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Richard B. Freeman
Alexander M. Gelber

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1050 Massachusetts Avenue
Cambridge, MA 02138
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ABSTRACT

This paper examines performance in a tournament setting with different levels of inequality in rewards and different provision of information about individual's skill at the task prior to the tournament. We find that the total tournament output depends on inequality according to an inverse U shaped function: We reward subjects based on the number of mazes they can solve, and the number of solved mazes is lowest when payments are independent of the participants' performance; rises to a maximum at a medium level of inequality; then falls at the highest level of inequality. These results are strongest when participants know the number of mazes they solved relative to others in a pre-tournament round and thus can judge their likely success in the tournament. Finally, we find that cheating/fudging on the experiment responds to the level of inequality and information about relative positions. Our results support a model of optimal allocation of prizes in tournaments that postulate convex cost of effort functions.

Richard B. Freeman
NBER 1050 Massachusetts Avenue
Cambridge, MA 02138
and NBER
freeman@nber.org

Alexander M. Gelber
National Bureau of Economic Research
1050 Massachusetts Ave.
Cambridge, MA 02138
agelber@nber.org

Views about the virtue or vice of inequality in economic rewards differ greatly. Economists often stress that inequality related to performance creates incentives. By contrast, non-economists often stress the inequity of high levels of inequality, and some argue that relating rewards to effort undermines "intrinsic motivation" and reduces effort (Kohn, 1993). Okun (1975) posed the equity-efficiency relation as a tradeoff in which egalitarian policies reduced efficiency. In a similar vein, many economists interpret the differing performances of the US and EU economies in recent years as reflecting choices on the "big tradeoff" curve, with the US choosing more inequality and efficiency than the EU.

Economic theory suggests that inequality has a more complicated relation to output than a simple tradeoff. Tournament models predict higher effort and output with higher payoffs for winning but also predict that multiple prizes produce greater effort and output than single prizes (Moldovanu and Sela (2001); Clark and Riis (1998); see also Parreiras and Rubinchik (2006)). Multiple prizes give more participants an incentive to work hard than does a single large prize, which many participants may have little chance of winning. Tournaments work best when participants have similar abilities (Lazear and Rosen (1981)).

If low inequality/incentives produce little effort and output, and high inequality motivates only persons with a good chance of winning while discouraging others, the graph of inequality against output could have an inverse-U shape, with an optimal level of inequality for production between the two extremes. Increases in inequality in a society or firm may be associated with more, or less, effort and output, depending on whether the society or firm has inequality above or below the optimum.

This study uses a maze-solving experiment to assess the relation in tournaments between inequality and output. We asked groups of six subjects to solve a set of paper mazes[1] in two rounds. In Round 1 of the experiment, we rewarded individuals by piece rates so that their reward depended only on their own performance. After the groups of six completed Round 1, we informed participants in half of the groups about the distribution of mazes solved in Round 1 in their group of six, but did not inform participants in the other half of the groups about the distribution in their groups. In the second round, we gave three incentive treatments: a no inequality treatment that paid each person the same regardless of performance; a high inequality treatment in the form of one large prize for the tournament winner; and a treatment with an intermediate level of inequality, with prizes for five of the six participants that increased with a participant's rank. We measured the effects of these treatments on output by the total number of mazes solved by all of the individuals in each group.

Previous experimental investigations of incentive schemes, on which we build, have not sought to identify the relation between inequality and aggregate output, nor the effect on tournament performance of providing subjects with information about their relative abilities. The experiments closest to ours (Müller and Schotter (2004); Harbring and Irlenbusch (2003); Nalbantian and Schotter (1997)) investigate tournaments in which subjects are given "cost-of-effort" functions, instead of performing real tasks such as maze-solving. The results closest to ours are Müller and Schotter, who find that some participants work hard in tournaments while others effectively drop out.[2] The Niederle

[1] Gneezy, Niederle, and Rustichini (2003) introduced maze-solving as a task to gauge experimental subjects' effort, using mazes on a computer.
[2] Harbring and Irlenbusch (2003) compare a tournament in which one prize is given to

and Vesterlund (2005) experiment, which also has subjects perform a real effort task (addition problems), focused on the supply decision of men and women to enter a tournament rather than on the response of subjects to variations in tournament incentives.

Growth and development economists have examined the relation between inequality and growth using cross-country and cross-state data, with inconclusive results. There is a strong inverse relation between inequality and output per head – high income countries have low inequality, controlling for other country characteristics – but the direction of causality is unclear. Looking at the relation between inequality and future growth rates, several studies found that countries with higher levels of inequality had lower rates of growth (Benabou (1996); Perotti (1996); Castello and Domenech (2002)). Deininger and Squire (1998) and Barro (2000) report a more complicated pattern, with higher inequality lowering growth in poor countries but not in rich countries.[3] Panel analysis across countries shows that increases in inequality raise growth (Forbes, 2000) but panel analysis across U.S. states shows the opposite (Panizza, 2002). Other studies have found that differences in the source of inequality – land tenure, educational expenditures, property rights – and different policies affect the relation between inequality and growth rates (Keefer and Knack (2002), Lundberg and Squire (2003)). Banerjee and Duflo (2003) find that changes in inequality in any direction around an initial level reduce growth, arguably for political economy reasons. Since inequality at

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the winner and the sum of the prizes is smaller, with a tournament in which two prizes are given and the sum of the prizes is larger. Subjects put forth more effort in the setting with higher total prize money and multiple prizes. Nalbantian and Schotter (1997) find that relative performance schemes outperform target-based schemes. Analogous results to ours are also found in the context of all-pay auctions; see Noussair and Silver (2006) and Barut, Kovenock, and Noussair (2002).

[3] Barro finds that in rich countries inequality raises growth. Deninger and Squire find no relation for the rich countries.

the national or state level varies for reasons unrelated to incentives, these studies cannot readily pin down the incentive-output relation on which we focus.

Our maze experiments give strong support for an inverted U relation between inequality and output. Total tournament output is lowest when payments to participants are independent of performance, rises to a maximum at a medium level of inequality, then falls at the highest level of inequality. The fall in output between medium inequality and high inequality is largest when participants know their relative position in solving mazes. The differences in output are, moreover, driven by the responses of persons with high or low maze solving skills to the incentives facing them: Subjects produce little when they have little chance of winning more through more effort. Finally, the paper and pencil maze technology allowed subjects to “cheat” by falsely reporting un-solved mazes as solved, which serendipitously provides an independent test of the impact of our treatments on behavior. This also shows a substantial response to incentives. This represents a new approach to detecting cheating in the laboratory.

I. The Experiment

Our experiment brought together groups of six participants. The participants were recruited from the Harvard Business School Computer Lab for Experimental Research subject pool, which included but was not limited to students from Boston-area universities. We gave the participants the task of solving the same packets of mazes from Phillips (1988, 1991) and presented these mazes to all participants in the same order. The experiment had two rounds, each lasting for 15 minutes: a non-tournament piece rate incentive round (Round 1) and a tournament round (Round 2). The maze packet used for the second round contained different mazes than those in the maze packet for the first round. The directions for each round and each treatment are in Appendix B.

The participants were paid a base rate of pay of $13.00 for participating in the experiment, so the participation reward was $6.50 per round. In the first round we paid each subject a piece rate of 20 cents per maze solved, to motivate effort and thus identify their skills at solving mazes. Since the subjects were randomly assigned to treatment groups, the first round results should be similar across groups having different second round treatments. On average, the experiment took approximately 50 minutes, and the mean total earnings, including the base pay, Round 1 earnings, and Round 2 earnings, was $20.46.

