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ASYMMETRIC TOURNAMENTS, EQUAL OPPORTUNITY LAWS AND AFFIRMATIVE ACTION: SOME EXPERIMENTAL RESULTS

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ASYMMETRIC TOURNAMENTS, EQUAL OPPORTUNITY LAWS AND AFFIRMATIVE ACTION: SOME EXPERIMENTAL RESULTS*

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This paper assesses the impact of social policies on agent output when agents are engaged in a rank order tournament the prizes of which may be considered promotions within a hierarchy. In these tournaments, an agent's payoff depends only on the rank of his performance relative to others in the tournament.

In summary, we find that observed experimental results generally support both the qualitative and quantitive predictions of the theory of tournaments; although subjects tend to oversupply effort (i.e., supply more effort than predicted by the Nash equilibrium). Both laboratory equal opportunity laws and affirmative action programs increase the probability of winning for disadvantaged groups. Further, equal opportunity laws are quite effective in increasing the effort levels of <u>all</u> subjects and hence the profits of the tournament administrator. The effects of affirmative action programs depend on the severity of a group's cost disadvantage: When this disadvantage is not too severe, effort levels of both types of agents (and hence profits of the tournament administrators) are reduced. When the cost disadvantage is great, these programs significantly increase effort levels (and hence profits).

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I. Introduction

Society has enacted several policies to rectify discrimination in the workplace. The effect of these policies on agent output is an important, yet still unanswered empirical question. This paper assesses the impact of social policies on agent output when agents are engaged in a rank order tournament the prizes of which may be considered promotions within a hierarchy. In these tournaments, an agent's payoff depends only on the rank of his performance relative to others in the tournament.

Recent papers investigate theoretical properties of such tournaments [Lazaer and Rosen 1981; Green and Stokey 1983; Nalebuff and Stiglitz 1983; and O'Keeffe, Viscusi, and Zeckhauser 1984]. Tournaments are either symmetric or asymmetric. Symmetric tournaments occur when agents are identical and are treated equally by the rules of the tournament. Tournaments can be asymmetric in two ways. Using the terminology of O'Keeffe et.al. [1984], a tournament is "uneven" when agents differ in ability, i.e., agents have different cost-of-effort functions. A tournament is "unfair" if agents are identical but the rules favor one of them; for example, in order to be promoted, an agent's output must exceed another's by some fixed amount, k. That is, the agent is discriminated against.

Social policies address these asymmetries. For instance, in unfair tournaments, rules (either explicit or implicit) are used to treat identical agents unequally. Prejudice leads to preferential treatment for certain types of agents; i.e., the performance of a group member who is discriminated against must exceed the performance of a member of the favored group by k ($k > 0$) in order for the member who is discriminated against to win the big prize (get a promotion). In such situations, society has forced tournament administrators (employers) not to favor one group of agents (i.e. $k = 0$) through the use of equal opportunity laws.

Uneven tournaments are different: here, one group of agents may have a higher cost of effort than another. This differential might result from historical discrimination against a group which manifests itself in lower levels of education and hence lower levels of human capital acquisition. Because of these lower levels, work is more onerous and effort more costly. To compensate for past discrimination, society mandates affirmative action programs. In effect, these programs induce unfair tournaments by using unfair rules ($k > 0$) to give cost disadvantaged groups preferential treatment. In short, equal opportunity laws force tournament organizers to run symmetric tournaments, while affirmative action programs define unfair, uneven tournaments with the rules favoring cost disadvantaged groups.

Investigating the behavioral impact of these social policies within a tournament setting seems worthwhile. Tournament-like incentive schemes are common. A recent study finds that hierarchical structures in organizations and the incentives generated by them have characteristics of rank order tournaments [Lambert, Larcker, and Weigelt, 1989]. Empirical studies have assessed the effectiveness of social policies in inducing organizations to hire more minorities [Goldstein and Smith, 1976; Heckman and Wolpin, 1976; Leonard, 1984]. However, there is a lack of empirical data on the efficiency of these social policies. For example, how do these policies affect organizational output?

In this paper we examine whether subjects behave in asymmetric tournaments as predicted by tournament theory, and investigate the efficiency implications of equal opportunity laws and affirmative action programs. It is difficult to address these questions with the use of natural data. Doing so requires the availability of data for relevant parameters (e.g., utility functions, monitoring systems), and the ability to control these parameters. We therefore use an experimental setting. Bull, Schotter and Weigelt [1987] [BSW 1987] studied symmetric rank order tournaments using a similar experimental design. They found that on average subjects in symmetric tournaments behaved as predicted by the theory.[1]

Our findings are described later in the paper. In summary, we find that observed experimental results generally support both the qualitative and quantitative predictions of the theory; although subjects tend to oversupply effort (i.e., supply more effort than predicted by the Nash equilibrium).[2] Both equal opportunity laws and affirmative action programs increase the probability of winning for disadvantaged groups. Further, equal opportunity laws are quite effective in increasing the effort levels of all subjects and hence the profits of the tournament administrator. The effects of affirmative action programs depend on the severity of a group's cost disadvantage: When this disadvantage is not too severe, effort levels of both types of agents (and hence profits of the tournament administrators) is reduced. When the cost disadvantage is great, these programs significantly increase effort levels (and hence profits). This occurs because disadvantaged subjects tend to "drop-out" and supply zero effort in extremely uneven tournaments; the affirmative action program seems to alleviate this drop-out problem.

We proceed as follows: In Section 2 we review the theory of symmetric and asymmetric tournaments and present the relevant characteristics of the equilibria of the games they define. In Section 3 we present our experimental design. Experimental results are presented in Section 4. The results of our equal opportunity laws and affirmative action programs are presented in Section 5. Finally, in Section 6 we offer concluding comments and discuss implications of our results.

Section II: Tournaments And Their Equilibria

Consider the following two-person tournament. Two identical agents i and j have the following utility functions that are separable in the payment received and the effort exerted.

$$(1) \qquad u_i(p,e) = u(p)-c(e),$$

$$u_j(p,e) = u(p)-\alpha c(e),$$

where p denotes the nonnegative payment to the agent, e, a scalar, is the agent's nonnegative effort, and $\alpha > 1$ is a constant. Note that agent j's costs are α times those of agent i, $\alpha > 1$. The positive and increasing functions u(.) and c(.) are, respectively, concave and convex. Agent i provides a level of effort that is not observable and which generates an output y_i according to,

$$(2) \qquad y_i = f(e_i) + \epsilon_i,$$

where the production function f(.) is concave and ϵ_i is a random shock.[3] Agent j has a similar technology and simultaneously makes a similar decision. The payment to agent i is $M > 0$, if $y_i > y_j + k$, and $m < M$ if $y_i < y_j + k$, where k is a constant.[4] A positive k indicates that j is favored in the tournament while a negative k indicates that i is favored. Agent j faces the same payment scheme. Given any pair of effort choices by the agents, agent i's probability of winning M, $\pi^i(e_i,e_j,k)$, is just equal to the probability that $(\epsilon_i - \epsilon_j) > f(e_j) - f(e_i) + k$. Thus i's expected payoff from such a choice is,

$$Ez^i(e_i,e_j) = \pi^i(e_i,e_j,k)u(M) + [1 - \pi^i(e_i,e_j,k)]u(m) - c(e_i),$$

(3) while agents j's is

$$Ez^j(e_i,e_j) = \pi^j(e_i,e_j,k)u(M) + [1 - \pi^j(e_i,e_j,k)]u(m) - \alpha c(e_j)$$

The above equations specify a game with payoffs given by (1) and a strategy set E given by the feasible set of effort choices. The theory of tournaments restricts itself to the pure strategy Nash equilibria of this game. If the distribution of $(\epsilon_i - \epsilon_j)$ is degenerate either because there are no random shocks to output or because such shocks are perfectly correlated across agents, and k is not too large, then the game has no pure strategy Nash equilibrium.

With suitable restrictions on the distribution of random shocks and the utility functions a unique, pure strategy Nash equilibrium will exist. This is the behavioral outcome predicted by the theory of tournaments. This theory requires the specification of the utility function, the production function, the distribution of $(\epsilon_i - \epsilon_j)$ and the prizes M and m. One simple specification is the following.

(1′) $$U_i(p_i,e_i) = p_i - e_i^2/c$$
$$U_j(p_j,e_j) = p_j - \alpha e_j^2/c$$

(2′) $$y_\ell = e_\ell + \epsilon_\ell, \quad \ell = 1, j$$

where $c > 0$ and ϵ_1 is distributed uniformly over the interval $[-a, a]$, $a > 0$, and independently across the agents. e_i and e_j are restricted to lie in [0,100]. In this particular case, the agents' expected payoff in the tournament is given by,

(3′) $$Ez_i(e_i,e_j) = m + \pi^i(e_i,e_j,k)[M - m] - e_i^2/c \ .$$
$$Ez_j(e_i,e_j) = m + \pi^j(e_i,e_j,k)[M - m] - \alpha e_j^2/c$$

If a pure strategy Nash equilibrium exists and is in the interior of [0,100], each agent's first order condition must be fulfilled,

$$\frac{\partial Ez_i}{\partial e_i} = \frac{\partial \pi(e_i^*, e_j^*, k)}{\partial e_i} [M - m] - 2e_i^*/c = 0$$

(4)

$$\frac{\partial Ez_j}{\partial e_j} = \frac{\partial \pi(e_i^*, e_j^*, k)}{\partial e_j} [M - m] - \alpha 2e_j^*/c = 0$$

The concavity of the agent's payoff function ensures that (4) is sufficient for a maximum.[5]

