitors	31.7	34.4	73.20	10.74	66 / 87	6.3

Note: The "share" column represents the proportion of each cluster in the population submitted to the treatment. The "relative frequency" column represents the proportion of periods in which the tournament has been chosen by the subjects in each cluster.

In the Benchmark Treatment, each cluster represents almost the same proportion in the population (30%), except the steady competitors who account for only 10% of the subjects.

The contrast between these four clusters is consistent with the high variance of effort when tournaments are exogenously imposed.

The comparison between the Benchmark Treatment and the Choice Treatment allows us to identify who among these groups are more attracted by a competitive payment scheme. Is the observed reduction of the variability of effort when tournament is chosen due to the fact that the most extreme categories in terms of average effort stay out of the competition or to the fact that the most unstable category prefers the piece-rate scheme? It turns out that both are true.

In the Choice Treatment, the clusters are defined by taking into account the frequency of choice of the tournament. We can then compare the strategies of the frequent users of the tournament, i.e. those who choose this mode of payment in at least half of the periods, to that of the occasional competitors who are more attracted by the piece-rate scheme and choose the tournament in about one third of the periods. Interestingly, these two groups also differ in terms of effort variability, with the frequent competitors characterized by a higher within-subject stability of effort.

The group of frequent contestants consists mainly of the motivated competitors who represent 40% of all subjects. They exert an effort above the equilibrium to win the competition and they probably expect to compete with subjects who also self-selected on the basis of the same motivation. Their high and stable effort indicates that they do not underestimate their competitors. This group is very homogenous as indicated by the between-subject standard deviation.

Steady competitors representing 18.3% of the population also choose the tournament relatively often. Unlike the previous cluster, they choose on average a below equilibrium level of effort and are characterized by the lowest within-subject variance and a high between-subject variability. This cluster includes subjects who do not expect to win the tournament except by mere chance and hence, minimize their cost of effort. It also includes subjects who exert a level of effort slightly below the equilibrium, possibly due to overconfidence or perception biases with respect to uncertainty.[8] We know from psychology that many individuals have misconceptions of chance (Kahneman, Slovic and Tversky, 1982); they overestimate their perspectives (Taylor and Brown, 1988), the precision of their knowledge (Lichtenstein, Fischhoff and Phillips, 1982) or their relative abilities (Camerer and Lovallo, 1999; Kahneman and Lovallo, 1993). Psychologists (Langer, 1975) have also shown that being given a choice increases the illusion of control over external events of some subjects. Some of our steady competitors may have the same illusion of control, which could explain that they choose on average a level of effort below the equilibrium.

Among the occasional tournament participants are the hesitant competitors who represent 10% of all subjects and are characterized by the greatest within-subject instability. These subjects face difficulties in dealing with the strategic uncertainty attached to the tournament and this most likely explains their preference for the piece-rate scheme. The underconfident competitors are also found among the occasional contestants. They make up 31.7% of all subjects and choose a stable strategy with a very high level of average effort (73.2, i.e. 52.5% above the equilibrium). Clearly, these subjects exert a too high level of effort.

---

[8] In the first period of the game, after the subjects have chosen their level of effort, we asked them the following question : « *How big do you estimate your chances are that you will draw a random number that increases your payoff ?* ». Three quarters of the subjects reported the correct answer, but 14.2% reported a probability lower than .49 and 13.3% a probability exceeding .50. 61.1% of the optimistic subjects opted for the tournament, whereas the percentage of subjects choosing the tournament was 47.3 for the pessimistic ones and 48.3% for the well-calibrated subjects. In most regression analyses, miscalibration is not significant, however. This is not surprising since the subjects revise their subjective beliefs throughout the game. However, according to a probit regression (not shown) including only individual observable characteristics,. optimism significantly (at the 10% level) increases tournament entry in the first period.

Can we identify a winning strategy in the Choice Treatment? The steady competitors receive the highest average net payoff per period in the tournament (45.8 points), followed by the motivated competitors (42.7). This difference is due to the too high cost of effort borne by the latter, whereas the former secure the loser's prize without bearing a high cost of effort. A strong taste for competition could be stimulating the motivated competitors to focus on the winner's prize and to pay less attention to the cost of effort.

