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

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This paper assesses whether affirmative action programs and equal opportunity laws affect the output of economic agents. More precisely, we find that equal opportunity laws and affirmative action programs always benefit disadvantaged groups. Equal opportunity laws also increase the effort levels of all subjects and hence the profits of the tournament administrator (usually the firm). The effects of affirmative action programs depend on the severity of a group's cost disadvantage. When the cost disadvantage is severe, these programs significantly increase effort levels (and hence profits). The opposite is true when the disadvantage is slight.

I. INTRODUCTION

Affirmative action programs have stirred a vigorous debate in recent years. Opponents claim that their supposed equity benefits are more than offset by the efficiency losses they impose on firms when more qualified candidates are passed over for promotion in preference to candidates from specific minority groups. This paper presents experimental evidence indicating that this supposed trade-off may not exist in some situations. More specifically, we find that the imposition of affirmative action programs (and equal opportunity laws) may lead to an increase in the effort expended by all of the workers in the firm. When this is true, no equity-efficiency trade-off exists, since both equity and efficiency are enhanced by the programs. To study these programs and laws in the lab, we model them as rank order tournaments in which an agent's payoff depends only on the rank of his performance relative to others in the tournament.

A set of recent papers have investigated the theoretical properties of such tournaments [Lazear and Rosen, 1981; Green and Stokey, 1983; Nalebuff and Stiglitz, 1983; 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.

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Tournaments can be asymmetric in two ways. Using the terminology of O’Keeffe et al., 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.

Social policies address these asymmetries. For instance, in unfair tournaments, rules (either explicit or implicit) treat identical agents unequally. Prejudice leads to preferential treatment for certain types of agents; i.e., to win the big prize (e.g., a promotion), the performance of a discriminated against group member must exceed that of a favored group member by some fixed amount $k (k > 0)$. To remedy this asymmetry, society has enacted equal opportunity laws: they prevent tournament administrators (employers) from favoring one group of agents (i.e., $k = 0$).

Uneven tournaments are different: here, one group of agents has a higher cost of effort than another has. The 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 administrators 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 incentives generated by them have characteristics of rank order tournaments [Lambert, Larcker, and Weigelt, 1989]. While empirical studies have assessed whether social policies are effective in inducing organizations to hire more minorities [Goldstein and Smith, 1976; Heckman and Wolpin, 1976; Leonard, 1984], there are little data on the efficiency of such policies. For example, does the perceived equity-efficiency trade-off exist; and if it does, to what extent is organizational output reduced?

This paper examines the efficiency implications of equal opportunity laws and affirmative action programs and investigates
whether subjects behave in asymmetric tournaments as predicted by tournament theory. It is difficult to address these questions with 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 similar to that of Bull, Schotter, and Weigelt [1987] in their study of symmetric rank order tournaments. They found that on average subjects in symmetric tournaments behaved as predicted by the theory.\(^1\)

Our findings are described later. In summary, we find that observed behavior generally supports both the qualitative and quantitative predictions of the theory, although subjects tend to oversupply effort (i.e., supply more effort than predicted).\(^2\) Also, we find that the perceived trade-off between equity and efficiency does not always exist. What is equitable may also be efficient. Both equal opportunity laws and affirmative action programs increase the probability of winning for disadvantaged groups. Further, equal opportunity laws increase the effort levels of all subjects and hence 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 slight, effort levels of all agents (and hence profits of the tournament administrator) are reduced. When the cost disadvantage is severe, 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 apparently alleviates this dropout behavior.

We proceed as follows: Section II reviews the theory of symmetric and asymmetric tournaments and presents the equilibria of the games they define. In Section III we present our experimental design. Experimental results are presented in Section IV. Efficiency implications of our equal opportunity laws and affirmative action programs are presented in Section V. Finally, in Section VI we offer concluding comments.

1. The term on average means that on an aggregate level, the mean effort choices of subjects converged to the predicted level, although the variance of effort levels chosen remained substantial.