Given the distributional assumptions on ϵ_i and ϵ_j, the probability of winning functions with $k > 0$ is

$$\pi^i(e_i, e_j, k) = \begin{cases} 1/2 - (e_i - k - e_j)/2a + (e_i - k - e_j)^2/8a^2, & \text{if } e_i - k > e_j \\ 1 - (1/2 - (e_j - e_i - k)/2a - (e_j - e_i - k)^2/8a^2) & \text{otherwise,} \end{cases} \tag{5}$$

$$\pi^j(e_i, e_j, k) = \begin{cases} 1/2 - (e_j + k - e_i)/2a + (e_j + k - e_i)^2/8a^2, & \text{if } e_j + k > e_i \\ 1 - (1/2 - (e_i - e_j - k)/2a - (e_i - e_j - k)^2/8a^2) & \text{otherwise} \end{cases}$$

with,

$$\frac{\partial \pi^j(.)}{\partial e_j} = \frac{1}{2a} - \frac{(e_j - e_i + k)}{4a^2} \quad \text{if } e_j + k > e_i,$$

(6)

$$\frac{\partial \pi^j(.)}{\partial e_j} = \frac{1}{2a} - \frac{(e_i - e_j - k)}{4a^2} \quad \text{if } e_j + k < e_i,$$

and

$$\frac{\partial \pi^i(.)}{\partial e_i} = \frac{1}{2a} - \frac{(e_i - e_j - k)}{4a^2} \quad \text{if } e_i - k > e_j,$$

(7)

$$\frac{\partial \pi^i(.)}{\partial e_i} = \frac{1}{2a} - \frac{(e_j - e_i - k)}{4a^2} \quad \text{if } e_i - k < e_j.$$

Note that the marginal probability of winning is equal for both agents no matter what the value of k is, and this probability is a function only of the difference in effort levels (including k). It does not depend on absolute effort levels.

Plugging (6) and (7) into (4) and solving for e_i^* and e_j^*, we find,

$$e_j^* = \frac{[(1/2a) - (k/4a^2)](c(M - m)/2\alpha)}{1 + [(1 - \alpha)/4a^2](c(M - m)/2a)}$$

(8)

$$e_i^* = \alpha e_j$$

When $k = 0$ and $\alpha = 1$, (8) defines the equilibrium of a symmetric tournament with

$$(9) \quad e_i^* = e_j^* = \frac{c(M-m)}{4a} .$$

When $\alpha = 1$ and $k > 0$, (8) defines the equilibrium of an unfair tournament with

$$(10) \quad e_i^* = e_j^* = [(1/2a) - (k/4a^2)] (c(M - m)/2) .$$

Note that in unfair tournaments, despite j's advantage, at equilibrium both agents choose the same effort level. The logic underlying this result is simple. As noted in (6) and (7), the marginal probability of winning function for any k and effort levels e_i and e_j are equal for both advantaged and disadvantaged subjects and depends only on the difference between $e_j + k$ and e_i. Since both i and j have identical cost functions, because their marginal probability of winning functions are equal at all e_i and e_j means that the same effort level which equates the marginal benefits of increased effort to marginal costs for i, will also do so for j. Hence, both choose the same effort level at equilibrium. Effort levels fall when k is increased from 0 (i.e., the symmetric equilibrium) because such an increase in k decreases the marginal probability of winning for agents at each e_i and e_j.

Finally, when $\alpha > 1$ and $k = 0$, (8) defines the equilibrium of an uneven tournament,

$$e_j^* = \frac{c(M - m)/4a\alpha}{1 + [(1 - \alpha)/4a^2](c(M - m)/2a)} \tag{11}$$

$$e_i^* = \alpha e_j$$

To investigate the impact of an affirmative action program we need only compare the equilibrium of an uneven tournament ($\alpha > 1$, $k = 0$) (equation 11) to that of an appropriately defined affirmative action tournament ($\alpha > 1$, $k > 1$) (equation 8). Imposing an affirmative action program upon a previously uneven tournament leads to lower equilibrium effort levels for the new rules advantaged (but cost disadvantaged) agent. Since the cost advantaged agent's effort is proportional to this effort level, the effort of both agents will drop. For most realistic sets of parameters, and all those investigated here, these decreases in effort levels increase the probability of cost disadvantaged agents receiving M. Hence, the impact of an affirmative action program upon a previously uneven tournament is; lower equilibrium effort levels for both agents, lower profits for the tournament administrator, and an increase in the probability of winning for cost disadvantaged agents.

To investigate the effect of equal opportunity laws we need merely compare equations (9) and (10). Here the ceteris paribus removal of discrimination (reduction of k from $k > 0$ to $k = 0$) increases the equilibrium effort levels of both agents and hence the profits of the tournament administrator. Again, the probability of winning for the agents who are discriminated agent increases. However, equal opportunity laws can decrease the welfare of these agents because they are expected to exert more effort at equilibrium. A negative welfare gain can result if the cost of this increased effort exceeds the expected benefits of winning. Welfare gain is, of course, always expected to be negative for previously favored agents.

Section III: The Experiment

We recruited subjects from economics courses at New York University. As they entered the room, they each chose 20 envelopes from a pile of 1000. Each envelope had a random number enclosed in it that was generated from a uniform distribution over the integers between -a and +a (including 0). Subjects were randomly assigned seats, subject numbers, and another subject as their "pair member". The physical identity of the pair member was not revealed. Subjects were told that the money amount they earned was a function of their decisions, their pair member's decisions, and the realization of a random variable. Subjects were then given written instructions with payoff sheets and two cost-of-effort functions; one function indicated the subject's costs and the other that of their pair member. (See Appendix A for a sample of this material). Hence, it was common knowledge that one subject in each pair was cost advantaged relative to his pair member.

The experiment then began. Subjects were asked to pick an integer between 0 and 100 (inclusive), called their "decision number", and to enter their choice on the work sheet. Corresponding to each decision number was a cost listed in their cost-of-effort function table. These functions took the form $c(e_i) =$

e_i^2/c, $c(e_j) = \alpha e_j^2/c$, $\alpha > 1$, where c was a scaling factor used to insure that payoffs were of reasonable size, and α was the disadvantageousness parameter indicating how much higher the disadvantaged agent's effort cost was. After subjects recorded their decision numbers, they opened one of their envelopes containing a random number. Subjects entered this random number on their work sheet, and added it to their decision number to yield a "total number" for that round. This information was recorded on a slip of paper which we then collected. We compared the total numbers for each subject pair and announced which member had the highest total in each pair.[6] The pair members with the highest and lowest total numbers were awarded, respectively, "fixed payments" M and m, $M > m$. Subjects then calculated their payoff for the round by subtracting the decision number cost from the fixed payment. All parameters were common knowledge except the identify of pair members.

When subjects completed a round and recorded their payoffs, the next round began. All rounds were identical. Each group of subjects repeated this procedure for 20 rounds. After the last round, subjects calculated their total payoffs by adding up their payoffs for the twenty rounds and subtracting $7.00. Experiments lasted approximately seventy five minutes and subjects earned between $7.02 and $23.85 (mean earnings equalled $15.41). These incentives seemed more than adequate.[7]

These experiments replicated the simple examples of tournaments given in the previous section. The decision number corresponds to effort, the random number to the random shock to productivity, the total number to output, and the decision cost to the disutility of effort.

B. Unfair Tournaments

The experimental design for unfair tournaments was similar to the one described above. The only differences were that subjects had identical cost functions and in each subject pair, one member had to realize an output k units greater than his or her pair member in order to earn the higher fixed payment. This subject was disadvantaged.[8] The cost functions and the value of k were common knowledge.

Several points need to be made about our experimental procedures. First, we avoided value-laden terms in the instructions. Subjects with high total numbers were called "high number subjects", not "winners". Similarly, M and m were never called "prizes" but simply "fixed payments". We wanted to de-emphasize the experiment's game-like nature and reduce the possibility that winning might affect the decision of subjects independently of payoffs. However, as shown in Section 4.4, despite our efforts subjects exhibited an apparently irreducible taste for winning. Second, subjects participated in only one experiment. This meant that each subject saw only one parameter set, thus guaranteeing the absence of carry-over effects from previous parameter sets. Third, in recruiting subjects we took steps to minimize subject contamination. We recruited from each class only once to minimize communication between experienced and new subjects.

Although the theory of tournaments deals with one-shot rather than repeated tournaments, the experimental tournaments were repeated 20 times. We did this because subjects faced a fairly complex decision task and decisions in the first few rounds might have been error-ridden simply because subjects did not fully understand the task. Such repetition is common experimental practice. This experimental design does introduce dynamic elements into a test of a static theory. However, the only subgame perfect Nash equilibrium to the 20 round repeated game involves the choice of Nash equilibrium effort levels to the one-shot game in each round. Thus, the theory's predictions for the experimental game are independent of finite repetition. More importantly, as shown in Section 4, results suggest the absence of any reputational effects. For instance, behavior in the last two or three rounds (where one would expect reputational effects to occur) is similar to behavior in previous rounds.

C. Experimental Design

Seven experiments investigated the impact of tournament asymmetries on subject behavior. Experimental parameters are presented in Table I.[9] Each experiment differs from some other by a change in just one parameter. Hence, comparisons of results between relevant experiments are not confounded by simultaneous parameter changes.

Experiment 1 is a symmetric baseline experiment. To investigate the impact of unfairness, we changed the rules in Experiments 2 and 3 so that the output of one member of each subject pair had to exceed the other's by 25 and 45 before that member would receive the high fixed payment M. Since this is the only experimental parameter changed, comparisons to the baseline demonstrate the impact of the discrimination treatment.