At the end of Round 1, in half of the groups we informed subjects of the scores of all group members in the first round. Since individuals knew their own score, this enabled them to place themselves in the distribution and assess their chances of ranking high or low in the second tournament round. We refer to this treatment as "full information" because it gives subjects all the information that we have relevant to assessing their chances of winning in the ensuing tournament. In the other half of the experiments, we said nothing about how others performed. In all treatments, we announced the Round 2 prize structures after Round 1 was complete.

In Round 2, we had subjects compete in a tournament with three incentive treatments, each of which distributed $30 in total prizes.[4] Our *no inequality* treatment gave each participant $5.00 regardless of their performance. The only incentive was thus the intrinsic desire to do well, either absolutely or relative to others. Since subjects had

[4] For a theoretical model that assumes a fixed prize purse and examines the optimal allocation of the prize money among several prizes, see Krishna and Morgan (1998).

less pecuniary incentive than they did under the piece rates, their performance would likely fall, save for the learning that they obtained from their first round maze solving and from the intrinsic motivation to perform well. Our *high inequality* treatment gave $30 to the top scorer and nothing to anyone else. This is the most unequal possible distribution of $30. The no inequality and high inequality treatments pin down the end points for the hypothesized curve relating output to inequality. In the "medium inequality" condition, we gave out multiple prizes. There are many ways to do this. We chose a reward structure in which the winner received $15, the second-prize winner received $7, the third-prize winner received $5, the fourth-prize winner received $2, the fifth-prize winner received $1, and the sixth-prize winner received nothing. This gave incentives to persons in all parts of the distribution of first round maze performances.

We presented the exercise to the subjects in paper and pencil form. We asked subjects to report the number of mazes they solved and told them that they had to solve them in the order they were presented in the packet. Initially, we did not realize the possibility of cheating or fudging, say by jumping over a line to complete a maze. When we checked the first sets of maze packets, however, we found discrepancies between the mazes subjects reported solving and the mazes that our rules would count as solved. Serendipitously, this provides a second test of the effect of incentives on behavior. Subject errors turn out to be sensitive to the reward and information structure in ways that complement our main findings, and give evidence on cheating in a tournament that differs greatly from the type of evidence in other experimental studies of cheating, such as studies on taxes.[5]

[5] Studies on cheating in taxes ask subjects to choose a level of cheating or shirking; see

Incentives and Potential Behavior in the Experiment

The performance of individuals in maze-solving (or any other activity) depends on their ability, the effort they expend, and the impact of that effort on performance. The individual controls his or her effort. With total output of the group as the measure of output (as opposed say to the highest value produced by an individual), the relation between output and the prize structure/inequality incentive in a tournament setting depends on the distribution of the ability of participants, their perceived probability that increased effort will gain them a prize, and the prizes' values. In the Lazear and Rosen (1981) model, participants have equal ability and the optimal prize for winning mimics an optimal piece rate. A prize that diverges from the optimum produces less profit for the firm, but higher prizes still increase effort. In the Moldovanu and Sela (2001) (M&S) model participants have different ability, which fits our experimental design better than models in which they have the same ability. In this analysis, multiple prizes (less inequality) can lead to greater output than a single prize (maximal inequality) because persons with little chance of winning the single prize put in greater effort when they can win the 2nd, 3rd, or nth prize. The most able person will be less motivated by the existence of a 2nd prize since the return to coming in first will be less than if there were only a single prize, but the 2nd prize will motivate the effort of other contestants, and so on. M&S show that with a convex cost of effort of function, more prizes/less inequality produces greater output.[6] The greater the number of competitors, the more likely it is that multiple prizes produce greater output because this gives more people greater marginal incentives to put out more effort.

Friedland, Maital, and Rutenberg (1978) and Alm, McClelland, and Schulze (1992)).
[6] This is their Proposition 5, p. 249.

The information structure of the tournament affects behavior as well. In the M&S model, individuals know the distribution function from which contestants are drawn. This enables those with high ability (low cost of effort) to assess their chances of winning. Our experiment has a stronger information condition: In the full information case individuals know the *realized* values of the abilities of other contestants.[7] The key insight from the M&S model, however, applies to our experiment: namely, that different prize/inequality structures affect differently the effort of persons in different positions in the distribution of maze-solving. The aggregate relation between inequality and outcomes depends on the differential responses of the more and less able maze-solvers.

II. Findings

Table 1 summarizes the results of our experiments in terms of the means and standard deviations of the subjects' scores in both rounds of the experiment. The columns under the heading "treatment" give the incentive treatment and information treatment used in the tournament round and the total number of persons in the treatments. The columns under the heading "the mean number of mazes solved per person" give the mean number solved, and in parentheses the standard deviation of the mean for all persons in the treatment group, in Rounds 1 and 2.

We specified that the "mazes you solve that follow mazes you skipped will not be included in your total number of mazes," but some participants ignored this instruction and proceeded to solve mazes after failing to solve one, perhaps intending to go back and

[7] This creates even greater potential for inverse-U type behavior than their model would suggest. A person with high maze-solving skills who is in a group where the random draw of persons produced very poor maze solvers may decide that they are so sure of winning that they reduce their effort and produce less than they would if they did not know the abilities of their competitors.

solve that one later, as students will do on GRE or SAT exams. Thus, one measure of output is the number of mazes that subjects completed even when some solved mazes followed unsolved mazes. A second measure of output is the number of mazes a subject solved prior to skipping a maze. The first measure provides a potentially better indicator of the effort induced by the treatment while the second follows our instructions. We analyzed both output measures and obtained similar results. We present in the text the results from the first measure; Appendix A gives the results with the second measure.[8]

Since we randomly assigned persons to treatments and gave the same first round piece rate incentive to all subjects, first-round scores should not differ noticeably among the groups. The data in the 1st round column show similar numbers of mazes solved by the different groups, and F-tests and pair-wise two-tailed Mann-Whitney U-tests[9] confirm that there are no statistically different results in this round. This means that the second round differences in means among the treatment groups provide reasonably valid measures of the impact of the treatments on performance. The second round means show noticeable differences in scores among the treatment groups, which are significant by F-

[8] We exclude fudged mazes from the totals and examine them in section III. The number of observations differs across treatments because in the early experiments we recorded subjects' self-reported scores and do not know the number of mazes fudged because subjects' maze packets were inadvertently discarded. Once we realized that subjects were cheating, we examined all maze packets to see if subjects were cheating. There is no reason to expect the observations for which we did not know the number of mazes fudged differ from those for which we have full information. We have self-reported scores for the full sample of individuals and the sample of individuals used in Tables 1-6, which includes only persons for which we observe *both* self-reported scores and the number of mazes fudged). We estimated our models for all persons using self-reported scores as the dependent and independent variables, and obtained similar results as those obtained on the sample for which we have information on fudges. Table A2, which gives these results, show the same inverse U-pattern as in the main tables.