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] and Drago and Heywood [1989]), we were careful in designing our experiments to provide incentives for subjects to change their behavior as we changed experimental parameters and also for asymmetric subjects to have an incentive to differentiate their behavior from each other.
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:

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

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

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 $\alpha$ 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 that generates an output $y_i$ according to

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

where the production function $f(.)$ is concave and $\epsilon_i$ 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 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

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

while agent $j$'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 game's pure strategy Nash equilibria. 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.

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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.
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. The theory requires the specification of the utility function, the production function, the distribution of \((\epsilon_i - \epsilon_j)\), and prizes \(M\) and \(m\). One simple specification is the following:

\[
\begin{align*}
U_i(p_i,e_i) &= p_i - e_i^2/c, \\
U_j(p_j,e_j) &= p_j - \alpha e_j^2/c
\end{align*}
\]

\[
(1')
\]

\[
y_i = e_i + \epsilon_i, \quad l = i,j,
\]

where \(c > 0\) and \(\epsilon_i\) 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

\[
\begin{align*}
Ez_i(e_i,e_j) &= m + \pi^i(e_i,e_j,k)[M - m] - e_i^2/c. \\
Ez_j(e_i,e_j) &= m + \pi^j(e_i,e_j,k)[M - m] - \alpha e_j^2/c.
\end{align*}
\]

\[(3')\]

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

\[
\begin{align*}
\frac{\partial Ez_i}{\partial \epsilon_i} &= \frac{\partial \pi(e_i^*,e_j^*,k)}{\partial \epsilon_i} [M - m] - \frac{2e_i^*}{c} = 0; \\
\frac{\partial Ez_j}{\partial \epsilon_j} &= \frac{\partial \pi(e_i^*,e_j^*,k)}{\partial \epsilon_j} [M - m] - \frac{\alpha 2e_j^*}{c} = 0.
\end{align*}
\]

\[(4)\]

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

Given distributional assumptions on \(\epsilon_i\) and \(\epsilon_j\), the probability of winning functions with \(k > 0\) is

\[
\pi^i(e_i,e_j,k) = \begin{cases} 
\frac{1}{2} - \frac{e_i - k - e_j}{2a} + \frac{(e_i - k - e_j)^2}{8a^2}, & \text{if } e_i - k > e_j \\
1 - \frac{1}{2} - \frac{e_j - e_i - k}{2a} - \frac{(e_j - e_i - k)^2}{8a^2}, & \text{otherwise},
\end{cases}
\]

5. Naturally we must check for a corner solution.
\[ \pi^j(e_i, e_j, k) = \begin{cases} \frac{1}{2} - \frac{e_j + k - e_i}{2a} + \frac{(e_j + k - e_i)^2}{8a^2}, & \text{if } e_j + k > e_i \\ 1 - \frac{1}{2} - \frac{e_i - e_j - k}{2a} - \frac{(e_i - e_j - k)^2}{8a^2} & \text{otherwise}; \end{cases} \]

with

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

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

and

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

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

Note that the marginal probability of winning is equal for both agents, regardless of the value of \( k \), 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 that

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

\[ e^*_i = \alpha e_j. \]

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

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6. This analysis does not take into account the possibility of a tie. With the parameters used in our experiments, taking ties into account changes the results in an almost imperceptible manner. For example, the instructions indicated that if a tie occurred a coin would be flipped and the winner would receive the large prize. Letting \( e_1 \) and \( e_2 \) be the effort levels chosen by subjects 1 and 2 in a symmetric tournament with \( e_1 > e_2 \), we see that the probability of a tie is \( P(\text{tie} | e_1, e_2) = [(\bar{a} - a) - (e_1 - e_2)]/4a^2 \). The marginal probability of a tie is \( 1/4a^2 \) and is independent of the effort levels chosen by the subjects. Hence, for the symmetric case, our first-order conditions derived in (4) remain intact except for the subtraction of a constant. This leads to equilibrium effort levels that are approximately 0.30 effort units less than those defined by (9) (74.45 instead of 74.75). We consider these differences imperceptible. They are of similar magnitudes in the asymmetric cases as well.
tournament with

\[ e_i^* = e_j^* = (c(M - m))/4a. \tag{9} \]