Experiments 4 ($\alpha = 2$) and 5 ($\alpha = 4$) investigate uneven tournaments. These tournaments are identical to the baseline except the costs of one pair member is a multiple (α) of the other's. Finally, Experiments 6 and 7 examine the effects of our laboratory affirmative action programs. In Experiment 6 we take the parameters of Experiment 4 ($\alpha = 2$) and introduce a $k = 25$ rule that favors cost disadvantaged subjects. In Experiment 7, $\alpha = 4$ and $k = 25$.

Section IV: Results

Experimental results are presented in Figures I - V, and Tables II and III. Figures I - V present the round by round mean effort levels chosen by each subject type in symmetric, unfair and uneven tournaments. Table II presents the mean and variances of effort levels in the first half and second half of each experiment (i.e., in rounds 1-10 and 11-20). It also shows the final period means and variances. Table III presents the predicted and observed effort levels, probability of winning, total tournament effort, and mean payoffs for the seven tournaments. To avoid problems of terminal effects, we use the pooled data from the last 10 experimental rounds for statistical tests.

A. Symmetric Tournaments

Figure I shows the results of a symmetric baseline experiment which replicates the finding of BSW [1987] that observed behavior in symmetric tournaments is consistent with theoretical predictions. While the theory predicts that subjects choose effort levels of 73.75, we observe a mean effort level in rounds 11 - 20 of 77.9. The observed mean effort level did not deviate from the predicted level by more than 9 decision numbers in any round, and the mean deviation from the predicted mean was only 5.3 over the last 10 rounds. For rounds 11 - 20, we conducted a Wilcoxon signed rank test for every round, and could not reject the hypothesis that observed effort levels came from a population with a mean of 73.75.[10] [11]

B. Unfair Tournaments

Experiments 2 (k = 25) and 3 (k = 45) tested the effects of unfairness. In general, effort levels in unfair tournaments tended to be higher than predicted. The theory predicts effort level choices for both advantaged and disadvantaged subjects of 58.39 in Experiment 2 and 46.09 in Experiment 3. Observed mean effort levels over the last 10 rounds in Experiment 2 were 58.65 for advantaged subjects and 74.5 for disadvantaged subjects. In Experiment 3 the observed means were 59.29 and 48.65. Using the data from rounds 11 - 20 of each experiment, we conducted a Wilcoxon signed rank test. Only in the case of advantaged subjects in Experiment 2 (mean effort level = 74.5), could we reject the hypothesis that the observed effort levels came from a population with the predicted mean. Using a median test, we then tested the theoretical prediction that the observed effort level of advantaged and disadvantaged subjects were equal . Only in Experiment 2 could we reject the hypothesis that the effort levels of advantaged and disadvantaged subjects were equal, as advantaged subjects chose effort levels significantly higher than their disadvantaged counterparts. Figures II - III clearly demonstrate these conclusions.

The observed probability of winning for advantaged subjects was higher than predicted. This may have been caused by their relatively greater oversupply of effort. For instance, in Experiment 2, while advantaged subjects were predicted to win with probability .687, they actually won with probability .898. In Experiment 3 their actual probability of winning was .827 instead of the predicted .805.[12]

In summation, subjects in unfair tournaments tend to choose higher effort levels than predicted, but below those of an analogous symmetric tournament. However, because of the relative oversupply of effort by advantaged subjects their probability of winning increases. While the profits of tournament administrators in unfair tournaments are above those predicted, profits are still below those realized in the symmetric (fair) version of the same tournament.

C. Uneven Tournaments

Experiments 4 ($\alpha = 2$) and 5 ($\alpha = 4$) tested the behavior of subjects in uneven tournaments. In Experiment 4 while the theory predicts effort levels of

74.26 and 37.26, we observed mean effort levels over the last 10 rounds of 78.13 and 37.06 (Figure IV). Using a Wilcoxon signed rank test we could not reject the hypothesis that observed mean effort levels came from a population with the predicted means. In terms of the probability of winning, we again see consistency with the theory. The expected probability of winning for advantaged and disadvantaged subjects is .762 and .238 respectively; we observed winning probabilities of .79 and .21. Using a binomial test (corrected for continuity) these observations were not significantly different from predicted levels. Finally, since effort levels are as predicted, the profits of the tournament administrator are also.

In Experiment 5 the degree of asymmetry is larger ($\alpha = 4$). Advantaged subjects supplied effort levels as predicted (Figure V). Disadvantaged subjects however took one of two possible actions. Either a disadvantaged subject would "drop out" and supply approximately zero effort, or she would significantly oversupply effort.[13] Over the last ten rounds of Experiment 5 half the disadvantaged subjects (8 of 15) dropped out and had median effort levels ranging from 0 - 4 (mean 8.16) while the other half had median effort levels ranging from 20 - 50 (mean 30.24) which was above the predicted effort level of 19.02. This data is presented in Table IV.

Figures VIa and VIb show the period by period mean effort levels of tournament pairs in a split sample of those disadvantaged subjects who dropped out by period 20 and those who did not. The difference in behavior is clear. While over the first six rounds, the drop-outs chose mean effort levels approximately equal to those subjects who eventually did not drop out (27.2 vs. 38.7), in periods 7 - 20 effort levels diverged significantly. In period 20 the mean effort levels of the seven subjects who dropped out was 2.4 while the mean for those who did not was 34.1 (significantly above the predicted level of 19.06 using a Wilcoxon signed rank test). The responses of their advantaged opponents was also interesting. The advantaged subjects paired with the non-drop out subjects had a mean effort level of 64.74 over the last ten rounds, while the advantaged subjects paired with the drop-outs had a mean effort level of 85.3. Surprisingly, the advantaged opponents of disadvantaged drop-outs continued to choose high effort levels even after their opponents dropped out.

This result becomes less surprising when one hypothesizes that perhaps it was the extremely aggressive play of opponents in early rounds that originally forced disadvantaged drop outs to become discouraged and drop out. This hypothesis is given support when we note that there was a difference in the win history between disadvantaged subjects who eventually dropped out and those that did not. While eventual non drop-outs won on average 28.7% of their tournaments in the first six rounds (with 3 of the 7 winning two or more), drop outs won only 8% of theirs. Since the cost-of-effort was quite high, these losses were costly and could easily have discouraged subjects. This experience may have made them sufficiently pessimistic and caused them to play their mini-max strategy of choosing zero, i.e., dropping out.

In Experiment 4 the observed probability of winning was approximately that which was predicted. However, in Experiment 5, the story is more complex. At equilibrium, the expected probability of winning for disadvantaged subjects is .138 and their expected payoff is $0.92. Using the <u>total</u> sample of tournament pairs over the last ten rounds, we observed an expected probability of winning (given their mean effort choices) of .130 and an expected payoff $0.92. However, results are dramatically different if the sample is divided into drop-out and non drop-out pairs. For drop-out pairs the observed expected probability of winning was .09 and the expected payoff \$0.92. Their advantaged opponents could expect to win with probability .91 and had an expected payoff of \$1.53. For non drop-out pairs, we observed an expected probability of winning of .191 for disadvantaged subjects (.809 for advantaged ones). With these probabilities and efforts we expect payoffs of \$0.85 and \$1.53 for our non drop-out disadvantaged and advantaged subjects respectively. Consequently, dropping out, actually yielded higher payoffs (though a lower probability of winning) than not dropping out for disadvantaged subjects.

To substantiate these descriptive statistics we ran a repeated measures ANOVA to test the hypothesis that the behavior of advantaged and disadvantaged subjects was significantly different in these experiments. The null hypothesis of no difference is strongly rejected for subjects in both experiment 4 ($F(1,16) = 33.06$; $p < .0001$) and experiment 5 ($F(1,28) = 83.00$; $p < .0001$).

Section V: Affirmative Action and Equal Opportunity

A. Equal Opportunity Laws

We investigate the impact of laboratory equal opportunity laws by comparing the results of Experiments 1 with those of Experiments 2 and 3. As previously noted, equal opportunity laws attempt to symmetrize previously unfair tournaments by eliminating the degree of unfairness ($k = 0$). Experiments 1, 2, and 3 are identical except for changes in the k factor.

Table V shows that eliminating rule asymmetries increases the mean effort levels of subjects and hence increases total output. As predicted, this impact increases as the degree of unfairness increases. The observed mean effort level in the last 10 rounds of Experiment 1 ($k = 0$) was 77.9, in Experiment 2 ($k = 25$) it was 66.5, and in Experiment 3 ($k = 45$) it was 53.9. Thus, tournament output increases when equal opportunity law are imposed. These laws also increase the probability of winning for previously disadvantaged groups. The observed probability of winning for disadvantaged subjects increased from .102 in Experiment 2 and .173 in Experiment 3 to a theoretical level of .500 in Experiment 1 (where no disadvantaged subjects existed). Finally, we can see whether disadvantaged subjects suffered a welfare loss after we imposed equal opportunity laws. We earlier noted that disadvantaged subjects could be worse off if the costs of their increased effort outweigh the benefits derived from higher probabilities of winning. This was clearly not the case. The mean expected payoff of subjects in Experiment 1 was $1.09. In Experiments 2 and 3, the mean expected payoffs of disadvantaged subjects were $0.83 and $0.75[14]

In summation, our laboratory equal opportunity law clearly increases the probability of winning and the payoffs for disadvantaged subjects. Total tournament output was also increased, and hence the profit of the tournament administrator. Previously advantaged subjects were obviously hurt by the imposition of such a law.

B. Affirmative Action

We investigate the impact of affirmative action programs by comparing the results of Experiments 4 and 5 with those of Experiments 6 and 7 (Table VI). Comparing Experiment 4 ($\alpha = 2$, $k = 0$) to Experiment 6 ($\alpha = 2$, $k = 25$) reveals the effects of an affirmative action program which alters an intermediate amount of cost asymmetry ($\alpha = 2$) by imposing a rules change ($k = 25$). In moving from Experiment 5 to 7, we investigate the effects of an identical affirmative action program when the degree of cost asymmetry is greater ($\alpha = 4$). Clearly our point is to investigate whether the degree of previous societal discrimination influences the effects of a given affirmative action program.