The occasional competitors receive lower net payoffs per period: the hesitant competitors earn on average 40.8 points and the underconfident competitors 36.0. One can thus conclude that the occasional competitors are probably right in choosing the piece-rate more often since they perform better under this scheme (the hesitant competitors earn on average 51.0 points under the piece-rate and the underconfident competitors 50.6).

It should be also noted that, due to the difficulty to compute equilibrium effort in this game, all receive less than the expected utility of 55.1. The experiment also points to a potential limitation of sorting. The motivated competitors provide an over-supply of effort and consequently their net earnings are not very high. These subjects do not enter into a rat race since effort does not increase over time, but nevertheless, sorting reinforces a tendency to exert excess effort from some employees.

5. Discussion and Conclusions

In an environment almost similar to that in Bull, Schotter and Weigelt, 1987, Nalbantian and Schotter, 1997; Schotter and Weigelt, 1992, our results confirm that both the average level and the variance of effort are higher under a tournament than under a piece-rate payment scheme. The higher variability of effort in tournaments has long been considered an important disadvantage since the employers have to bear uncertainty as to how the agents behave in relative performance compensation schemes. However, by analyzing an experimental setting which accounts for a key feature of markets, that the agents can choose their payment scheme, our results paint a fundamentally different picture. When the subjects choose the tournament, the average effort is higher and the variance of effort is substantially lower compared to the less realistic situation in which the payment scheme is imposed on all subjects.

In our experiment, average effort in the freely chosen tournament is 32.5% higher than in the exogenously imposed piece-rate scheme. This differential can be further decomposed into an incentive and a sorting effect. The difference between effort levels in the imposed piece-rate and in the imposed tournament is an estimate of the incentive effect of tournaments: here, this is of the magnitude of a 14.6% increase in effort. The difference between the total increase in effort and the estimated incentive effect can be attributed to the sorting effect of tournaments. Sorting increases effort by 17.9%. The sorting effect makes up slightly more than half of the total increase in effort and this result emphasizes the importance of taking sorting into account when evaluating the efficiency of compensation schemes. Interestingly this relative importance of the sorting effect of tournaments is about the same magnitude as the relative influence of sorting in the switch from a fixed pay to a variable pay scheme in the Safelite company examined by Lazear, 2000.

Another important and new result is that sorting dramatically decreases the variance of effort in tournaments. When agents are allowed to choose to enter the tournament, the between-subject variance is four times smaller than when this scheme is imposed and it is even lower than the variance of effort under the piece-rate scheme. It is worth noting that we obtain this result in spite of the fact that we increased the complexity of the task to be performed as compared to previous experimental studies. First, the subjects have to compare the expected utility of both schemes in addition to searching for the equilibrium effort in the tournament, and second, because of the stranger matching protocol, our subjects cannot predict the behavior of their new competitor. Consequently, our experiment does not lead to the same recommendations as Bull, Weigelt and Schotter 1987. They suggest that to attract employees, an employer should offer them a higher expected utility with a tournament than under a piece-rate scheme. Our conclusion is that labor market flexibility, in particular the absence of restrictions on mobility between firms with different payment schemes, is a key condition for a higher efficiency of relative performance pay.

Our results suggest that the efficiency-enhancing effect of sorting derives from a higher degree of homogeneity of contestants. Since tournaments involve additional uncertainty to that attached to the piece-rate scheme, it is not surprising that risk averse subjects choose them to a lesser extent. Underconfident subjects also prefer the piece-rate scheme since they exert too much effort in the tournament, entailing an excessive cost of effort. Hesitant subjects, alternating between high and low levels of effort, are not attracted by the tournament either, possibly because of difficulties computing the equilibrium effort. On the other hand, individuals who are motivated to work hard do not hesitate to choose the tournament in which equilibrium effort is higher. We have shown that among frequent contestants, the motivated competitors represent a higher proportion than the steady competitors who work less hard. At any rate, the degree of homogeneity of the contestants is higher when the tournament is chosen and this contributes to the lower variance of effort. Worth noting is also that more homogeneity does not give rise to collusion.