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

\[ e_i^* = e_j^* = \left( \frac{1}{2a} - \frac{k}{4a^2} \right) \left( \frac{c(M - m)}{2} \right). \tag{10} \]

Note 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 \( e_i \). Because their marginal probability of winning functions are equal at all \( e_i \) and \( e_j \), and both \( i \) and \( j \) have identical cost functions, the same effort level that equates the marginal benefits of increased effort to marginal costs for \( i \), also does so for \( j \). Hence, at equilibrium both choose the same effort level. 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)) with 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 efforts of both agents 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 theoretic impact of an affirmative action program upon a previously uneven tournament is to lower equilibrium effort levels for both agents, lower profits for the tournament administra-
tor, and increase the probability of winning for cost disadvantaged agents.

We compare equations (9) and (10) to investigate the effect of equal opportunity laws. The ceteris paribus removal of discrimination ($k$ is reduced 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 agents who are discriminated against 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 results 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.

III. The Experiment

A. Experimental Procedures

We recruited subjects from economics courses at New York University. As they entered the room, they each chose 20 envelopes from a pile of 1,000. Inside each envelope was a random number 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 the money amount they earned was a function of their decisions, their pair member's decisions, and the realization of a random variable. They were then given written instructions, payoff sheets, and cost-of-effort functions for themselves and their pair member. The instructions were very similar to those used in Bull et al. [1987]. All parameters were common knowledge except the identity of a subject's pair member.

The experiment then began. Subjects were asked to select an integer between 0 and 100 (inclusive) and to record this number on their payoff sheet. This number was called their "decision number." Corresponding to each decision number was a cost listed in the cost-of-effort function table. These costs took the form, $c(e_j) = e_j^2/c$, $c(e_i) = \alpha e_i^2/c$, $\alpha > 1$, where $c$ was a scaling factor used to insure payoffs of reasonable size, and $\alpha$ was the disadvantage parameter indicating how much greater the cost disadvantaged subject's effort cost was (in uneven tournaments). After a subject recorded her decision number, she opened one envelope containing a
random number. The subject recorded this random number, and added it to the decision number to yield a "total number" for that round. This information was then recorded on a slip of paper that was collected. We compared the total numbers for each subject pair and announced which member had the highest total in each pair.\(^7\) These subjects received the "fixed payment" \(M\), the others received \(m, M > m\). Subjects then calculated their payoff for the round by subtracting the decision number cost from their fixed payment.

When subjects completed a round and recorded their payoffs, the next round began. Rounds were identical, and subjects played for twenty rounds. After the last round, subjects calculated their total payoff by summing their payoffs for the twenty rounds and subtracting $7. Experiments lasted approximately 75 minutes, and subjects earned between $7.02 and $23.85 (mean earnings equaled $15.41). These incentives seemed more than adequate.\(^8\)

The experiments replicated the examples of tournaments given in Section II. 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.

The experimental design for unfair tournaments was similar to the one described above. 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 \(M\). This subject was disadvantaged. The value of \(k\) was common knowledge.

In uneven tournament experiments, \(k = 0\), but one member of each subject pair was cost disadvantaged: that subject was assigned a cost function \(\alpha\) times (\(\alpha > 1\)) greater than the other. The cost functions 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 deemphasize the experiment's gamelike nature and reduce the possibility that winning might affect the decision of subjects independently of payoffs. Second, subjects participated in only one experiment.

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\(^7\) If both members of a pair had the same total number, a coin was tossed to decide which pair member was to be designated as having the highest total number. Subjects were informed of this tie-breaking procedure before the experiment began.

\(^8\) To check that these incentives were adequate, Bull et al. [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.
Hence, each subject saw only one parameter set, thus guaranteeing the absence of carryover effects from previous parameter sets. Third, to avoid 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 twenty 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. Though the experimental design introduces dynamic elements into a test of a static theory, the only subgame perfect Nash equilibrium to the 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 IV, 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.