[9] The test between No Inequality (N) and Medium Inequality (M) treatments gives a $p > 0.40$; the test between N and High Inequality (F) treatments gives a $p > 0.40$; the test for the M and H treatments also gives a $p > 0.40$.

tests and pair-wise two-tailed Mann-Whitney U-tests.[10] In the full information treatment, output rises from no inequality to medium inequality and then falls with the high inequality treatment, giving an inverted U relation between inequality and output. In the no information treatment, the lowest mean score is in the no incentive group, but mean output in the high inequality and medium inequality groups is roughly the same. Comparing the full information and no information treatments, mean mazes solved are higher in the no inequality and medium inequality treatments under full information (15.79 and 18.76) than under no information (13.28 and 16.43, respectively) but are slightly lower for the high inequality group under full information (16.10) than under no information (16.60).

We examine these findings in detail.

The Inverted U

We use regression analysis to probe the Table 1 finding of an inverted U relation between inequality and output for the full information case but not for the no information case. We regress the number of mazes solved in Round 2 on the number solved in Round 1 and dummy variables for treatments. Individuals who scored high in Round 1 tended to score high in Round 2 as well (a correlation for all subjects of 0.74), which indicates that the Round 1 score is a reasonable indicator of the person's maze solving ability.

Table 2 reports the estimated coefficients and standard errors relating Round 2 scores to Round 1 scores, the inequality treatment and, where relevant, a dummy variable for full information. The deleted group in all of the regressions is the group in which

[10] The two-tailed Mann-Whitney test for Medium vs No Inequality give a $p < 0.05$. The statistics of Medium versus High are $p < 0.05$. But the statistics for No versus High are gives a $p > 0.40$.

everyone was paid the same—the no inequality treatment. Columns 1-3 are based on regressions for all individuals in the experiment, while columns 4-6 take the six-person groups as the unit of observation, by aggregating the scores of everyone by group. This scales up the scores by a factor of six and produces a slightly different specification since the Round 2 score for the group is related to the Round 1 score for the group.

The estimated coefficients on the round 1 score uniformly exceed 1.0, which indicates that individuals/groups with higher scores improved their scores by larger absolute amounts than those with lower scores. The coefficient on the full information treatment in columns 1 and 4 is positive, indicating that on average the provision of information improved performance. But the key result from the Table 2 regressions is that inequality/incentive treatments affect output per person in the inverse U relation. The regressions in Columns 1 and 4 for all treatments show strong inverse U relations: The mazes solved by the low inequality group are markedly less than those solved by persons in the other two treatments, and the medium inequality group has a statistically significantly higher number of mazes solved than the high inequality group. When the sample is divided by information treatment, the difference in coefficients between the medium inequality and high inequality treatment dummies is much larger in the full information case (a difference of 1.80 in column 2; 8.00 in column 4) than in the no information case (a difference of 0.56 in column 3; 3.1 in column 6), giving a much more pronounced inverse U under full information.

To examine the robustness of this result, we investigated other specifications. We had data on the gender of subjects and added a female dummy variable to the regression, with little impact on the coefficients on inequality treatments.[11] We entered the square of Round 1 score (along with Round 1 score) in the regressions, again without impacting the finding that output was highest in the middle inequality group. We introduced the first-round scores of the highest-scoring person in the group as an independent variable, on the hypothesis that this could affect performances in the full information condition.[12] The inverse U relation remained and again was stronger in the full information case.

Finally, as an alternative specification, we calculated changes in the mean number of mazes solved from Round 1 to Round 2 for each of the treatments and used this as the dependent variable. The change format imposes a unit coefficient on the impact of the first round score on the second round number of mazes solved, which is inconsistent with the estimated coefficients on the first round scores in the table 2 regressions. Still, the change specification is a natural summary of the data and probes the robustness of the result. Figure 1 displays the mean changes in the number of mazes solved for the groups. The full information case shows a pronounced inverted U. The increase in the number of mazes between the first and second rounds is larger for the medium inequality group (a gain of 6.1 mazes) under full information than under no information; while the increase in the number of mazes solved for the high inequality group (a gain of 4.4 mazes) is nearly the same as under the no information. Again, in the no information case, the inverted U is weak: The group with no inequality has a modest increase in mazes solved

[11] Gneezy, Niederle and Rustichini (2003)'s findings suggest that women may perform differently in tournaments than men.

[12] In the full information high inequality condition, a high top first-round score in a group lowered the second round scores of other participants. The point estimate of the effect (-0.54) is large and precisely estimated (with a standard error of .10). By contrast, in the no information high inequality condition, the point estimate is an insignificant -.12 with a standard error of .65. This result suggests that when one person was far ahead of the rest, and this was known, subjects put substantially less effort into solving mazes.

(1.0), due presumably to learning; the medium inequality group has an increase in mazes solved of 4.4; while the high inequality group has an increase of 4.1.

The finding that the medium level of inequality leads to greater output is consistent with Moldovanu and Sela (2001)'s analysis that multiple prizes are optimal. The finding that this is stronger under full information than under no information goes beyond their model because in our experiment individuals have, as noted, information not only about their own abilities but also about the realized distribution of abilities of their competitors, which goes beyond knowledge or expectation about the general distribution of abilities.

Unpacking the results

The analysis in Section I predicted that the different incentive treatments would affect persons with different maze-solving skills differently. The high inequality treatment should induce greater effort from persons with a reasonable chance to win the single prize, but could have a depressant effect on the efforts of those with little chance. By contrast, the medium inequality treatment should give incentives to persons at all levels of the skill distribution. To what extent do our results reflect these expectations?

To see whether the differential responses of persons in different parts of the maze-solving skill distribution explains the strong inverse U pattern in the full information compared to the weaker inverse U in the no information case, we divided the sample into those in the upper half of the distribution of mazes solved in the first round of the experiment in the group in which they participated, and those in the lower half of that group. We estimated the effect of the treatments on the upper and lower halves separately, and compared the difference in coefficients between the halves.

Table 3 shows the estimated regression coefficients and standard errors. Panel A gives the results from regressions in which the independent variables were measures of the six treatments with no other independent variables. In this case the coefficient on the constant term reflects the score for the deleted group – no information, no inequality – while the other coefficients reflect deviations from that score. The estimated coefficients under the column labeled "all" replicate the results in Table 2: a strong inverted U for the full information group and a weaker one for the no information group. The coefficients under the columns labeled top half and bottom half of the round one distribution, however, show very different effects of the treatments, and reveal some differences in performance by information treatment.

Under full information, the high inequality treatment is associated with a greater number of mazes solved for persons in the top half of the distribution but has only a negligible relation with the performance of persons in the lower half of the distribution. Knowledge of their differential chances of winning seemingly discouraged people in the lower half of the distribution while encouraging those in the upper half. By contrast, there is only a modest difference between the affect of the medium inequality treatment on the two halves of the distribution. Finally, the no inequality treatment also led to a greater impact on persons in the top half of the distribution than on those in the bottom half of the distribution. As a result, the inverse U is most pronounced for the bottom half of the distribution.

The results for no information are different. Persons in the top half of the distribution score more under both high inequality and medium inequality than those in no inequality group. There is no evidence of an inverted U in the bottom half of the distribution, as the score for the middle inequality treatment just exceeds that for the no inequality and falls short of that for the high inequality treatment. The implication is that provision of information has its biggest effect on persons in the bottom half of the distribution of maze-solving scores from Round 1, as the knowledge that they have little chance of winning a large prize discourages them.

Panel B of Table 3 repeats the regressions with the addition of the person's Round 1 score as an additional explanatory variable. This does not affect the qualitative results. The estimated coefficients show that the strong inverse U among persons in the full information case is largely the result of behavior in the bottom half of the distribution, seemingly generated by reduced effort among persons there in response to the high inequality treatment. Controlling for the Round 1 score does, however, produce a more noticeable inverse U in the no information treatment.