Results are mixed when we compare the results of Experiment 4 with those of Experiment 6. Effort levels fall for the cost advantaged subjects and remain the same for cost disadvantaged subjects. Using the Wilcoxon signed rank test, the observed effort levels of 36.41 and 64.17 (for cost disadvantaged-rules advantaged and cost advantaged-rules disadvantaged subjects respectively) are not significantly different from the predicted levels of 29.49 and 58.99. Given these effort level changes, the total output for Experiment 6 is lower than that of Experiment 4. The probability of winning for the previously cost disadvantaged group increases from .212 to .47 as does their expected payoffs.

Thus, our affirmative action program was successful in increasing the probability of winning and the expected payoff for cost disadvantaged subjects. The cost of this increase was a decrease in tournament output. Hence, for organizations with intermediate levels of cost asymmetries amongst agents, affirmative action programs appear to be profit decreasing. This fact makes it unlikely that such programs would be undertaken voluntarily.

Findings are slightly different when we compare results of Experiment 5 and 7. Remember in Experiment 5 ($\alpha = 4$) half the cost disadvantaged subjects dropped out. Our laboratory affirmative action program eliminated this drop-out behavior. Hence, mean effort levels significantly increase as we move from Experiment 5 from 18.47 and 77.33 for cost disadvantaged and advantaged subjects to 32.41 and 85.51 for cost disadvantaged, rules advantaged and cost advantaged, rules disadvantaged subjects in Experiment 7. As a result, the total output increases as do the profits of the tournament administrator. Probabilities of winning for the previously cost disadvantaged subjects increase from .130 to .293 while expected payoffs increase from \$0.92 to \$0.93.

This experiment implies that imposing an affirmative action program when cost asymmetries are severe is both beneficial for cost disadvantaged groups and profit increasing for tournament administrators. Programs appear to increase output because while disadvantaged subjects tend to drop out when cost asymmetries are great, they participate when given the opportunity to compete on a more equal footing.

C. Aggregation and Individual Behavior

When one attempts to investigate a proposed economic institution such as an economic tournament and the theory supporting it, there are two types of hypotheses one can subject the data to. Type I (the strong-form hypothesis) requires support for the underlying theory on a case-by-case basis with all individual subject pairs behaving in strict accordance to the theory. This hypothesis implies that the across subjects mean will be at predicted levels with a variance of zero. BSW [1987] rejected this strong hypothesis, and we reject it here. In the present experiments (as in BSW [1987]) we observe support for a Type II (weak-form) hypothesis. That is, on average, the data supports the predicted theoretical results, and hence, the proposed institution functions as predicted. While aggregate or mean data (of the type we use here) may sometimes be considered to yield misleading conclusions [see Brown and Rosenthal, forthcoming], we do not feel this is the case here. First, the mean behaviors plotted in Figures I - VI are clearly not statistical flukes created by "washing out" the behavior of outliers, but rather are the results of effort choices distributed around predicted equilibrium levels. Figure VII shows the mean effort levels of subject pairs in Experiments 2 and 3. Clearly these effort levels are not bi-modal distributions yielding misleading means, but rather full (almost symmetric) distributions centered around the mean. While we can not explain the existence of such a distribution (results were similar in BSW [1987] for symmetric tournaments), we feel comfortable in saying that rank order tournaments are reliable institutions which yield, on average, behavior consistent with the underlying theory.

Furthermore, disaggregated individual data clearly indicate that subjects qualitatively behave as predicted. Figures IV and V and Table III show that when the theory predicts differentiated behavior between advantaged and disadvantaged subjects, that is how they behave.[15] Figures II and III likewise indicate that when the theory predicts undifferentiated behavior (in unfair tournaments) that is what we find. For example, both types of subjects were predicted to choose effort levels of 58.39 in Experiment 2. Over the last 5 rounds, the fraction of advantaged and disadvantaged subjects choosing above and below this predicted level is approximately equal. 53.3% of advantaged subjects chose below the predicted level versus 57% of disadvantaged subjects. Similar results exist for experiment 3. These results sharply contrast to those of Experiments 4 and 5 where behavior was predicted to be differentiated, and it was.

The fact that a variance around the predicted effort levels exists may imply that such institutions carry an "institutional risk" to the tournament administrator. That is, actual behavior in tournament settings may, in fact, vary from firm to firm or from plant to plant. Such risks may be mechanism specific; for example, variance in the piece-rate mechanism tested by BSW [1987] was significantly lower.

Section VI: Conclusions And Implications

This research has two purposes: to determine whether behavior in asymmetric tournaments conformed to that predicted by tournament theory, and to investigate efficiency implications of policies enacted by society to rectify asymmetries in the workplace.

Behavior in asymmetric tournaments approximated that predicted by the theory. This result is similar to that attained by BSW [1987] for symmetric tournaments. We have now run more than twenty-five tournament experiments, which incorporated a wide range of parameter changes. Results are surprisingly robust; observed behavior approximates that predicted. We no longer question the theory's descriptive validity. Two behavioral tendencies that are persistent however are the variance in across-subject behavior, and the slight oversupply of effort. While an explanation of these tendencies was not the focus of this paper, both tendencies are intriguing and deserve more research.

Our results, if replicable, hold significant import for discussions of efficiency implications for social policies. Answers to questions about the efficiency of programs, such as, equal opportunity laws and affirmative action programs are suggested by the data. Results suggest that imposing equal opportunity laws are clearly beneficial to disadvantaged agents: the laws increase promotion rates (i.e."probability of winning") and equilibrium payoffs of previously disadvantaged agents. More importantly, the laws significantly increase the effort levels of all types of agents in the tournament. Hence, if M and m are unchanged, the laws actually increase the profit of tournament administrators (firms). If the results have external validity, then the business community should support such laws because they are profit increasing. From the firms' viewpoint, our results imply there is no tradeoff between equity and efficiency.

Affirmative action programs also clearly benefit disadvantaged agents. Results suggest that the programs "level the playing field" and thus discourage disadvantaged agents from dropping out. This result is similar to that of Osterman [1982]. Using field data, Osterman found that affirmative action programs significantly lower the quit rate of women in organizations. Lower quit rates can increase efficiency because the firm realizes greater returns on its training investment. Our results suggest that the effect of affirmative action programs on output depends on the degree of discrimination. When the differential in ability was severe, then the programs did increase total tournament effort, and hence the profit of tournament administrators. Such an effect was not observed when cost disadvantaged subjects has less severe handicaps.

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Notes

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[1]The term on average means that while the mean effort level of subjects converged to its theoretical mean as the experiment was iterated, the variance of effort levels chosen remained substantial. Hence there was only a weak form of substantiation for the theory.

[2]While this tendency to oversupply effort may be an artifact of the flatness of a subject's payoff function around the equilibrium point [see Harrison, 1990; Drago and Heywood, 1989], we were careful in designing our experiments to provide incentives for subjects to change their behavior as we change experimental parameters and also for asymmetric subjects to have an incentive to differentiate their behavior from each other.

[3]O'Keeffe et.al [1984] point out that one can interpret the random shock not only as true randomness in the technology but alternatively as random measurement error in the principal's monitoring of output.

[4]Some rule is necessary to deal with cases in which $y_i = y_j + k$. For simplicity of exposition we ignore this possibility.

[5]Naturally we must check for a corner solution.

[6]If both members of a pair had the same total number then a coin was tossed to decide which pair member was to be designated as having the highest total number. The subjects were informed of this tie-breaking procedure before the experiment began.

[7]To check that these incentives were adequate, BSW [1987] ran our baseline experiment with payoffs quadrupled so that subjects could, and did, win over $40. The results of the experiment did not differ substantially from the baseline.

[8]See Appendix B for sample instructions.

[9]Experimental parameters were constrained by equation (8) - (11). These equations define necessary conditions for an interior solution, but do not rule out corner solutions. We wanted to avoid corner solutions because in corner solutions the subject predicted to choose the lower effort level finds it more advantageous to choose zero and "drop out".

[10]The Wilcoxon signed rank test requires that the distribution from which the data was drawn was symmetric. Using a Kolmogorov-Smirnov test, we could not reject the hypothesis that the data were drawn from a normal, hence, symmetric distribution. For a discussion of this procedure see Pratt and Gibbons [1981].

[11]All statistical tests in this paper use a significance level of 5%.

[12] These probabilities are calculated using the observed mean effort levels and equation (5).

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[13]An identical experimental result was found by Bull, Schotter, and Weigelt (1986) in an earlier unpublished set of experiments on this same topic. In those experiments the parameters were -- $M - m = .\$80$, $c = 25{,}000$, $a = 40$, and $\alpha = 4$. Final period mean effort levels for that half of the disadvantaged subject group that dropped out was 1.17 while for those who did not drop out it was 43.29. The predicted effort level is 14.3.

[14]Payoffs are expected in the sense that subjects should realize these payoffs based on their observed mean effort levels.

[15]We have also established, again with the use of a repeated measures ANOVA, that there are significant differences between the choices of asymmetric subjects and the predicted equilibrium choice of their opponent. Hence, not only do asymmetric agents differentiate themselves with respect to their observed behavior, but also with respect to the behavior that is predicted for them.