B. Experimental Design

Seven experiments investigated the impact of tournament asymmetries on subject behavior. Experimental parameters are presented in Table I. 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 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 with the baseline demonstrate the impact of the discrimination treatment.

Experiments 4 (\( \alpha = 2 \)) and 5 (\( \alpha = 4 \)) investigate uneven tour-

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9. Experimental parameters were constrained by equations (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."
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<th>Random # range</th>
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nements. These tournaments are identical to the baseline except the costs of one pair member is a multiple ($\alpha$) of the other's. Finally, experiments 6 and 7 examine the effects of our laboratory affirmative action programs. In experiment 6 we use the parameters of experiment 4 ($\alpha = 2$) and introduce a $k = 25$ rule that favors cost disadvantaged subjects. In experiment 7, $\alpha = 4$, and $k = 25$.

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 possible terminal effects, we use the pooled data from the last ten experimental rounds for statistical tests.

A. Symmetric Tournaments

Figure I shows the results of the baseline experiment which replicates the finding of Bull et al. [1987]; observed behavior in symmetric tournaments is consistent with theoretical predictions. While the theory predicts that subjects choose effort levels of 73.75, observed mean effort level in rounds 11–20 is 77.9. Observed mean effort did not deviate from the predicted level by more than 9 decision numbers in any round, and the mean deviation from predicted was only 5.3 over the last 10 rounds. For rounds 11–20, a round-by-round Wilcoxon signed rank test does not reject the hypothesis that observed effort levels came from a population with a mean of 73.75.\(^{10}\)

B. Unfair Tournaments

Experiments 2 ($k = 25$) and 3 ($k = 45$) tested the effects of unfairness. Figures II and III show that effort levels in these unfair

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10. The Wilcoxon signed rank test requires that the distribution from which the data were 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]. All statistical tests in this paper use a significance level of 5 percent.
tournaments tended to be higher than predicted. The theory predicts that effort level choices of advantaged and disadvantaged subjects will be the same, and will equal 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. A Wilcoxon signed rank test was conducted on rounds 11–20 of each experiment. Only in the case of advantaged subjects in experiment 2 (mean effort level = 74.5), could we reject the hypothesis that observed effort levels came from a population with the predicted mean. Using a median test, only in experiment 2 could we reject the hypothesis that the effort levels of advantaged and disadvantaged subjects were equal.

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 0.687, they actually won with probability 0.898. In experiment 3 their actual probability of winning was 0.827 instead of the predicted 0.805.\textsuperscript{11}

In summary, subjects in unfair tournaments tend to choose higher effort levels than predicted, but below those of an analogous symmetric tournament.\textsuperscript{12} Because of the relative oversupply of

\textsuperscript{11} These probabilities are calculated using the observed mean effort levels and equation (5).

\textsuperscript{12} Using different parameters, Weigelt, Dukerich, and Schotter [1989] found similar results. In unfair tournaments, observed effort levels were significantly higher than predicted, and there was no significant difference in the effort levels of advantaged and disadvantaged subjects.
effort by advantaged subjects, their probability of winning increases. While the profits of tournament administrators in unfair tournaments are above those predicted, they 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 the theory predicts effort levels of 74.26 and 37.26; over the last 10 rounds we observed mean effort levels 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. Observed results are also consistent with the theory in terms of the probability of winning. The expected
probability of winning for advantaged and disadvantaged subjects is 0.762 and 0.238, respectively; we observed winning probabilities of 0.79 and 0.21. 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.\(^{13}\) This dropout behavior was rarely seen in the other

\(^{13}\) An identical experimental result was found by Bull, Schotter, and Weigelt [1986] in an earlier unpublished set of experiments. In those experiments the
experiments. One subject dropped out in experiments 2 and 4, and none dropped out in experiment 3. Over the last 10 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. These data are presented in Table IV.