One other pattern in the data requires explanation. This is the higher scores of persons in the full information no inequality group compared to the scores of persons in the no information no inequality (deleted) group. In Panel A, the coefficient in the all column for the no inequality full information treatment is 2.51, nearly as large as the 2.82 coefficient for the high inequality full information treatment. Since subjects gained no money from solving more mazes in the no inequality treatment, pecuniary incentives cannot account for this result. One possible explanation is that persons at the low end realized they could do better in the full information treatment and tried harder due to intrinsic competitive motivation. Niederle and Vesterlund (2005)'s finding that men respond more competitively to tournaments than women suggests that men may be more subject to this intrinsic motivation effect. Indeed, our data shows that in the no inequality treatment men raised their scores more in the full information case than did women. In the no inequality treatment the mean Round 1 to Round 2 gain in scores was 2.16 more in Full Information than in No Information for men, whereas it was 1.30 more for women ($p<.05$).

As a final check on the differential response of persons at different places in the maze-scoring distribution to the treatments, we compared the Round 2 performance of the person who scored highest in their group in Round 1 and the person who scored lowest in their group in Round 1. Under full information these persons knew where they ranked in the realized distribution. Under no information, they may have had some idea that they did well or poorly but they could not be sure. Table 4 shows that in both the full information and no information cases, the persons who did best in the first round increased their scores more in the medium and high inequality treatment than in the no inequality treatment, while those who did worst in the first round improved their scores most in the medium treatment, giving the inverted U relation. In addition, comparing the difference in scores between full information and no information, those with high scores increased their scores the most in the no inequality case and least in the medium inequality case. By contrast, the lowest scoring persons in Round 1 increased their scores most under full information in the medium inequality treatment, presumably because they realized that they had a chance to win some reward from greater effort, and reduced their scores in the high inequality treatment, presumably because they realized they had almost no chance to win the single prize.

In sum, our experiment found an inverse-U relation between inequality and output that reflects the differential impact of incentives and information on subjects in different parts of the distribution of maze-solving skills. Consistent with tournament theory, offering multiple prizes is better than a fixed payment with no prizes or offering a single large prize in a tournament setting. The impact of full information on behavior adds an element to the standard theory of prizes, by highlighting the importance of the realized position of persons competing in a tournament on behavior.

Effects of treatments on maximum and minimum scores

Thus far, we have treated the sum of the number of mazes solved by each person in a group as the measure of group output, just as one would take total (or per capita) GDP as the measure of output in an economy. In some situations, however, what matters is the maximum output from any individual in a group – the top score rather than the sum of all the scores. How do our treatments influence the maximum score? Since the high inequality treatment gives the greatest incentive for those at the very top of the maze-solving distribution, we would expect this treatment to create greater top scores and thus possibly undermine the inverse U relation for the total score. The upper panel of Table 5 shows the effect of the different inequality and information treatments on the maximum score in a group. Column 1 shows that the inverse U relation remains, though it is weaker than in the comparable regression in Table 3; the inverse U is strongest in this case, however, in the no information treatment and weaker in the full information.

Finally, we also examined the effect of the treatments on the minima number of mazes solved. If one had a Rawlsian perspective, in which the goal of society is to maximize the well being of the least productive person, this would be an appropriate social maximand. The lower panel of Table 5 shows a very strong inverse U in this case, due to the effect of the medium inequality incentives on persons in the lower part of the distribution. In the full information treatment, moreover, the medium inequality treatment reduces the difference between the maxima and minima scores (-0.40 =1.96-2.36) while the high inequality treatment increases the difference between the maxima and minima scores (2.09 = 1.51 – (-0.58)). But there is little difference in the effects of those treatments in the no information case. The data thus suggest mildly that actual inequality in outcomes may reflect in part the inequality in incentives—inequality begets inequality, as inequality of incentives may create inequality of output.

III. Incentives and Cheating

By asking subjects to solve paper mazes, where the subjects had to draw lines from the beginning of the maze to the end with a pencil, we serendipitously created another test of the effect of incentives on behavior: the effect on “fudging” or cheating. Breaking the rules of a maze solving experiment is not possible when people solve mazes on the computer. The computer knows when someone has completed a maze. With paper and pencil, however, subjects could violate the rules of our experiment and thus improve their chances of winning prizes.

Our instructions told subjects to solve the mazes in the order that they appeared in their packets and that "any mazes you solve that follow a maze you skipped will not be counted in your total number of mazes...." We also told subjects that "solving a maze means drawing a continuous line from the place marked 'Start' to the place marked 'Finish,' without crossing any of the walls of the maze with your line." Finally, we asked subjects to report the number of mazes they solved, according to the rules we had given them. Reviewing the packets of solved mazes after the first set of experiments, we discovered that subjects occasionally reported more mazes solved than met our rules. The vast majority of fudging consisted of subjects starting a maze but not finishing it, then moving on to subsequent mazes in their maze packet, and reporting the subsequent mazes in their total number solved. There were three other less frequent forms of fudging: some subjects completely skipped a maze, yet reported subsequent mazes they solved in the number solved; some subjects reported a different total number solved than the total they actually solved; some subjects crossed one of the walls of a maze with a line, yet counted this maze among the total number they solved. Rather than redesigning the experiment, we decided to continue with the paper maze design and examine whether *subject violations varied with the incentive and information treatment.* This provides another test of the effects of the treatments on behavior and a new take on the responsiveness of cheating to incentives.

Table 6 presents summary statistics on the frequency of fudging by treatment. It gives the number of persons who fudged and the mean number of mazes on which they fudged on each round. In Round one the number of individuals who fudged a maze at least once ranges from 2 to 6 (see column 1) with the largest number occurring under the full information medium inequality treatment. With the number of fudges small, however, an F- or chi-squared test of the effect of the treatments shows no statistically significant difference among the treatments. Similarly, the mean number of fudges among those who fudged displayed in column 2 also shows only modest differences, though the two people who fudged at least once in the high inequality treatment fudged a lot. Combining the statistics on the number of people who fudged and the number of times they fudged gives the summary statistic on fudging in column 3 of the table.

The data show markedly different fudging behavior between the two rounds and across treatments. Round 1 had fewer fudges, with 48 total fudged mazes or about 1% of all mazes solved than in Round 2, when the number of fudged mazes rose more than threefold to 151. The number of persons who fudged at least one maze rose from 26 to 82.

The information treatments also affected the number of mazes fudged. Round 2 fudging is higher in the full information treatment (107 fudges) than in the no information treatment (44 fudges) – presumably because people in full information have a better idea of how they might improve their chances of gaining a prize by fudging. Finally, the number of fudges in the full information case is highest for those in the medium inequality (64 fudges) treatment compared to 10 fudges with the no inequality treatment and 33 fudges with high inequality. The inverse U is thus found in fudging as well as in genuine maze solving.

Table 7 presents the coefficients and standard errors from a Poisson regression of the number of fudges on the 2nd round. We use the Poisson model because fudges are a relatively rare event, so that it seems best to use a model that takes account of this.[13] In the full information case, the regressions show an inverted U (column 1). Looking at behavior among persons in the upper and lower halves of the distribution of maze-solving in the first round, the regression coefficients in columns 2 and 3 show that this result is due to much higher fudging by persons in the medium and high inequality treatments than persons in the no inequality treatment for those at upper half of the distribution and a low number of fudges among persons in the high inequality treatment in the bottom half

[13] Negative binomial regressions show similar results to the Poisson regressions.

of the distribution. When a lot of prize money is at stake and participants know that they have a chance of winning, there is cheating to win it. By contrast, there are no statistically significant differences in fudging in the no information treatment.