TABLE I

Experimental Parameters

Experiment	Decision # range	Cost function	Random # range	M	m	(M - m)	Equilibrium Advantaged	Equilibrium Disadvantaged
1	(0-100)	$e_i^2/15,000$	(-60,60)	$2.04	0.86	$1.18	73.75	73.75
unfair tournaments								
2 k = 25	(0-100)	$e_i^2/15,000$	(-60,60)	$2.04	0.86	$1.18	58.39	58.39
3 k = 45	(0-100)	$e_i^2/15,000$	(-60,60)	$2.04	0.86	$1.18	46.09	46.09
uneven tournaments								
4 α = 2	(0-100)	advantaged $e_i^2/15,000$ disadvantaged $2e_i^2/15,000$	(-60,60)	$2.04	0.86	$1.18	74.51	37.26
5 α = 4	(0-100)	advantaged $e_i^2/15,000$ disadvantaged $4e_i^2/15,000$	(-60,60)	$2.04	0.86	$1.18	76.09	19.02
affirmative action tournaments								
6 α = 2 k = 25	(0-100)	cost advantaged $e_i^2/15,000$	(-60,60)	$2.04	0.86	$1.18	58.99	
		cost disadvantaged $2e_i^2/15,000$						29.49
7 α = 4 k = 25	(0-100)	cost advantaged $e_i^2/15,000$	(-60,60)	$2.04	0.86	$1.18	60.24	
		cost disadvantaged $2e_i^2/15,000$						15.06

TABLE II

Experimental Results: Means and Standard Deviations of Subjects' Effort Levels

Experiment	Mean Decision Numbers				Mean Standard Deviations			
	Predicted	Rounds 1 - 10	Rounds 11-20	Round 20	Rounds 1 - 10	Rounds 11-20	Round 20	Number of subjects
1 - symmetric	73.75	73.87	77.91	80.75	25.04	24.75	23.46	24
2 - unfair $k = 25$								
rule advantaged	58.39	65.88	74.50	68.22	19.48	19.94	26.89	18
rule disadvantaged	58.39	64.66	58.65	62.44	30.85	37.87	37.54	
3 - unfair $k = 45$								
rule advantaged	46.09	47.00	48.65	55.25	15.70	20.35	28.72	16
rule disadvantaged	46.09	53.67	59.29	65.00	27.57	27.90	26.65	
4 - uneven $\alpha = 2$								
cost advantaged	74.51	73.71	78.83	88.67	24.90	21.80	11.63	18
cost disadvantaged	37.26	41.70	37.06	46.89	29.55	28.90	31.16	
5 - uneven $\alpha = 4$								
cost advantaged	76.09	68.46	77.33	80.60	26.36	21.05	16.26	30
cost disadvantaged	19.02	28.18	18.47	17.20	21.25	19.73	20.81	
6 - affirmative action $k = 25$, $\alpha = 2$								
cost advan/rule disadvan	58.99	72.29	64.17	68.43	25.45	32.32	33.24	14
cost disadvan/rule advan	29.49	42.49	36.41	26.57	26.35	27.68	25.26	
7 - affirmative action $k = 25$, $\alpha = 4$								
cost advan/rule disadvan	60.24	61.94	85.51	87.27	29.91	19.58	19.11	22
cost disadvan/rule advan	15.06	32.62	32.41	27.45	26.14	25.67	21.24	

TABLE III

Summary of Predicted and Observed Experimental Results

Experiment:	1 ($k = 0$)	2 ($k = 25$)	3 ($k = 45$)	4 ($\alpha = 2$)	5 ($\alpha = 4$)	6 ($\alpha = 2$, $k = 25$)	7 ($\alpha = 4$, $k = 25$)
Advantaged Subjects - Rounds 1-20*							
Effort Level:							
Predicted	73.75	58.39	46.09	74.51	76.09	58.99	60.24
Observed	75.89	70.19	47.82	76.27	72.90	68.23	73.72
Disadvantaged Subjects Rounds 1-20							
Effort Level:							
Predicted	73.75	58.39	46.09	37.26	19.02	29.49	15.06
Observed	75.89	61.65	56.48	39.38	23.32	39.45	32.51
Advantaged Subjects*							
Probability of Winning:							
Expected	.500	.687	.805	.762	.862	.537	.654
Observed	.500	.898	.827	.788	.870	.523	.707
Advantaged Subjects*							
Mean Monetary Payoff:							
Expected	$1.09	$1.44	$1.67	$1.38	$1.55	$1.26	$1.39
Observed	$1.09	$1.55	$1.68	$1.39	$1.49	$1.21	$1.20
Disadvantaged Subjects							
Probability of Winning:							
Expected	.500	.313	.195	.238	.138	.463	.346
Observed	.500	.102	.173	.212	.130	.477	.293
Disadvantaged Subjects							
Mean Monetary Payoff:							
Expected	$1.09	$1.00	$0.95	$0.96	$0.92	$1.29	$1.21
Observed	$1.09	$0.75	$0.83	$0.93	$0.92	$1.24	$0.93

* - For affirmative action tournaments (experiment 6 & 7), advantaged subjects are the cost advantaged, rules disadvantaged subjects.

Note: Expected probabilities of winning are calculated using the observed mean effort levels and equation (5). Expected payoffs are calculated using the expected probabilities of winning and equation (3).

TABLE IV

Experiment 5 ($\alpha = 4$)
Effort Levels of Advantaged and Disadvantaged Subjects - Rounds 11 - 20

Drop-Out Group			Non Drop-Out Group		
	median effort level			median effort level	
subject group	advantaged subject	disadvantaged subject	subject group	advantaged subject	disadvantaged subject
1	95	0	1	89	44
2	100	0	2	85	50
3	67	4	3	60	47
4	90	0	4	71	20
5	95	3	5	46	20
6	55	3	6	63	35
7	69	0	7	80	30
8	100	5			
mean	85.3	8.16		64.7	30.2

TABLE V

The Impact of Laboratory Equal Opportunity Laws

Experiment:	1 (k = 0)	2 (k = 25)	3 (k = 45)
Mean Effort Level for Rounds 11 - 20 for:			
Advantaged Subjects	-	74.50	48.65
Disadvantaged Subjects	-	58.65	59.29
All Subjects	77.90	66.50	53.90
Expected Probability of Winning:			
Advantaged Subjects	.500	.898	.827
Disadvantaged Subjects	.500	.102	.173
Expected Monetary Payoffs:			
Advantaged Subjects	$1.09	$1.55	$1.68
Disadvantaged Subjects	$1.09	$0.75	$0.83

Note: Expected probabilities of winning are calculated using the observed mean effort levels and equation (5). Expected payoffs are calculated using the expected probabilities of winning and equation (3).

TABLE VI

The Impact of Laboratory Affirmative Action Programs

Experiment:	4 ($\alpha = 2$)	6 ($\alpha = 2$, $k = 25$)	5 ($\alpha = 4$)	7 ($\alpha = 4$, $k = 45$)
Mean Effort Level for Rounds 11 - 20 of:				
Advantaged Subjects	78.83	64.17	77.33	85.51
Disadvantaged Subjects	37.06	36.41	18.47	32.41
Expected Probability of Winning:				
Cost Advantaged Subjects	.788	.523	.970	.797
Cost Disadvantaged Subjects	.212	.477	.130	.293
Expected Monetary Payoff:				
Cost Advantaged Subjects	$1.38	$1.24	$1.49	$1.20
Cost Disadvantaged Subjects	$0.93	$1.21	$0.92	$0.93

Note: Expected probabilities of winning are calculated using the observed mean effort levels and equation (5). Expected payoffs are calculated using the expected probabilities of winning and equation (3).