Figures VIa and VIb show the round-by-round mean effort levels of tournament pairs in a split sample of those disadvantaged subjects who dropped out and those who did not. The difference in behavior is clear. While over the first six rounds, the dropouts

parameters were $M - m = .80$, $c = 25,000$, $a = 40$, and $a = 4$. Final period mean effort levels for the disadvantaged subjects who dropped out (half of the total number of disadvantaged subjects) was 1.17, while for those who did not drop out it was 43.29. The predicted effort level is 14.3.
<table>
<thead>
<tr>
<th>Experiment</th>
<th>Predicted</th>
<th>Mean decision numbers</th>
<th>Mean standard deviations</th>
<th>Number of subjects</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Rounds 1–10</td>
<td>Rounds 11–20</td>
<td>Round 20</td>
</tr>
<tr>
<td>1—Symmetric</td>
<td>73.75</td>
<td>73.87</td>
<td>77.91</td>
<td>80.75</td>
</tr>
<tr>
<td>2—Unfair $k = 25$</td>
<td></td>
<td>rule advantaged</td>
<td>58.39</td>
<td>65.88</td>
</tr>
<tr>
<td></td>
<td></td>
<td>rule disadvantaged</td>
<td>58.39</td>
<td>64.66</td>
</tr>
<tr>
<td>3—Unfair $k = 45$</td>
<td></td>
<td>rule advantaged</td>
<td>46.09</td>
<td>47.00</td>
</tr>
<tr>
<td></td>
<td></td>
<td>rule disadvantaged</td>
<td>46.09</td>
<td>53.67</td>
</tr>
<tr>
<td>4—Uneven $\alpha = 2$</td>
<td></td>
<td>cost advantaged</td>
<td>74.51</td>
<td>73.71</td>
</tr>
<tr>
<td></td>
<td></td>
<td>cost disadvantaged</td>
<td>37.26</td>
<td>41.70</td>
</tr>
<tr>
<td>5—Uneven $\alpha = 4$</td>
<td></td>
<td>cost advantaged</td>
<td>76.09</td>
<td>68.46</td>
</tr>
<tr>
<td></td>
<td></td>
<td>cost disadvantaged</td>
<td>19.02</td>
<td>28.18</td>
</tr>
<tr>
<td>6—Affirmative action $k = 25, \alpha = 2$</td>
<td></td>
<td>cost advan/rule disadvan</td>
<td>58.99</td>
<td>72.29</td>
</tr>
<tr>
<td></td>
<td></td>
<td>cost disadvan/rule advan</td>
<td>29.49</td>
<td>42.49</td>
</tr>
<tr>
<td>7—Affirmative action $k = 25, \alpha = 4$</td>
<td></td>
<td>cost advan/rule disadvan</td>
<td>60.24</td>
<td>61.94</td>
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<tr>
<td></td>
<td></td>
<td>cost disadvan/rule advan</td>
<td>15.06</td>
<td>32.62</td>
</tr>
<tr>
<td>Experiment:</td>
<td>1 ((k = 0))</td>
<td>2 ((k = 25))</td>
<td>3 ((k = 45))</td>
<td>4 ((\alpha = 2))</td>
</tr>
<tr>
<td>------------</td>
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<td>----------------</td>
</tr>
<tr>
<td>Advantaged subjects—rounds 1–20* Effort Level:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Predicted</td>
<td>73.75</td>
<td>58.39</td>
<td>46.09</td>
<td>74.51</td>
</tr>
<tr>
<td>Observed</td>
<td>75.89</td>
<td>70.19</td>
<td>47.82</td>
<td>76.27</td>
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<tr>
<td>Disadvantaged subjects Rounds 1–20 Effort level:</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Predicted</td>
<td>73.75</td>
<td>58.39</td>
<td>46.09</td>
<td>37.26</td>
</tr>
<tr>
<td>Observed</td>
<td>75.89</td>
<td>61.65</td>
<td>56.48</td>
<td>39.38</td>
</tr>
<tr>
<td>Advantaged subjects* Probability of winning:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Expected</td>
<td>0.500</td>
<td>0.687</td>
<td>0.805</td>
<td>0.762</td>
</tr>
<tr>
<td>Observed</td>
<td>0.500</td>
<td>0.898</td>
<td>0.827</td>
<td>0.788</td>
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<tr>
<td>Advantaged subjects* Mean monetary payoff:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Expected</td>
<td>$1.09</td>
<td>$1.44</td>
<td>$1.67</td>
<td>$1.38</td>
</tr>
<tr>
<td>Observed</td>
<td>$1.09</td>
<td>$1.55</td>
<td>$1.68</td>
<td>$1.39</td>
</tr>
<tr>
<td>Disadvantaged subjects Probability of winning:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Expected</td>
<td>0.500</td>
<td>0.313</td>
<td>0.195</td>
<td>0.238</td>
</tr>
<tr>
<td>Observed</td>
<td>0.500</td>
<td>0.102</td>
<td>0.173</td>
<td>0.212</td>
</tr>
<tr>
<td>Disadvantaged subjects Mean monetary payoff:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Expected</td>
<td>$1.09</td>
<td>$1.00</td>
<td>$0.95</td>
<td>$0.96</td>
</tr>
<tr>
<td>Observed</td>
<td>$1.09</td>
<td>$0.75</td>
<td>$0.83</td>
<td>$0.93</td>
</tr>
</tbody>
</table>