Having demonstrated that sorting has profound implications for the level and variance of effort in tournaments, further work should focus on how sorting is affected by differences in skills, introduction of common random shocks and variations in prize spreads. It also suggests to reconsider the influence of sorting in many economic decisions.

Appendix. Instructions of the Choice Treatment

You are about to participate in an experiment on decision-making organized for the GATE research institute and the Aarhus School of Business in Denmark. During this session, you can earn money. The amount of your earnings depends on your decisions and on the decisions of the participants you will have interacted with. During the session, your earnings will be calculated in points,

with 80 points = 1Euro

During the session, losses are possible. However, they can be avoided with certainty by your decisions. In addition, if a loss would occur in a period, the gains realized during the other periods should compensate this loss.

At the end of the session, all the profits you have made in each period will be added up and converted into Euros. In addition, you will receive a show-up fee of 3 Euros. You will have also an opportunity to earn additional money by participating in a decision task at the end of the session. Your earnings will be paid to you in cash in a separate room in order to preserve confidentiality.

The session consists of 20 independent periods.

Description of each period

Each period consists of two stages.

- **In stage 1**, you choose between two modes of payment, mode X and mode Y.
- **In stage 2**, you carry out a task.

Your profit during each period depends on the mode of payment you have chosen and on your result from the task.

Description of the task

- A table is attached to these instructions: numbers, from 0 to 100, are given in column A. In the second stage of each period, your task consists of selecting one of these numbers. This number will be called your “decision number”. Associated with each number is a cost, called “decision cost”. These decision costs are listed in column B. Note that the higher the decision number chosen, the greater is the associated cost. You make your choice by means of a scrollbar on your computer screen and you confirm this choice by clicking the “OK” button.
- Then, you have to click a button on your screen that will generate a random number. This number is called your “personal random draw number”. This number can take any value between – 40 and + 40. Each number between – 40 and + 40 is as likely to be drawn and there is one independent random draw between – 40 and + 40 for each subject in the lab.

Your “result” for the task is the sum of your decision number and your personal random draw number.

Your result = your decision number + your personal random draw number

Choice of the mode of payment and calculation of your payoff

There are two different modes of payment, mode X and mode Y. In the first stage of each period, you choose to be paid according to mode X or to mode Y. If you like, you can change the mode of payment at each new period.

- Description of mode of payment X

If you choose the mode of payment X, your result is multiplied by 0.52. You also receive a fixed amount of 45 points. Next, the decision cost associated to the choice of your decision number is subtracted. Note, the amount subtracted (your decision cost) is only a function of your decision number; that is, your personal random draw number does not affect the amount subtracted.

Your payoff thus depends on your decision number and your personal random draw number. Your net payoff under mode X is thus given by the following formula:

Your net payoff of the period under mode X =   45 + (your result * 0.52) – your decision cost

At the end of the period, you are informed about your result and about your net payoff for the current period.

Example of net payoff calculation under mode of payment X
For example, say that you choose a decision number of 55 and you draw a personal random number of 10. Your net payoff calculation will look like:

*45 + [(55 + 10) * 0.52] – 20.17 = 58.63*

- Description of mode of payment Y

If you choose the mode of payment Y, another subject in the room, who has also chosen the mode of payment Y, is paired with you at random for the current period. This subject is called your "pair member". The identity of your pair member will never be revealed to you.

Your pair member has an identical sheet as yours. Like you and simultaneously, he has to select a decision number and he will draw his personal random number. As for you, the "result" of your pair member is computed by adding his decision number and his personal random draw number.

Then, the computer program will compare your result and the result of your pair member.

- If your result is greater than your pair member's result, you receive the fixed payment M, equal to 96 points.
- If your result is lower than your pair member's result, you receive the fixed payment L, equal to 45 points.
- In case of equal results, a fair random move decides on which subject receives M and who receives L.