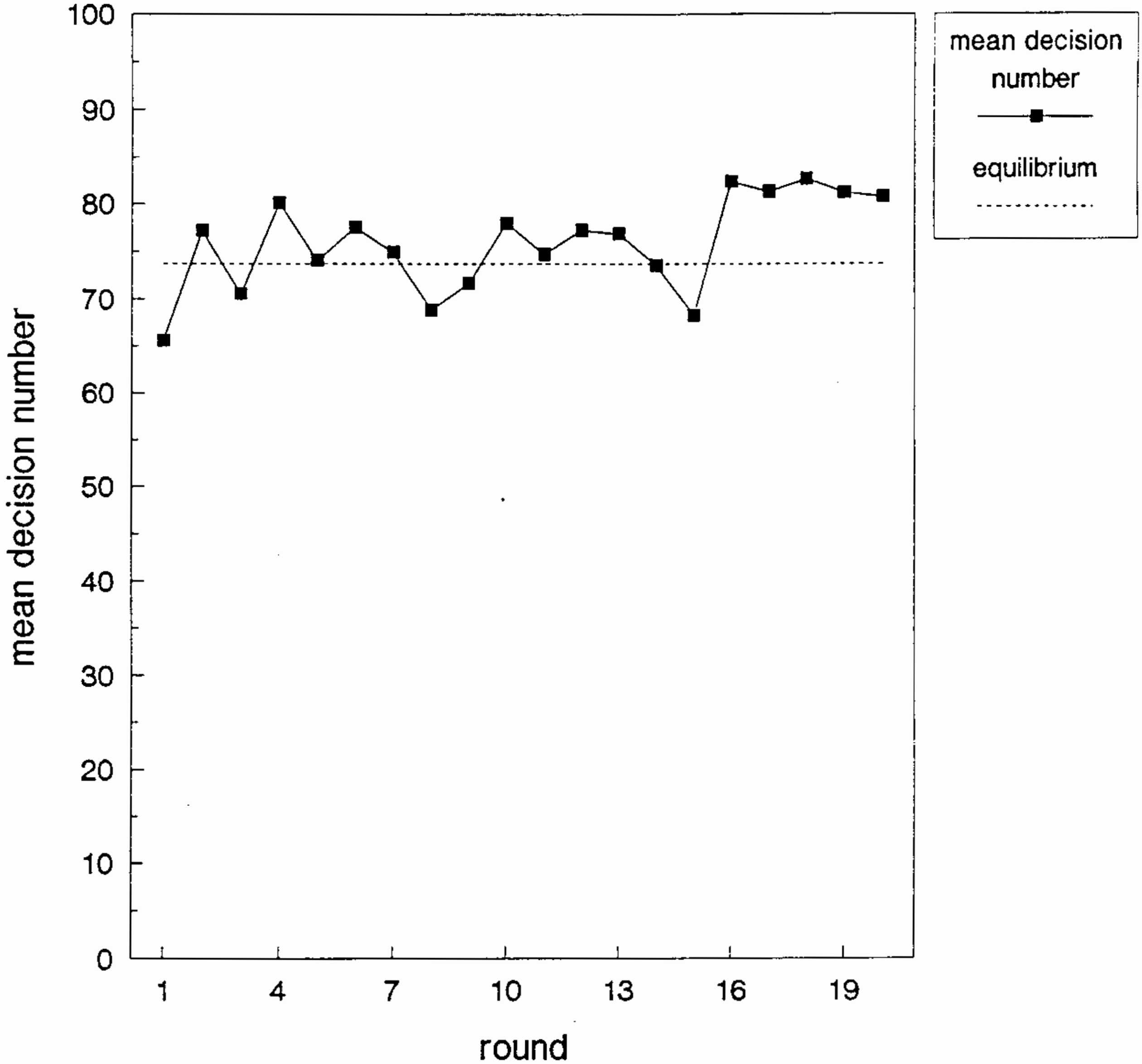

FIGURE I

Experiment 1

Symmetric Tournament

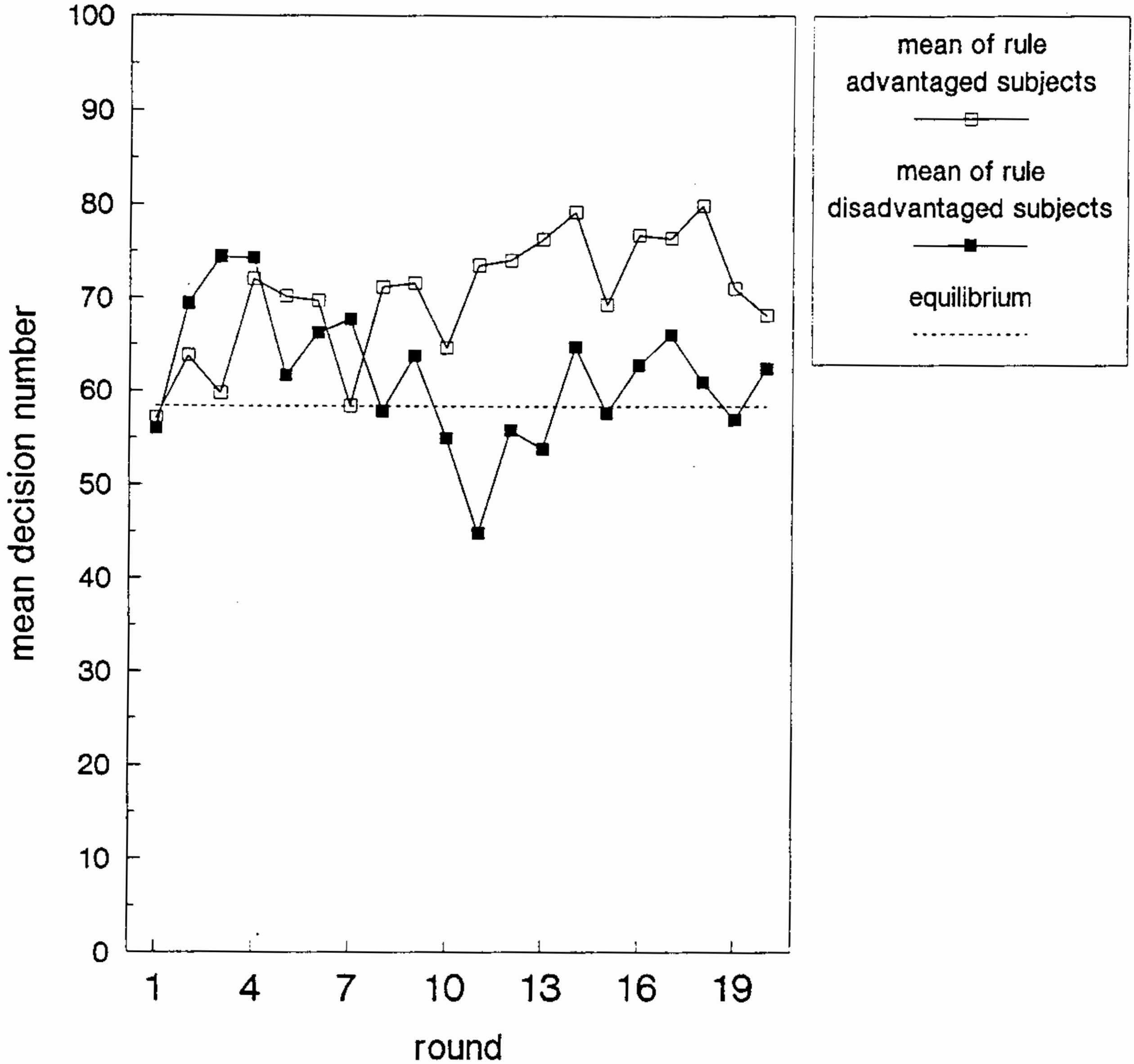

FIGURE II

Experiment 2

Unfair Tournament (k = 25)

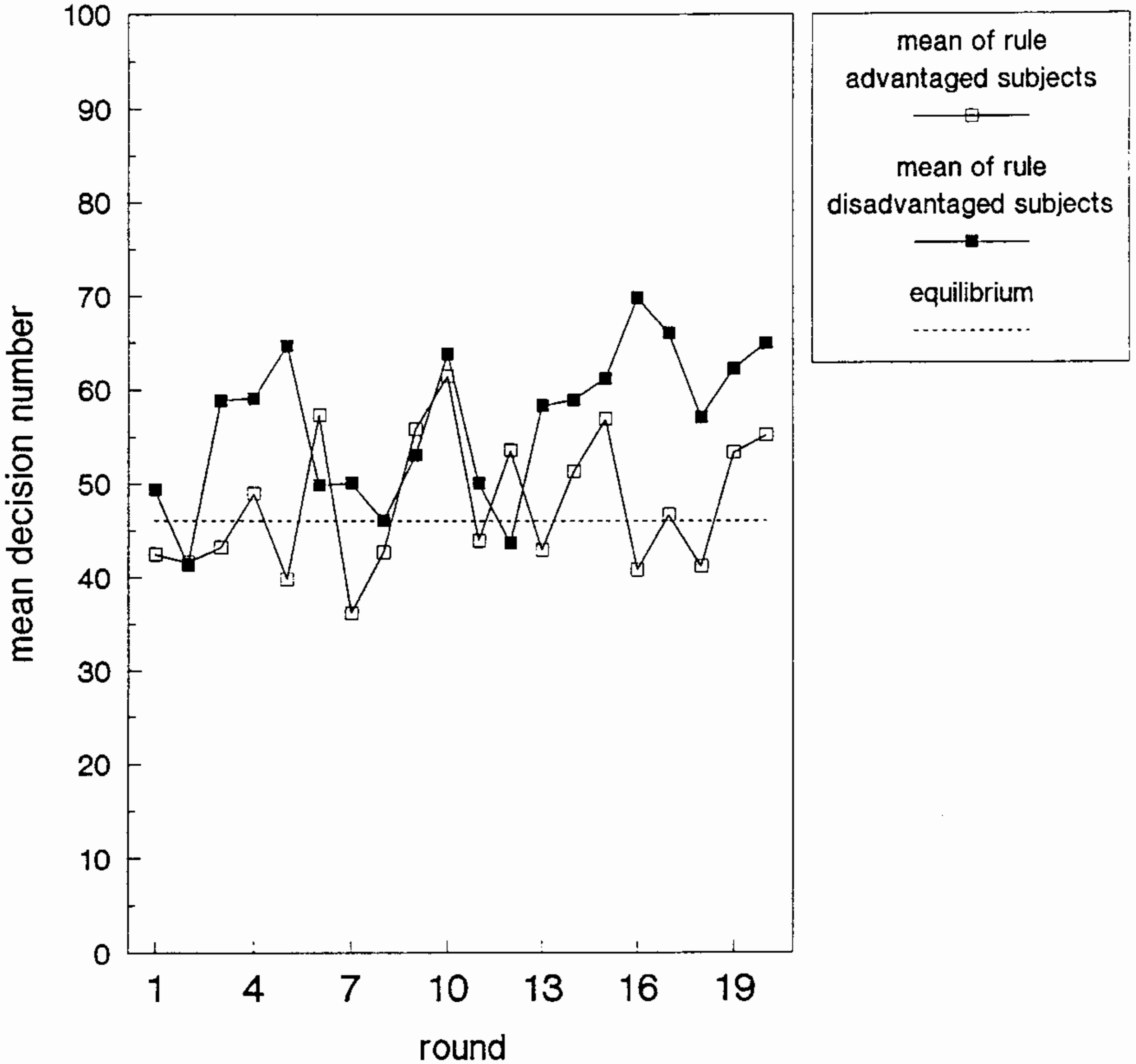

FIGURE III

Experiment 3

Unfair Tournament (k = 45)