*For affirmative action tournaments (experiments 6 and 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 (5).
chose mean effort levels approximately equal to those subjects who eventually did not drop out (27.2 versus 38.7), in periods 7–20 effort levels diverged significantly. In period 20 the mean effort level of 8 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 nondropout subjects had a mean effort level of 64.74 over the last ten rounds, while the advantaged subjects paired with the dropouts had a mean effort level of 85.3. Surprisingly, the advantaged opponents of disadvantaged dropouts continued to choose high effort levels even after their opponents dropped out.

This result becomes less surprising when one hypothesizes that perhaps the aggressive play of opponents in early rounds caused disadvantaged subjects to become discouraged and drop out. This hypothesis is given support when we compare the difference in win history between disadvantaged subjects who eventually dropped out and those that did not. While eventual nondropouts won on average 28.7 percent of their tournaments in the first six rounds (with three of the seven winning two or more), dropouts won only 8 percent of theirs.

The aggressive play of opponents partially explains the differential in win history. Roughly half this differential was caused by
the advantaged opponents of dropouts choosing, on average, higher decision numbers than the opponents of nondropouts. The other contributing factor to disadvantaged subjects becoming discouraged and dropping out appears to be bad luck. This bad luck consisted of negative random numbers for the disadvantaged subjects or high random numbers for their opponents. To crudely estimate the effect of this bad luck, we simulated play (for rounds 1–6) between each disadvantaged subject who dropped out, and each advantaged opponent of the nondropout subjects. In this simulation, disadvantaged subjects won 22.4 percent of the time, a significant increase over the 8 percent they won during the first six rounds of experiment 5. We also simulated play between the disadvantaged nondropout subjects and the advantaged opponents of the dropout group. The winning percentage of the disadvantaged subjects was reduced slightly, from 28.7 percent to 25.4 percent.

In our experiments subjects know the distributional form of random numbers, so in theory they should not worry about streaks
of bad luck. In a natural setting agents do not know the distribution, so the effect may intensify. Bad luck may be mistaken for differential in ability (i.e., cost of effort) or prejudice and cause even greater dropping out than we observed.

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 0.138 and their expected payoff is $0.92. Using the total sample of tournament pairs over the last ten rounds, we observed an expected probability of winning (given their mean effort choices) of 0.130 and an expected payoff of $0.92. However, results are dramatically different if the sample is divided into dropout and nondropout pairs. For dropout pairs the observed expected probability of winning was 0.09 and the expected payoff $0.92. Their advantaged opponents could expect to win with probability 0.91 and had an expected payoff of $1.53. For nondropout pairs we observed an expected probability of winning of 0.191
for disadvantaged subjects (0.809 for advantaged ones). With these probabilities and efforts we expect payoffs of $0.85 and $1.53 for our nondropout 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.