Figure 2 displays the pattern of fudging across treatments using a change format. Paralleling Figure 1's analysis of changes in numbers of maze solved, Figure 2 shows the change in mean numbers of mazes fudged from Round 1 to Round 2 in each treatment. The pattern of the results is similar to the shape for output in Figure 1. There is a strong inverted U in the full information condition but not in the no information condition. The parallelism in results presumably reflects similar responses to incentives. The percentage difference in cheating across treatments is, moreover, greater than the percentage differences across treatments in output, much as labor force participation is more sensitive to incentives than hours worked.[14]

Finally, if incentives underlie the differences in the amount of fudging, we would expect that fudging would affect the ranking of subjects and thus their potential rewards. In the first round, where there was little financial incentive to fudge, the correlation between subjects' first-round ranks that included fudged mazes and subjects' actual ranks according to the rules we specified, was 0.95, so that the fudging made little difference in rankings. In the second round, .the correlation between the ranks based on subjects' self-reported scores and the ranks based on scores according to the rules we specified was 0.78, implying that the fudging changed rankings and thus paid off for those who did it. The correlation between the rank of the scores that persons self-reported and the scores defined by our instructions among persons in the full information high inequality

[14] This is consistent with Jacob and Levitt (2003) who also find that cheating is extremely sensitive to the incentives given to cheat.

treatment fell from 0.95 in the first round of the experiment to 0.53 in the second round – implying that the fudging had a huge impact on ranks. The correlation fell from 0.95 in the first round to 0.75 in the second round in the full information medium inequality treatment. By contrast, the differences in the rank correlation were modest in the other cases.

IV. Conclusion

This paper has examined the impact of inequality in rewards and provision of information about individual's skill at the task in a tournament experiment, where the task is solving mazes. The first round of the experiment gave all participants the same piece rate incentive. The second round varied the incentives and information about how the number of mazes they solved by others in the pre-tournament round.

The primary finding is that output is related to inequality according to an inverse U function, and that this is strongest when subjects are aware of their maze-solving skills relative to that of others in their group. The number of solved mazes was lowest in the "no inequality" condition when payments were independent of the participants' performance (Socialism of a sort). The number rose to a maximum at a medium level of inequality, in which all but the lowest scoring individual could earn a prize, and then fell at the single prize tournament which had the highest level of inequality. The results were strongest for persons in the bottom half of the distribution, where output fell in the high inequality treatment relative to the other treatments. Our results support models of optimal allocation of prizes in tournaments which postulate convex cost of effort functions. Finally, we find that cheating in the experiment also responded to the level of inequality and information about relative positions in ways that produced an inverse-U relation between inequality and the number of fudges. While previous laboratory investigations of cheating have artificially asked subjects to choose a level of cheating, our experimental design offers a new way to detect cheating without alerting participants to the fact that their cheating will be detected by the experimenters.

The evidence that inequality/incentives are not monotonically related to output but follow the inverse U shape suggests that equity aside, inequality can be too high as well as too low for efficiency. While it is difficult to imagine an experiment identifying "the" optimal level of inequality for efficiency in a particular economy, the evidence that there is an optimum in a simple experiment directs attention away from arguments that more inequality is always good or always bad for efficiency.

References

Alm, James, Gary H. McClelland, and William Schulze (1992). "Why do People Pay Taxes?" *Journal of Public Economics*, June 1992, 48(1), pp. 21-36.

Banerjee, Abhijit V. and Esther Duflo. "Inequality And Growth: What Can The Data Say?," *Journal of Economic Growth*, 2003, v8(3,Sep), 267-299.

Barro, Robert J. (2000). Inequality and growth in a panel of countries. *Journal of Economic Growth*, 5(1), March, 87-120.

Barut, Yasar, Dan Kovenock, and Charles Noussair, 2002. "A Comparison of Multiple-Unit All-Pay and Winner-Pay Auctions under Incomplete Information." *International Economic Review* 43, 675-707.

Benabou, Roland. (1996). Inequality and growth. *NBER macroeconomics annual*, 11-76.

Bull, Clive, Schotter, Andrew, and Keith Weigelt. "Tournaments and Piece Rates: An Experimental Study," *Journal of Political Economy*, Vol. 95, No. 1, 1987, pp. 1-33.

Castello, Amparo and Domenech, Rafael (2002). "Human capital inequality and economic growth: some new evidence." *Economic Journal*, 112(478), C187-200.

Corns, Allan and Andrew Schotter. "Can Affirmative Action be Cost Effective: An Experimental Examination of Price-Preference Auctions", *American Economic Review*, Vol. 89, no. 1, 1999, pp. 291-305.

Deininger, Klaus and Lyn Squire (1998). New ways of looking at old issues: inequality and growth. *Journal of Development Economics*, 57(2), 259-287.

Forbes, Kristin, "A Reassessment of the Relationship Between Inequality and Growth" *American Economic Review* 90 (4, September), 2000, pp. 869-887.

Friedland, Nehemiah, Shlomo Maital, and Aryen Rutenberg 1978. "A Simulation Study of Income Tax Evasion." *Journal of Public Economics* 10(1): pp 107-116.

Gneezy, Uri, Rustichini, Aldo (2000). "Pay enough or don't pay at all." *Quarterly Journal of Economics* 115 (2), 791-810.

Gneezy, Uri, Muriel Niederle, and Aldo Rustichini (2003). "Performance in Competitive Environments: Gender Differences," Q*uarterly Journal of Economics*, August 2003, p. 1049-1074.

Harbring, Christine, and Irlenbusch, Bernd. “An Experimental Study on Tournament Design.” *Labour Economics* (10) 2003, 443-464.

Jacob, Brian, and Steven Levitt, “Rotten Apples: An investigation of the Prevalence and Predictors of Teacher Cheating,” *Quarterly Journal of Economics,* vol. 118(3), 843-877.

Keefer, Philip and Knack, Stephen, 2002 "Polarization, Politics, and Property Rights: Links between Inequality and Growth," *Public Choice* 111(1-2), pp. 127-54.

Krishan, Vijay and John Morgan “The Winner-Take-All Principle in Small Tournaments” Advances in Applied Microeconomics 1998, 7, pp 841-64

Kohn, Alfie, Punished by Rewards (Houghton Mifflin, 1993/1999)

Lazear, Edward and Sherwin Rosen, “Rank Order Tournaments as Optimum Labor Contracts,” *Journal of Political Economy*. 1981, 89(5), pp 841-64

Lundberg, Matthias, and Lyn Squire, “The Simultaneous Evolution of Growth and Inequality,” *Economic Journal* 113 (487), 326-344, 2003.

Moldovanu, Benny and Aner Sela, “The Optimal Allocation of Prizes in Contests.” *American Economic Review,* 91*,* 542-558 (2001).

Mueller, Weilland and Andrew Schotter, “Workaholics and Dropouts in Optimal Organizations.” Working paper, NYU.

Nalbantian, Haig and Andrew Schotter, “Productivity Under Group Incentives: An Experimental Study,” *American Economic Review*, Vol. 87, No.3, pp. 314-340, June 1997.

Noussair, Charles and Jonathon Silver, 2006. “Behavior in All-Pay Auctions with Incomplete Information.” *Games and Economic Behavior*, 55: 189-206.