Whether you receive M or L as your fixed payment depends only on whether your result is greater or not than your pair member's. It does not depend on how much bigger it is.

To determine your net payoff, the decision cost associated with the choice of your decision number is subtracted. Note, the amount subtracted is only a function of your decision number; that is, your personal random draw number does not affect the amount subtracted.

Therefore, your net payoff depends on your decision number, your personal random draw number, and your pair member's decision number and his personal random draw number.

Your net payoff under mode Y is given by the following formula:

Your net payoff of the period under mode of payment Y =   Fixed payment (M or L) – your decision cost

At the end of the period, you are informed about your result; you are told by how much your total is greater or less than that of your pair member and you are informed about your net payoff for the current period.

Example of net payoff calculation under mode of payment Y
For example, say that pair member A chooses a decision number of 25 and draws a personal random number of 20, while pair member B selects a decision number of 55 and draws a personal random number of -5.

A's result is: 25 + 20= 45

B's result is: 55 - 5= 50

B's result is larger than A's result. Thus, B receives M (=96) and A receives L (=45).

A's net payoff is: 45 – 4.17 = 40.83

B's net payoff is: 96 – 20.17 = 75.83

To sum up, in each period you make two decisions:

- In stage 1, you choose between mode of payment X and mode of payment Y. Note that if an uneven number of participants has chosen mode Y, one of these participants will be randomly chosen and paid according to mode X. To be paid according to mode Y, pairs must be formed. This participant will be informed of this before moving to stage 2.

- In stage 2, you select your decision number and you draw a personal random number. Your net payoffs for the current period are then computed.

At the end of a period, a new period starts automatically. Each period is independent. The random draws are independent from one period to the next. In each period, under mode of payment Y, pairs are composed at random among the participants who have chosen this mode of payment.

If you have any question regarding these instructions, please raise your hand. Your questions will be answered in private. Throughout the entire session, talking is not allowed. Any violation of this rule will result in being excluded from the session and not receiving payment.

Thank you for your participation.

Decision Costs Table

Column A Decision Nb	Column B Cost of Decision	Column A Decision Nb	Column B Cost of Decision	Column A Decision Nb	Column B Cost of Decision
0	0.00	35	8.17	70	32.67
1	0.01	36	8.64	71	33.61
2	0.03	37	9.13	72	34.56
3	0.06	38	9.63	73	35.53
4	0 .11	39	10.14	74	36.51
5	0.17	40	10.67	75	37.50
6	0.24	41	11.21	76	38.51
7	0.33	42	11.76	77	39.53
8	0.43	43	12.33	78	40.56
9	0.54	44	12.91	79	41.61
10	0.67	45	13.50	80	42.67
11	0.81	46	14.11	81	43.74
12	0.96	47	14.73	82	44.83
13	1.13	48	15.36	83	45.93
14	1.31	49	16.01	84	47.04
15	1.50	50	16.67	85	48.17
16	1.71	51	17.34	86	49.31
17	1.93	52	18.03	87	50.46
18	2.16	53	18.73	88	51.63
19	2.41	54	19.44	89	52.81
20	2.67	55	20.17	90	54.00
21	2.94	56	20.91	91	55.21
22	3.23	57	21.66	92	56.43
23	3.53	58	22.43	93	57.66
24	3.84	59	23.21	94	58.91
25	4.17	60	24.00	95	60.17
26	4.51	61	24.81	96	61.44
27	4.86	62	25.63	97	62.73
28	5.23	63	26.46	98	64.03
29	5.61	64	27.31	99	65.34
30	6.00	65	28.17	100	66,67
31	6.41	66	29.04		
32	6.83	67	29.93		
33	7.26	68	30.83		
34	7.71	69	31.74		

Post experimental questionnaire

[*Instructions for the test of risk aversion directly taken from Holt and Laury, 2002*]

We thank you for filling out this form that enables you to earn additional money. The attached sheet of paper shows ten decisions. Each decision is a paired choice between "Option A" and "Option B". You will make ten choices and record these in the column on the right, but only one of them will be used in the end to determine your additional earnings. Let us explain how these choices will affect your earnings.