V. AFFIRMATIVE ACTION AND EQUAL OPPORTUNITY

A. Equal Opportunity Laws

We investigate the impact of laboratory equal opportunity laws by comparing the results of experiment 1 with those of experiments 2 and 3. Recall that 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. 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 ($k = 25$) 66.5, and in experiment 3 ($k = 45$) 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

<table>
<thead>
<tr>
<th>TABLE V</th>
<th>THE IMPACT OF LABORATORY EQUAL OPPORTUNITY LAWS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experiment:</td>
<td>1 ($k = 0$)</td>
</tr>
<tr>
<td>Mean effort level for rounds 11–20 for:</td>
<td></td>
</tr>
<tr>
<td>Advantaged subjects</td>
<td>—</td>
</tr>
<tr>
<td>Disadvantaged subjects</td>
<td>—</td>
</tr>
<tr>
<td>All subjects</td>
<td>77.90</td>
</tr>
<tr>
<td>Expected probability of winning:</td>
<td></td>
</tr>
<tr>
<td>Advantaged subjects</td>
<td>0.500</td>
</tr>
<tr>
<td>Disadvantaged subjects</td>
<td>0.500</td>
</tr>
<tr>
<td>Expected monetary payoffs:</td>
<td></td>
</tr>
<tr>
<td>Advantaged subjects</td>
<td>$1.09</td>
</tr>
<tr>
<td>Disadvantaged subjects</td>
<td>$1.09</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Experiment:</th>
<th>4 ((\alpha = 2))</th>
<th>6 ((\alpha = 2, k = 25))</th>
<th>5 ((\alpha = 4))</th>
<th>7 ((\alpha = 4, k = 45))</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean effort level for rounds</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11–20 of:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Advantaged subjects</td>
<td>78.83</td>
<td>64.17</td>
<td>77.33</td>
<td>85.51</td>
</tr>
<tr>
<td>Disadvantaged subjects</td>
<td>37.06</td>
<td>36.41</td>
<td>18.47</td>
<td>32.41</td>
</tr>
<tr>
<td>Expected probability of winning:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cost advantaged subjects</td>
<td>0.788</td>
<td>0.523</td>
<td>0.970</td>
<td>0.797</td>
</tr>
<tr>
<td>Cost disadvantaged subjects</td>
<td>0.212</td>
<td>0.477</td>
<td>0.130</td>
<td>0.293</td>
</tr>
<tr>
<td>Expected monetary payoff:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cost advantaged subjects</td>
<td>$1.38</td>
<td>$1.24</td>
<td>$1.49</td>
<td>$1.20</td>
</tr>
<tr>
<td>Cost disadvantaged subjects</td>
<td>$0.93</td>
<td>$1.21</td>
<td>$0.92</td>
<td>$0.93</td>
</tr>
</tbody>
</table>

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).

probability of winning for disadvantaged subjects increased from 0.102 in experiment 2 and 0.173 in experiment 3 to a theoretical level of 0.500 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 for disadvantaged subjects were $0.83 and $0.75.14

In summary, our laboratory equal opportunity law clearly increases the probability of winning and the payoffs for disadvantaged subjects. Total tournament output 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 \((\alpha = 2, k = 0)\) with experiment 6 \((\alpha = 2, k = 25)\) reveals the effects

14. Payoffs are expected in the sense that subjects should realize these payoffs based on their observed mean effort levels.
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. Observed effort levels fall for 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 0.212 to 0.47 as does their expected payoffs.