Okun, Arthur, *Equality and Efficiency: The Big Trade-off* 1975 (Washington, D.C.: The Brookings Institution).

Orrison, Alannah, Andrew Schotter, and Keith Weigelt. 2004. “Multiperson Tournaments: An Experimental Examination,” *Management Science*, 50(2): 268-279.

Panizza, Ugo, “Income Inequality and Economic Growth: Evidence from American Data,” *Journal of Economic Growth* 7(1), 2002.

Parreiras, Sergio and Anna Rubinchik, 2006. “Contests with Many Heterogeneous Agents.” CORE Discussion Paper.

Perotti, Roberto, 1996. "Growth, Income Distribution, and Democracy: What the Data Say," *Journal of Economic Growth,* vol. 1(2), pages 149-87, June.

Phillips, Dave. *Space Age Mazes.* Dover: New York, NY. 1988.

Phillips, Dave. *Animal Mazes.* Dover: New York, NY. 1988.

Table 1 *Means and Standard Deviations of Mazes Solved per person, by Treatment*

Treatment			**Mean Mazes Solved**	
(1) Inequality Condition	(2) Information	(3) Total Participants	(4) Round 1	(5) Round 2
No Inequality	Full	72	12.69 (5.04)	15.79 (7.26)
Medium Inequality	Full	66	12.50 (4.49)	18.76 (7.29)
High Inequality	Full	78	11.74 (5.24)	16.10 (7.88)
No Inequality	No	54	12.41 (4.53)	13.28 (6.32)
Medium Inequality	No	72	11.82 (5.17)	16.43 (7.77)
High Inequality	No	72	12.46 (5.04)	16.60 (7.53)

Source: Tabulated from the experiment described in text. Columns 1 and 2 describe the treatment in terms of the prize structure (column 1) and information given to participants (column 2). Column 3 displays the total number of participants in each treatment across all of the experiments we ran. Column 4 displays the mean number of mazes solved in Round 1 in each treatment, with the standard deviation in parentheses. Column 5 displays the mean number of mazes solved in Round 1 in each treatment, with the standard deviation in parentheses.

Table 2 *Regression Coefficients and Standard Errors for Determinants of Mazes Solved in the 2nd Round, for individuals and groups*

	Individual Scores			**Total Group Scores**		
	(1) All Treatments	(2) No Info	(3) Full Info	(4) All Treatments	(5) No Info	(6) Full Info
NO	--	--	--	--	--	--
MEDIUM	3.43 (.65)***	3.82 (.79)***	3.19 (1.01)***	20.5 (3.97)***	22.7 (4.90)***	19.1 (6.34)***
HIGH	2.25 (.61)***	3.26 (.77)***	1.39 (.91)	13.4 (3.73)***	19.6 (4.74)***	8.10 (5.69)
FULL INFO	1.29 (.55)**			7.77 (3.38)**		
Round 1 Score	1.14 (.04)***	1.13 (.06)***	1.14 (.05)***	1.11 (.13)***	1.08 (.17)***	1.09 (.20)***
Constant	-.37 (.67)**	-.79 (.83)	1.32 (.78)*	7.77 (3.39)**	-1.09 (13.5)	11.5 (15.5)
R-squared	.59	.61	.58	.62	.71	.55
N	414	198	216	69	33	36

Notes: The dependent variable is the number of mazes solved in the second round. In columns 1, 2, and 3, individuals' scores are regressed on the independent variables for each individual. In columns 4, 5, and 6, groups' scores are regressed on the independent variables for each group. NO, MEDIUM, and HIGH represent dummies for the Low, Medium, and High Inequality Conditions, respectively; FULL INFO represents a dummy for Full Information conditions. "Round 1 score" is the total number of mazes an individual or group solved in Round 1. Robust standard errors, clustered by group, are in parentheses. *** denotes significance at the 1% level; ** denotes significance at the 5% level; * denotes significance at the 10% level.

Table 3 *Regression Coefficients and Standard Errors for Determinants of Mazes Solved in the 2nd Round, by position in Round 1*

Panel A: Regressions without controlling for round 1 score

Inequality Treatment	Information Treatment	All	Top Half of distribution of round one scores	Bottom Half of distribution of round one scores	Difference between top and bottom half coefficients
No	Full	2.51 (1.38)*	4.30 (1.63)**	.94 (1.76)	3.36
Medium	Full	5.48 (1.56)***	5.96 (1.71)***	5.00 (1.84)***	0.96
High	Full	2.82 (1.25)**	5.69 (1.80)***	-.48 (1.61)	6.21
No	No	--	--	--	
Medium	No	3.15 (1.42)**	5.70 (1.54)***	.45 (1.71)	5.25
High	No	3.32 (1.32)**	5.38 (1.69)***	1.44(1.72)	3.94
	Constant	13.3 (.95)***	15.1 (1.03)***	10.8 (1.36)***	4.3
	R-Squared	.04	.08	.09	
	# obs	414	226	188	

Panel B: **Regressions controlling for round 1 score**

No	Full	2.19 (.67)***	3.05 (1.10)***	1.06 (1.00)	1.99
Medium	Full	5.37 (1.03)***	5.43 (1.46)***	5.24 (1.19)***	0.21
High	Full	3.58 (.92)***	5.69 (1.42)***	.78 (.99)	4.91
No	No	--	--	--	
Medium	No	3.82 (.78)***	5.16 (1.12)***	1.99 (.97)**	3.17
High	No	3.26 (.76)***	4.62 (1.09)***	1.56(1.12)	3.06
	Round 1 Score	1.14(.04)***	1.11(.07)***	1.05 (.08)***	
	Constant	-.83 (.66)	-1.23(1.18)	1.14(.94)	
	R-Squared	.59	.45	.49	
	# obs	414	226	188	

Notes: The participants' second-round scores are regressed on dummies for each of the 6 treatments and a constant term. In Panel B, the Round 1 score is included as a control. Column 1 displays results for a regression in which the sample is all participants; column 2 displays results for a regression in which the sample is all participants with first-round ranks 1 to 3 (inclusive); column 3 displays results for a regression in which the sample is all participants with first-round ranks 4 to 6 (inclusive). The sample size is larger for the top half (i.e. ranks 1 to 3, inclusive) than the bottom half (i.e. ranks 4 to 6, inclusive) because tied scores were assigned the same rank. "Round 1 Score" represents the number of mazes an individual solved in Round 1. Robust standard errors, clustered by group, are in parentheses. *** denotes significance at the 1% level; ** denotes significance at the 5% level; * denotes significance at the 10% level.