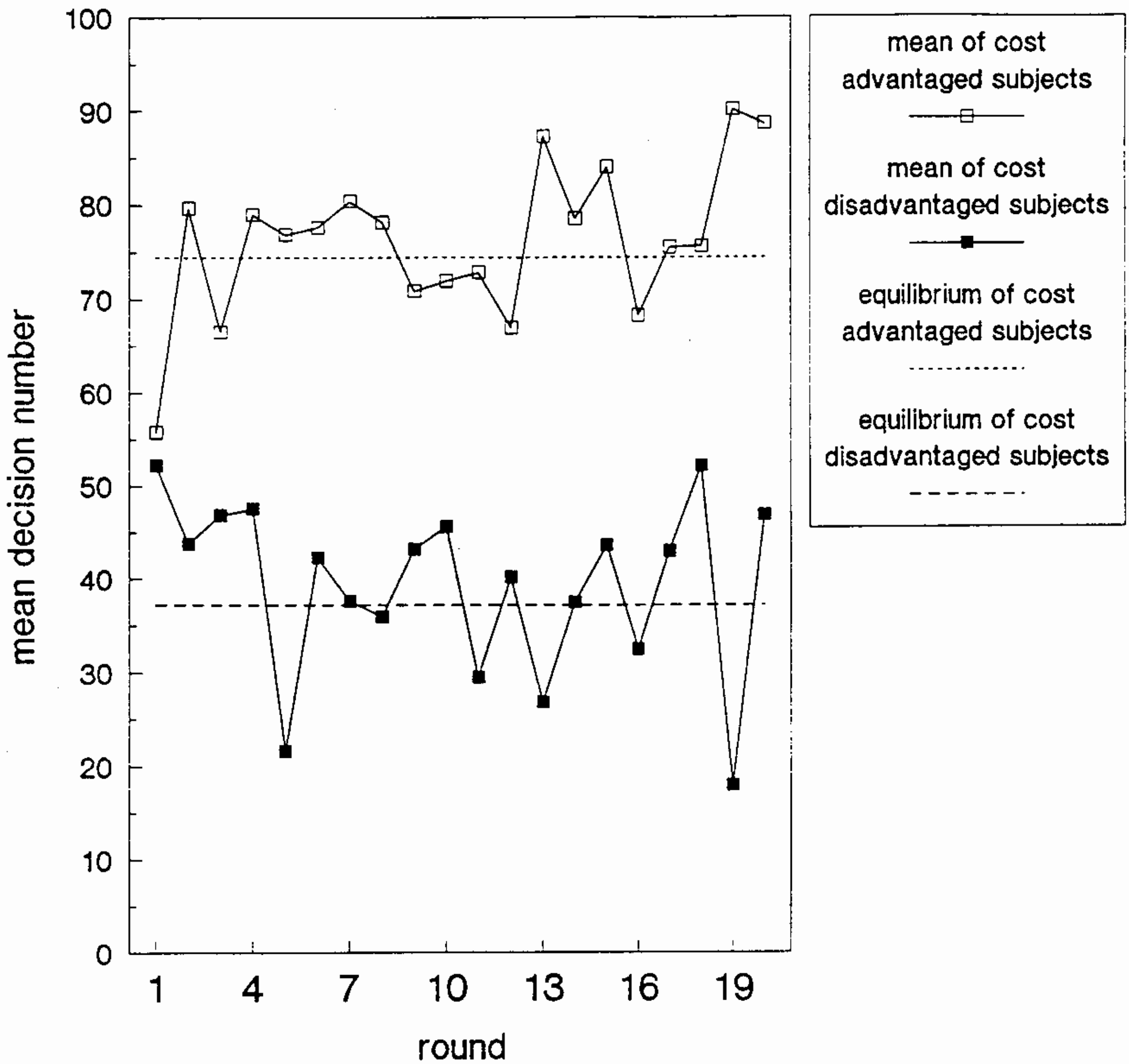

FIGURE IV

Experiment 4

Uneven Tournament ($\alpha = 2$)

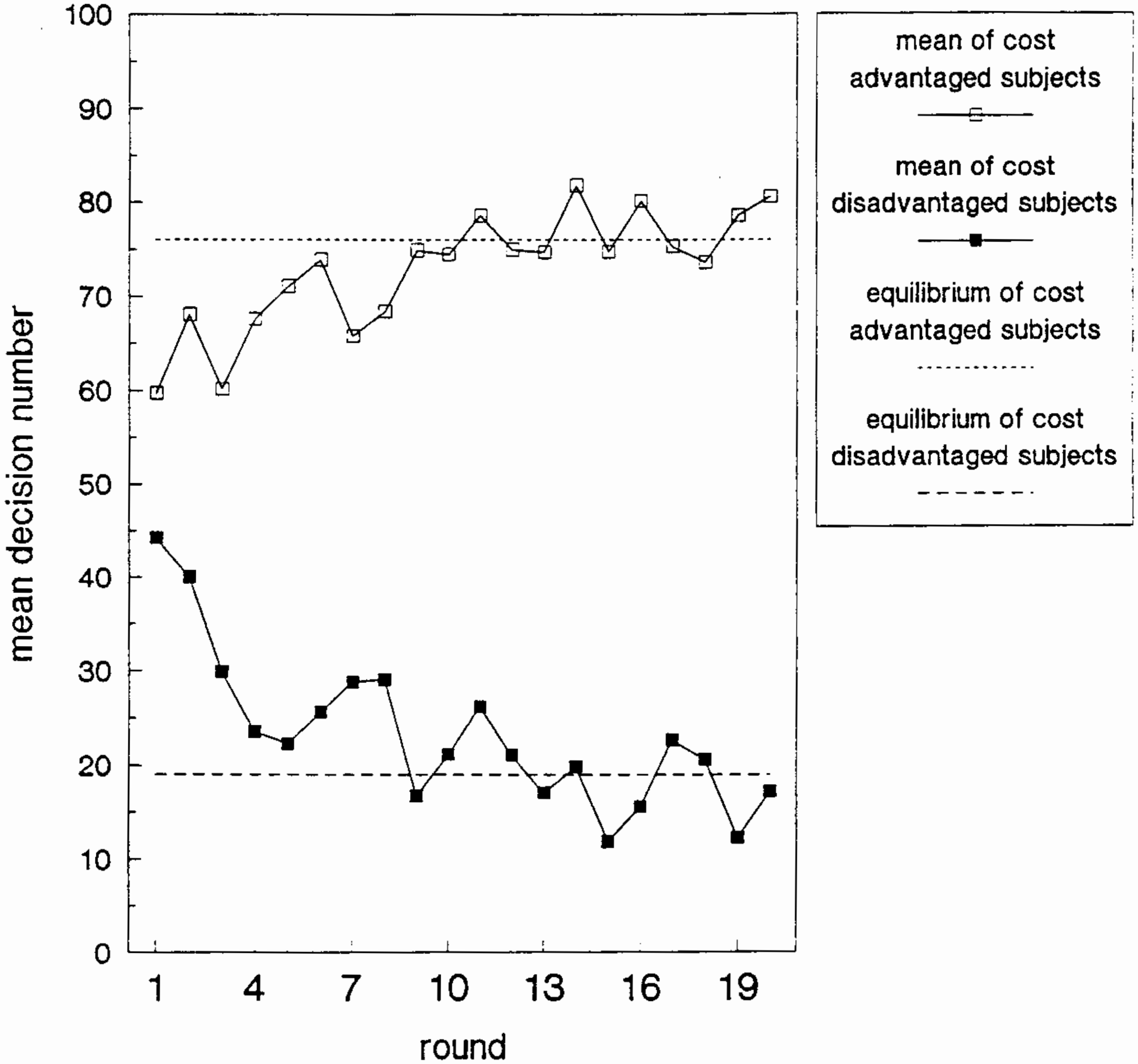

FIGURE V

Experiment 5

Uneven Tournament ($\alpha = 4$)