Here is a ten-sided die that will be used to determine this payoff. The faces are numbered from 1 to 10 (the "0" face of the die will serve as 10). After you have made all of your choices, and when you come to the other office to receive your payment, you will throw this die twice:

- once to select one of the ten decisions to be used,
- and a second time to determine what your payoff is for the option you chose, A or B, for the particular decision selected.

Even though we ask you to make ten decisions, only one of these will end up affecting your earnings. However, you will not know in advance which decision will be used. Obviously, each decision has an equal chance of being used in the end.

- Look at Decision 1.

Option A pays 2 € if the throw of the dice is 1, and it pays 1.6 € if the throw is 2-10.
Option B yields 3.85 € if the throw of the dice is 1 and it pays 0.1 € if the throw is 2-10.

- Look at Decision 2.

Option A pays 2 € if the throw of the dice is 1 or 2, and it pays 1.6 € if the throw is 3-10.
Option B yields 3.85 € if the throw of the dice is 1 or 2 and it pays 0.1 € if the throw is 3-10.

The other decisions are similar, except that as you move down the table, the chances of a higher payoff for each option increase. In fact, for Decision 10 in the bottom row, the dice will not be needed since each option pays the highest payoff for sure, so your choice here is between 2 € and 3.85 €.

To summarize,

- you will make ten choices. For each decision row, you will have to choose between Option A and Option B. You may choose A for some decision rows and B for other rows. You may change your decisions and make them in any order.

- When you come to the other room to receive your earnings from the experiment, you will throw the ten-sided die to select which of the ten decisions will be used.

- Then, you will throw the die again to determine your money earnings for the Option you chose for that Decision.

Earnings (in Euros) for this choice will be added to your previous earnings, and you will be paid all earnings in cash.
If you have any question, please raise your hand. Your questions will be answered in private. Please do not talk with anyone.

Please indicate for each of the following 10 decisions if you choose Option A or Option B.

	Your decision
Decision 1 Option A: 1/10 of 2 € and 9/10 of 1.6 € Option B: 1/10 of 3.85 € and 9/10 of 0.1 €	 Option A O Option B O
Decision 2 Option A: 2/10 of 2 € and 8/10 of 1.6 € Option B: 2/10 of 3.85 € and 8/10 of 0.1 €	 Option A O Option B O
Decision 3 Option A: 3/10 of 2 € and 7/10 of 1.6 € Option B: 3/10 of 3.85 € and 7/10 of 0.1 €	 Option A O Option B O
Decision 4 Option A: 4/10 of 2 € and 6/10 of 1.6 € Option B: 4/10 of 3.85 € and 6/10 of 0.1 €	 Option A O Option B O
Decision 5 Option A: 5/10 of 2 € and 5/10 of 1.6 € Option B: 5/10 of 3.85 € and 5/10 of 0.1 €	 Option A O Option B O
Decision 6 Option A: 6/10 of 2 € and 4/10 of 1.6 € Option B: 6/10 of 3.85 € and 4/10 of 0.1 €	 Option A O Option B O
Decision 7 Option A: 7/10 of 2 € and 3/10 of 1.6 € Option B: 7/10 of 3.85 € and 3/10 of 0.1 €	 Option A O Option B O
Decision 8 Option A: 8/10 of 2 € and 2/10 of 1.6 € Option B: 8/10 of 3.85 € and 2/10 of 0.1 €	 Option A O Option B O
Decision 9 Option A: 9/10 of 2 € and 1/10 of 1.6 € Option B: 9/10 of 3.85 € and 1/10 of 0.1 €	 Option A O Option B O
Decision 10 Option A: 10/10 of 2 € and 0/10 of 1.6 € Option B: 10/10 of 3.85 € and 0/10 of 0.1 €	 Option A O Option B O

References

Bognanno, Michael L., (2001). "Corporate Tournaments." *Journal of Labor Economics*, *19*(2), pp. 290-315.