Table 4 *Regression Coefficients and Standard Errors for Determinants of Mazes Solved in the 2nd Round for highest and lowest scorers on 1st round*

(1) Inequality Treatment	(2) Informatio n Treatment	(3) Round 1 Rank = 1	(4) Round 1 Rank = 6	(5) Difference between Rank 1 and Rank 6 Coefficients
No	Full	3.63 (2.34)	.59 (1.26)	2.04
Medium	Full	6.62 (2.29)***	4.84 (1.81)**	1.78
High	Full	6.08 (2.30)**	1.62 (1.01)	4.46
No	No	--	--	--
Medium	No	5.39 (2.43)***	1.58 (.94)*	3.81
High	No	4.62 (2.13)**	4.47 (1.59)***	.15
	Round 1 Score	.82 (.14)***	1.00 (.13)***	
	Constant	3.52 (2.84)	.59 (1.26)	
	R-Squared	.32	.58	
	# obs	82	59	

Notes: The participants' second-round scores are regressed on dummies for each of the 6 treatments, the participants' first-round scores, and a constant term. Column 1 displays results for a regression in which the sample is all participants; column 2 displays results for a regression in which the sample is all participants with first-round ranks 1 to 3 (inclusive); Column 3 displays results for a regression in which the sample is all participants with first-round ranks 4 to 6 (inclusive). The sample size is larger for the top scorers than the bottom scorers because tied scores were assigned the same rank, and if people were tied for last, they were assigned a rank of "5." "Round 1 Score" represents the number of mazes an individual solved in Round 1. Robust standard errors, clustered by group, are in parentheses. *** denotes significance at the 1% level; ** denotes significance at the 5% level; * denotes significance at the 10% level.

Table 5 *OLS Regression Coefficients and Standard Errors for Determinants of Maximum and Minimum Number of Second-Round Mazes Solved*

A. Dependent Variable is Maximum Score within Group

	(1) All	(2) No Info	(3) Full Info
Inequality Treatment			
No	--	--	--
Medium	2.91(1.18)**	3.90 (1.85)**	1.96 (1.54)
High	2.01(1.05)*	2.04 (1.85)	1.51 (1.28)
Round 1 Score	.66(.09)***	.86 (.13)***	.52 (.11)***
INFO	1.10(.89)		
Constant	11.84 (1.73)***	8.07 (2.11)***	15.94 (2.42)***
R-squared	.45	.58	.34
N	69	33	36

B. Dependent Variable is Minimum Score within Group

NO	--	--	--
MEDIUM	1.90 (.85)**	1.77 (1.03)*	2.36 (1.47)
HIGH	.21 (.71)	.97 (.90)	-.58 (1.06)
Round 1 Score	.45 (.06)***	.49 (.08)***	.34 (.11)***
FULL INFO	1.08 (.67)		
R-squared	.39	.53	.32
Constant	2.88 (.69)***	2.36 (.82)***	4.98 (1.15)***
N	69	33	36

Notes: In Panel A, the maximum second-round score within each group of participants is regressed on the independent variables. In Panel B, the minimum second-round score within each group of participants is regressed on the independent variables. NO, MEDIUM, and HIGH represent dummies for the Low, Medium, and High Inequality Conditions, respectively; FULL INFO represents a dummy for Full Information conditions. "Round 1 Score" represents the number of mazes an individual solved in Round 1. Robust standard errors, clustered by group, are in parentheses. In Column 1, the sample is all groups; in Column 2, the sample is all groups in a "No Information" treatment; in Column 3, the sample is all groups in a "Full Information" treatment. *** denotes significance at the 1% level; ** denotes significance at the 5% level; * denotes significance at the 10% level.

Table 6 *Summary Statistics for number of mazes fudged in Rounds 1 and 2*

Inequality Treatment Group	Information Treatment	(3) Number of Persons who Fudged (% in parentheses)		(4) Mean Number of Mazes Fudged by those who Fudged at least Once		(5) Number of mazes fudged (as % of mazes solved in round in parentheses)	
		Round 1	Round 2	Round 1	Round 2	Round 1	Round 2
No	No	4 (7.4)	4 (7.4)	1.25	1.75	5 (.75)	7 (.98)
Medium	No	5 (6.9)	8 (11)	2.17	2.67	11 (1.29)	21 (1.78)
High	No	5 (6.9)	11 (15)	1.29	1.42	6 (.67)	16 (1.34)
No	Yes	4 (5.6)	7 (9.7)	1.20	1.44	5 (.55)	10 (.88)
Medium	Yes	6 (9.1)	27 (41)	1.60	2.38	11 (1.33)	64 (5.20)
High	Yes	2 (2.6)	20 (26)	5	1.67	10 (1.09)	33 (2.62)
Total Over All Conditions		**26**	**77**	**2.09**	**1.89**	**48**	**151**

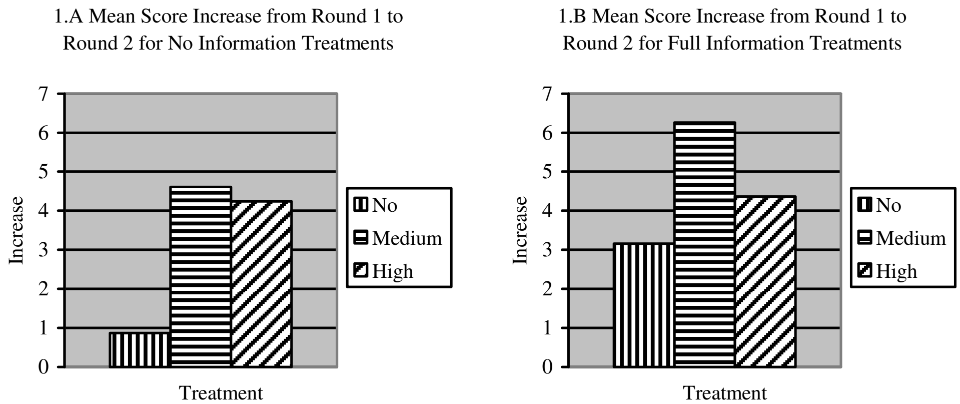
Source: Tabulated from the experiment described in text. "Fudging" a maze is defined as reporting a maze as "solved" that was actually not solved. Columns 1 and 2 describe the treatment in terms of the prize structure (column 1) and information given to participants (column 2). Column 3 displays the total number of participants in each treatment and each round who fudged at least one maze; the percent of participants who fudged at least one maze is in parentheses. Column 4 displays the mean number of mazes fudged by those who fudged at least one maze by treatment and round, with the standard deviation in parentheses. Column 5 displays the total number of mazes fudged in each treatment and round, with this number as a percentage of the number of mazes solved in parentheses. At the bottom of the table, totals over all conditions are displayed. The "total" row in column 3 represents the total number of participants who fudged in each round; the "total" row in column 4 represents the unweighted mean over all treatment of the mean number of mazes fudged by those who fudged at least once in each treatment; the "total" row in column 5 represents the total number of mazes fudged in each round.

Table 7 *Poisson Regression Coefficients and Standard Errors for Determinants of Total Number of Mazes Fudged in the Second Round*

	Full Information			No Information		
	(1) All Subjects	(2) Top Half	(3) Bottom Half	(4) All Subjects	(5) Top Half	(6) Bottom Half
NO	--	--	--	--	--	--
MEDIUM	1.12 (.43)**	1.30 (.57)**	1.01 (.47)**	-.24 (.70)	.07 (.76)	-.48 (1.15)
HIGH	.50 (.45)	1.70 (.55)***	-.75 (.77)	.56 (.51)	.34 (.74)	.60 (.71)
Mazes Fudged in Round 1	.38 (.05)***	.76 (1.07)	.46 (.08)***	.75 (.07)***	.68 (.99)	.75 (.13)***
Constant	-1.75 (.37)***	-2.51 (.50)***	-1.31 (.40)***	-2.16 (.40)***	-2.40 (.68)***	-1.93 (.60)***
# obs	216	118	98	198	108	90