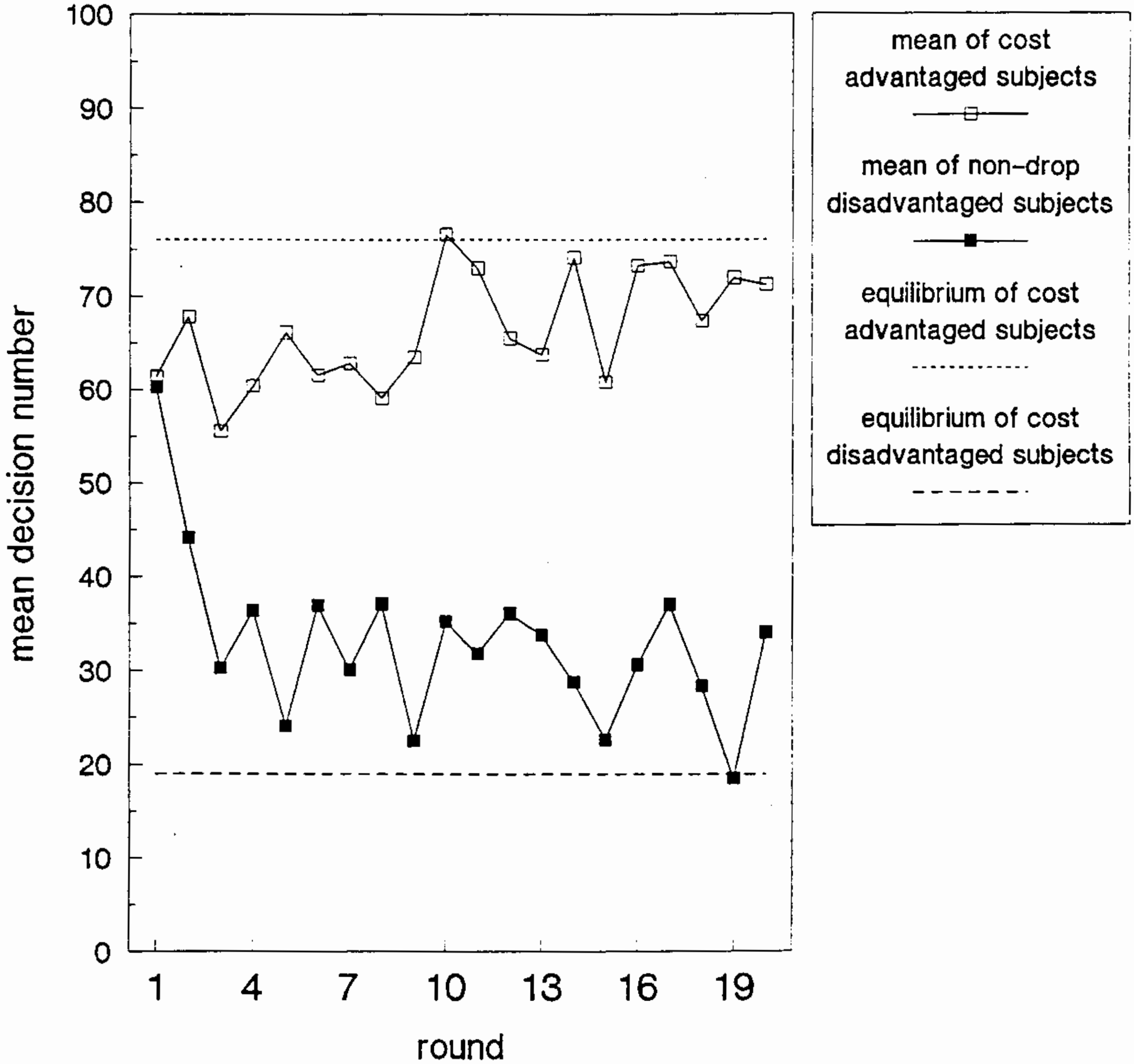

FIGURE VIa

Experiment 5 ($\alpha = 4$) Mean Effort Levels of Pair
Where Disadvantaged Member Didn't Drop Out

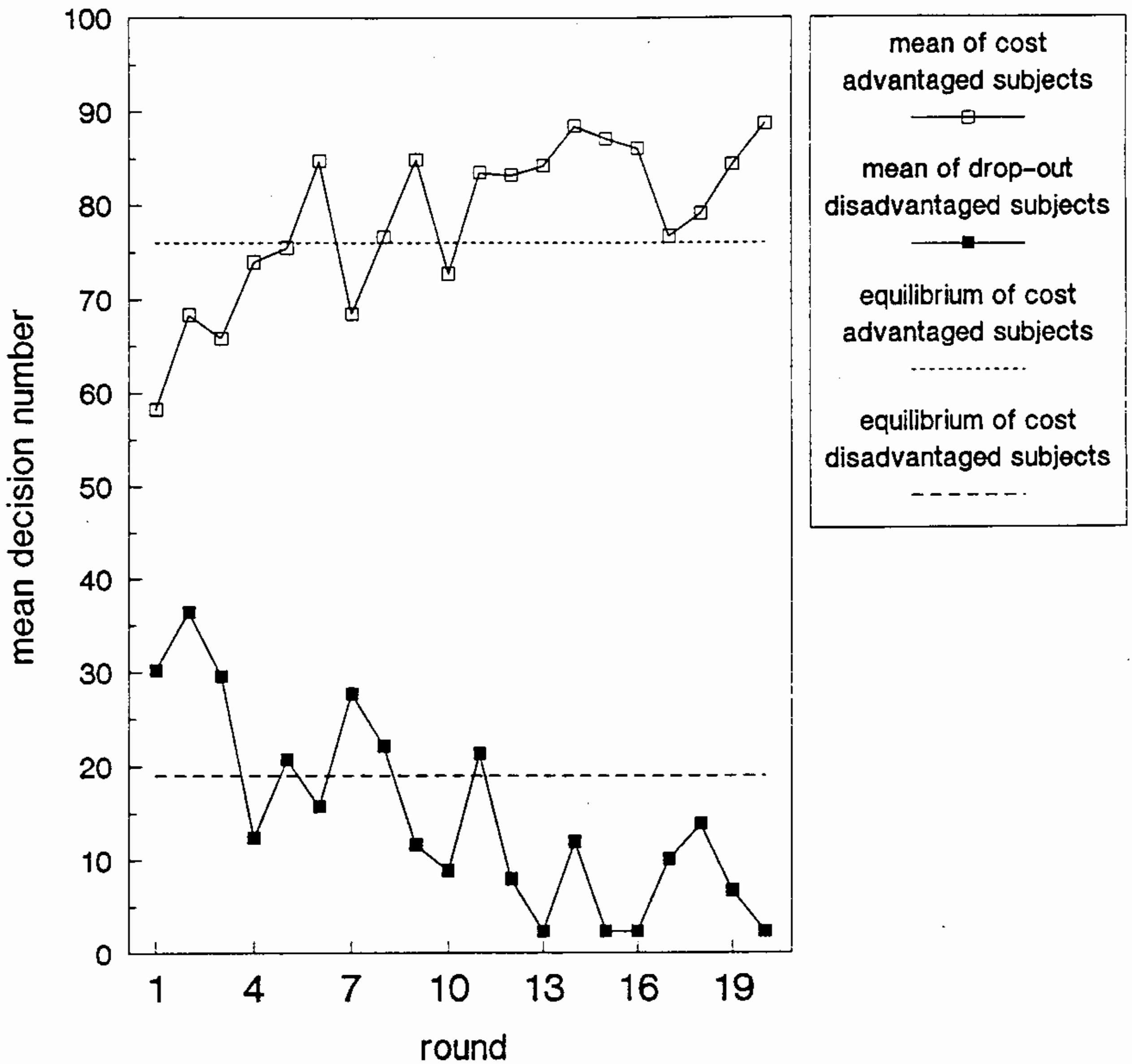

FIGURE VIb

Experiment 5 ($\alpha = 4$) Mean Effort Levels of Pair
Where Disadvantaged Member Dropped Out

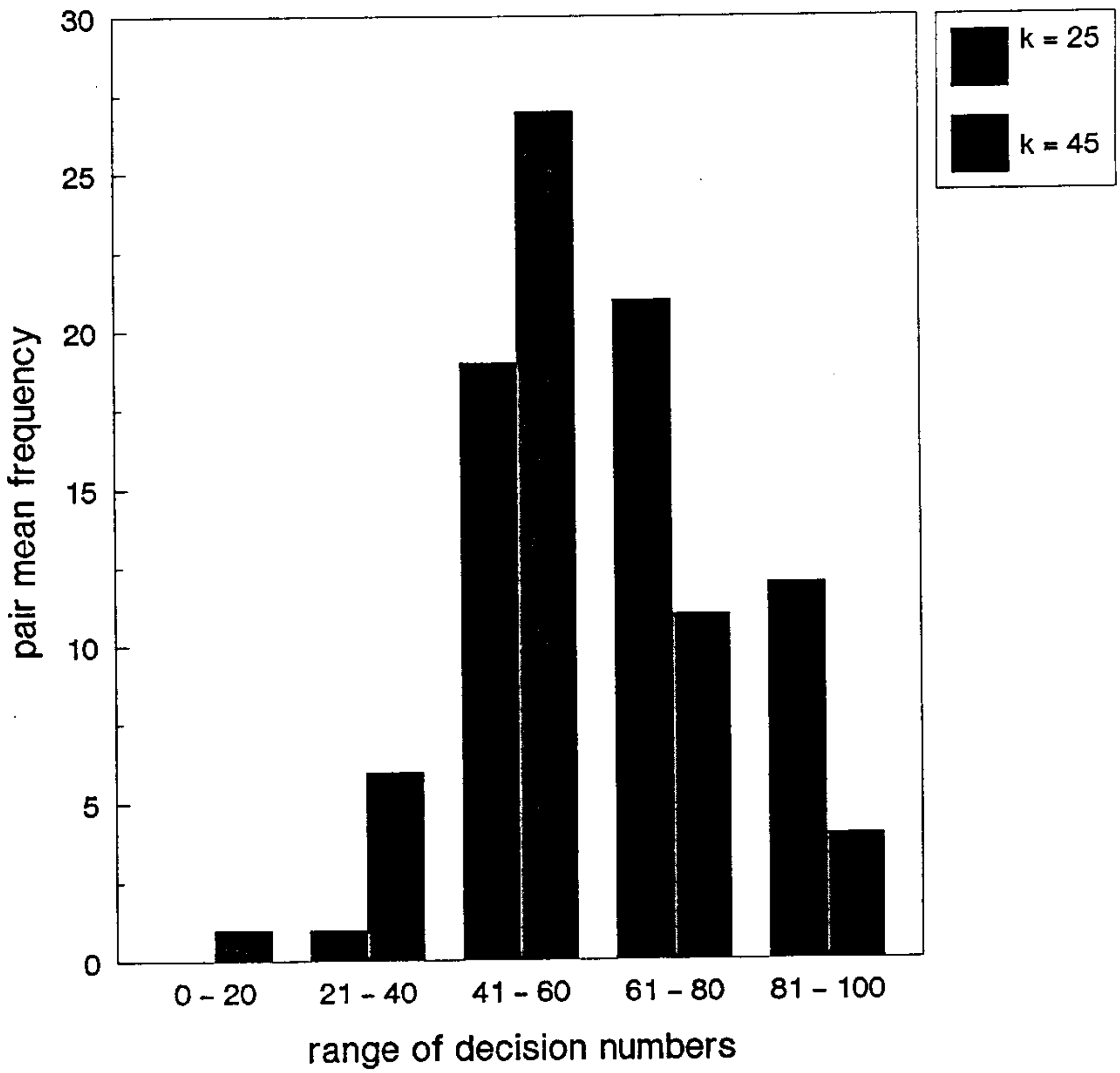

FIGURE VII

Mean Pair Effort Level Frequency

(k = 25 vs. k = 45)