Bohnet, Iris and Kübler, Dorothea,2004 "Comepsnatingthe Cooperators: Is Sorting in the Prisoner's Dilemma Game Possible?," *Working Paper.*

Bull, Clive; Schotter, Andrew and Weigelt, Keith, (1987). "Tournaments and Piece-Rates: An Experimental Study." *Journal of Political Economy*, *95*(1), pp. 1-33.

Cadsby, C. Bram; Song, Fei and Tapon, Francis,2004 "The Effects of Compensation Schemes on Self-Selection and Productivity: An Experimental Investigation," *Working Paper.*

Camerer, Colin F. and Lovallo, Dan, (1999). "Overconfidence and Excess Entry: An Experimental Approach." *American Economic Review*, *89*(1), pp. 306-18.

Datta Gupta, Nabanita; Poulsen, Anders and Villeval, Marie-Claire,2005 "Do (Wo)Men Prefer (Non)Competitive Jobs?," *Working Paper.*

Dohmen, Thomas and Falk, Armin,2005 "Sorting, Incentives and Performance."

Ehrenberg, Ronald G. and Bognanno, Michael L., (1990a). "Do Tournaments Have Incentive Effects?" *Journal of Political Economy*, *98*(6), pp. 1307-24.

____, (1990b). "The Incentive Effects of Tournaments Revisited: Evidence from the European Pga Tour." *Industrial and Labor Relations Review*, *43*(3), pp. 74S-88S.

Eriksson, Tor, (1999). "Executive Compensation and Tournament Theory: Empirical Tests on Danish Data." *Journal of Labor Economics*, *17*(2), pp. 262-80.

Eriksson, Tor and Villeval, Marie-Claire,2004 "Other-Regarding Preferences and Performance Pay: An Experiment on Incentives and Sorting," *IZA Discussion Paper.* Bonn.

Fullerton, Richard L. and McAfee, R. Preston, (1999). "Auctioning Entry into Tournaments." *Journal of Political Economy*, *107*(3), pp. 573-605.

Green, Jerry R. and Stokey, Nancy L., (1983). "A Comparison of Tournaments and Contracts." *Journal of Political Economy*, *91*, pp. 349-64.

Harbring, Christine and Irlenbusch, Berndt, (2003). "An Experimental Study on Tournament Design." *Labour Economics*, *10*, pp. 443-64.

____,2004 "Incentives in Tournaments with Endogenous Prize Selection," *IZA DP.* Bonn.

Harbring, Christine and Ruchala, Gabriele K.,2003 ""Separating the Wheat from the Chaff" - an Experimental Study on the Sorting Function of Tournaments," *Discussion Paper Series in Economics and Management.* Bonn.

Holt, Charles A. and Laury, Susan K., (2002). "Risk Aversion and Incentive Effects." *American Economic Review*, *92*(5), pp. 1644-55.

Hvide, Hans K. and Kristiansen, Eirik G., (2003). "Risk Taking in Selection Contests." *Games and Economic Behavior*, *42*(1), pp. 172-79.

Kahneman, Daniel and Lovallo, Dan, (1993). "Timid Choice and Bold Forecasts: A Cognitive Perspective on Risk Taking." *Management Science*, *39*(1), pp. 17-31.

Kahneman, Daniel; Slovic, Paul and Tversky, Amos, (1982). *Judgment under Uncertainty: Heuristics and Biases*. Cambridge: Cambridge University Press.

Knoeber, Charles R. and Thurman, Walter N., (1994). "Testing the Theory of Tournaments: An Empirical Analysis of Broiler Production." *Journal of Labor Economics*, *12*(2), pp. 155-79.

Krakel, Matthias,2004 "Tournaments Versus Piece-Rates under Limited Liability," *Economic Discussion Papers.* Bonn.

Langer, E., (1975). "The Illusion of Control." *Journal of Personality and Social Psychology*, *32*, pp. 311-28.