Thus, our affirmative action program did successfully increase 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 among 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 experiments 5 and 7. Remember in experiment 5 ($\alpha = 4$) half the cost disadvantaged subjects dropped out. Our laboratory affirmative action program eliminated this dropout behavior. Hence, mean effort levels significantly increase as we move from experiment 5 (18.47 and 77.33 for cost disadvantaged and advantaged subjects) to experiment 7 (32.41 and 85.51 for cost disadvantaged, rules advantaged; and cost advantaged, rules disadvantaged subjects). As a result, total output increases as do profits of the tournament administrator. Probabilities of winning for the previously cost disadvantaged subjects increase from 0.130 to 0.293 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 the theory supporting a proposed economic institution, such as tournaments, there are two levels of hypotheses one can subject the data to: individual and aggregate level. Individual level hypotheses require support for the underlying theory on a case-by-case basis with all individual subject pairs behaving in strict accordance with the theory. Like Bull et al. [1987] we reject this level of hypotheses, and find support for aggregate level hypotheses. That is, on average, the data support the predicted theoretical results, and hence, the proposed institution functions as predicted. While aggregate or mean data (of the type we use here) can yield misleading conclusions (see Brown and Rosenthal [forthcoming]), we do not feel this is the case here. First, the mean behavior plotted in Figures I–V are clearly not statistical flukes created by "washing out" the behavior of outliers, but rather are caused by effort choices distributed around predicted equilibrium levels. Figure VII shows the mean effort levels of subject pairs in experiments 2 and 3: effort levels are not bimodal distributions yielding misleading means, but rather full (almost symmetric) distributions centered around the mean. While we cannot explain the existence of such a distribution (results were similar in Bull et al. [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 show that when the theory predicts differentiated behavior between advantaged and disadvantaged subjects, that is how they behave.\textsuperscript{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 five

\textsuperscript{15} A repeated measures ANOVA shows that the behavior of advantaged and disadvantaged subjects in experiments 4 and 5 was significantly different. The null hypothesis of no difference is strongly rejected in experiment 4 ($F(1,16) = 33.06; p < 0.001$) and experiment 5 ($F(1,28) = 83.00; p < 0.001$). Also, the observed choices of advantaged (disadvantaged) subjects were significantly different from the predicted choices of disadvantaged (advantaged) subjects.
rounds the fraction of advantaged and disadvantaged subjects choosing above and below this predicted level is approximately equal. Of advantaged subjects, 53.3 percent chose below the predicted level versus 57 percent of disadvantaged subjects. Similar results exist for experiment 3. These results contrast sharply with 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 Bull et al. [1987] was significantly lower.
VI. CONCLUSIONS AND IMPLICATIONS

Our research goals were to determine whether social policies used to combat asymmetries in the workplace adversely affect output and whether behavior in asymmetric tournaments conformed to the predictions of tournament theory.

Behavior in asymmetric tournaments approximated that predicted by the theory. This result reflects that attained by Bull et al. [1987] for symmetric tournaments. We have now run more than 25 tournament experiments, which incorporated a wide range of parameter changes. Results are surprisingly robust; observed aggregate level behavior approximates that predicted by the theory. 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.16

Our results, if they have external validity, suggest that equity may be a necessary condition for efficiency. Equal opportunity laws clearly benefit disadvantaged agents: the laws increase promotion rates (i.e., probability of winning) and equilibrium payoffs of previously disadvantaged agents. More importantly, implementation of equal opportunity laws actually improves tournament performance. If \( M \) and \( m \) are unchanged, the effort level of all types of agents is increased, so the laws actually increase the profit of tournament administrators (firms). Proponents of equal opportunity may not have to appeal to the social conscience of managers. Firms should prohibit discrimination in the workplace because it is in their best interest. 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

16. One explanation for the variance in behavior is strategic uncertainty. Because subjects were uncertain about the strategy of opponents, they formed conjectural variations. However, Bull et al. [1987] found no support for this hypothesis. In their experiments, subjects played against an automaton whose strategy was fixed and publicly announced. Even when all conjectural and informational problems were apparently eliminated, variance in behavior remained.
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 programs did increase total tournament effort, and hence the profit of tournament administrators. Such an effect was not observed when cost disadvantaged subjects have less severe handicaps.

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