Lazear, Edward P., (2004). "Output-Based Pay: Incentives, Retention or Sorting?," S. W. Polachek, *Research in Labor Economics - Accounting for Worker Well-Being.* Amsterdam: Elsevier, 1-25.

____, (1989). "Pay Equality and Industrial Politics." *Journal of Political Economy*, *97*(3), pp. 561-80.

____, (2000). "Performance Pay and Productivity." *American Economic Review*, *90*(5), pp. 1346-61.

____, (1986). "Personnel Economics," Cambridge: MIT Press,

Lazear, Edward P.; Malmendier, Ulrike and Weber, Roberto,2005 "Sorting in Experiments with Applications to Social Preferences," *Working Paper.*

Lazear, Edward P. and Rosen, Sherwin, (1981). "Rank-Order Tournaments as Optimum Labor Contracts." *Journal of Political Economy*, *89*, pp. 841-64.

Lichtenstein, Sarah; Fischhoff, Baruch and Phillips, Lawrence, (1982). "Calibration of Probabilities: The State of the Art to 1980," D. Kahneman, P. Slovic and A. Tversky, *Judgment under Uncertainty: Heuristics and Biases.* Cambridge: Cambridge University Press,

Main, Brian G.M.; O'Reilly III, Charles A. and Wade, James, (1993). "Top Executive Pay: Tournament or Teamwork?" *Journal of Labor Economics*, *11*(4), pp. 606-28.

McLaughlin, Kenneth J., (1988). "Aspects of Tournament Models: A Survey," *Research in Labor Economics.* JAI Press, 225-56.

Nalbantian, H.R. and Schotter, Andrew, (1997). "Productivity under Group Incentives: An Experimental Study." *American Economic Review, 87*, pp. 314-41.

Nalebuff, Barry J. and Stiglitz, Joseph E., (1983). "Prizes and Incentives: Towards a General Theory of Compensation and Competition." *Bell Journal of Economics*, *14*, pp. 21-43.

Niederle, Muriel and Vesterlund, Lise,2005 "Do Women Shy Away from Competition?," *NBER Working Paper n°11474.*

O'Keeffe, Mary; Viscusi, Kip W. and Zeckhauser, Richard, (1984). "Economic Contests: Comparative Reward Schemes." *Journal of Labor Economics*, *2*, pp. 27-56.

Orrison, Alannah; Schotter, Andrew and Weigelt, Keith, (2004). "Multiperson Tournaments: An Experimental Examination." *Management Science*, *50*(2), pp. 268-79.

Prendergast, Canice, (1999). "The Provision of Incentives in Firms." *Journal of Economic Literature*, *37*(1), pp. 7-63.

Schotter, Andrew and Weigelt, Keith, (1992). "Asymmetric Tournaments, Equal Opportunity Laws, and Affirmative Action: Some Experimental Results." *Quarterly Journal of Economics*, *107*, pp. 511-39.

Taylor, Shelley E. and Brown, Jonathon D., (1988). "Illusion and Well-Being: A Social Psychological Perspective on Mental Health." *Psychological Bulletin*, *103*(2), pp. 193-210.

van Dijk, Frans; Sonnemans, Joep and van Winden, Frans, (2001). "Incentives Systems in a Real Effort Experiment." *European Economic Review*, *45*, pp. 187-214.

Vandegrift, Donald and Brown, Paul M., (2003). "Task Difficulty, Incentive Effects, and the Selection of High-Variance Strategies: An Experimental Examination of Tournament Behavior." *Labour Economics*, *10*, pp. 481-97.

Vandegrift, Donald; Yavas, Abdullah and Brown, Paul M.,2004 "Men, Women, and Competition: An Experimental Test of Labor Market Behavior," *Working Paper presented at the North American Meeting of the Economic Science Association, Tucson.*

Zeiliger, Romain,2000 "A Presentation of Regate, Internet Based Software for Experimental Economics," *http://www.gate.cnrs.fr/~zeiliger/regate/RegateIntro.ppt, GATE.* GATE.