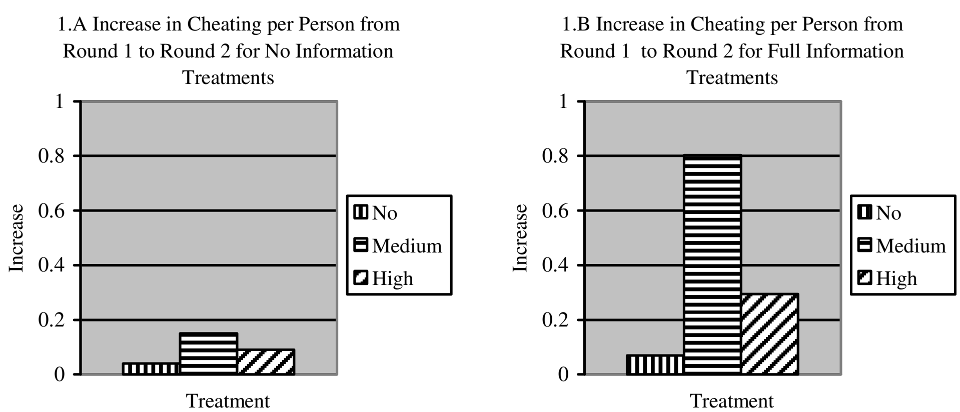
The number of mazes fudged in the second round is regressed on dummies for the incentive conditions, the number of mazes fudged in the first round, and a constant term. LOW, MEDIUM, and HIGH represent dummies for the Low, Medium, and High Inequality Conditions, respectively. "Mazes Fudged in Round 1" represents the number of mazes an individual fudged in Round 1. Columns 1 and 2 display results for a regression in which the sample is all participants; columns 3 and 4 display results for a regression in which the sample is all participants with first-round ranks 1 to 3 (inclusive); columns 5 and 6 display results for a regression in which the sample is all participants with first-round ranks 4 to 6 (inclusive). The sample size is larger for the top half than the bottom half because tied scores were assigned the same rank. Robust standard errors, clustered by group, are in parentheses. *** denotes significance at the 1% level; ** denotes significance at the 5% level; * denotes significance at the 10% level.

Figure 1 *Changes in Number of Mazes Solved from Round 1 to Round 2, for groups of subjects, by Treatment*



Source: Tabulated from the experiment described in the text. Figure 1.A shows the mean increase from Round 1 to Round 2 in the number of mazes solved by treatment, for no information conditions. Figure 1.B shows the mean increase from Round 1 to Round 2 in the number of mazes solved by treatment, for full information conditions.

Figure 2 *Increases in Fudging/Cheating per Person from Round 1 to Round 2, by Treatment*



Source: Tabulated from the experiment described in the text. Figure 1.A shows the mean increase from Round 1 to Round 2 in number of fudged mazes per person, by treatment, for no information conditions. Figure 1.B shows the mean increase from Round 1 to Round 2 in number of fudged mazes per person, by treatment, for full information conditions.

Appendix A

This appendix reports results on the inverse U shaped inequality–output relation, estimating all the tables in the main body of the paper for different plausible definitions of output and fudging. We obtain comparable results to those in the main body. Columns 1-3 of Table A1 gives the results for mazes solved in the second round *excluding mazes that followed an incomplete maze*. It yields the same patterns as in Table 2: 1) Highest output in the Medium Inequality condition when all treatments are included in the regressions; 2) similar output in the Medium and High conditions when no information is given to participants; 3) the highest output in the Medium condition when full information is given. The coefficients are smaller than those in Table 2 because excluding mazes reduces the mean number of mazes solved. Columns 4-6 of Table A1 gives the results for mazes solved in the second round *as reported by the subjects.* The same inverse U patterns hold as in the main text, but the coefficients are generally larger than those in Table 2, because the number of mazes reported by subjects themselves are sometimes higher than the number actually solved.

Table A1 *Regression Coefficients and Standard Errors for Determinants of Mazes Solved in the 2nd Round, for individuals, with alternative definitions of mazes solved*

The dependent variable:

	Mazes solved in the second round, excluding mazes following an incomplete maze			Mazes reported by subject		
	(1) All Treatments	(2) No Information	(3) Full Information	(4) All Treatments	(5) No Information	(6) Full Information
NO	--	--	--	--	--	--
MEDIUM	2.40 (.69)***	2.98 (.75)***	2.04 (.90)**	4.04 (.68)***	3.85 (.82)***	4.26 (1.04)***
HIGH	.84 (.71)	2.52 (.82)***	-.58 (1.06)	2.27 (.63)***	3.29 (.81)***	1.37 (.92)
FULL INFO	.07 (.61)			1.74 (.57)***		
Round 1 Score	1.05 (.06)***	1.06 (.10)***	1.04 (.07)***	1.13 (.04)***	1.12 (.06)***	1.04 (.07)***
Constant	.91 (.94)	.01 (1.30)	1.78 (1.02)*	-.42 (.94)	-.62 (.88)	1.60 (.81)*
R-squared	.45	.49	.43	.59	.60	.58
N	414	198	216	468	234	234

Notes: Individuals' scores are regressed on the independent variables for individuals. NO, MEDIUM, and HIGH represent dummies for the No, Medium, and High Inequality Conditions, respectively; FULL INFO represents a dummy for Full Information conditions. "Round 1 Score" is the number of mazes an individual or group solved in Round 1, not counting mazes in individuals' totals if the mazes followed mazes that were not completed. Robust standard errors, clustered by group, are in parentheses. *** denotes significance at the 1% level; ** denotes significance at the 5% level; * denotes significance at the 10% level.

As noted in the text, some observations were discarded because early in the experiment we only recorded subjects' self-reported scores and inadvertently some maze packets, so we do not know the number of mazes fudged. We have self-reported scores for both the full sample of individuals and the sample of individuals used in Tables 1-6 Table A2 gives regression results for the exact sample that we used in the main analysis with self-reported numbers solved as the dependent variable. These results mimic those in Columns 4-6 of Table A1 (which included all persons) and those in the main body of the paper.

Table A2 *Regression Coefficients and Standard Errors for Determinants of Self-Reported Mazes Solved in the 2nd Round, only for subjects who are included in tables 1-6*

	(1) All Treatments	(2) No Information	(3) Full Information
NO	--	--	--
MEDIUM	3.61 (.76)***	3.85 (.92)***	3.50 (1.13)***
HIGH	2.26 (.73)***	3.30 (.91)***	-1.38 (1.03)
FULL INFO	1.46 (.67)**		
Round 1 Score	1.13 (.04)***	1.12 (.06)***	1.13 (.06)***
Constant	-.29 (.68)	-.62 (.88)	1.51 (.81)*
R-squared	.58	.60	.58
N	414	198	216

Notes: The sample is restricted to only those individuals included in the regressions and statistics in Tables 1-6. Individuals' scores are regressed on the independent variables for individuals. NO, MEDIUM, and HIGH represent dummies for the No, Medium, and High Inequality Conditions, respectively; FULL INFO represents a dummy for Full Information conditions. "Round 1" is the number of mazes an individual or group solved in Round 1, not counting mazes in individuals' totals if the mazes followed mazes that were not completed. Robust standard errors, clustered by group, are in parentheses. *** denotes significance at the 1% level; ** denotes significance at the 5% level; * denotes significance at the 10% level.

Table A3 reports results of OLS regressions analogous to those in Table 6. The results are broadly similar to those in Table 6, but the coefficients in Table A3 may be more easily comparable with those in the main body of the paper (which are also estimated via OLS).

Table A3 *Regression Coefficients and Standard Errors for Determinants of Number of mazes fudged in the second round, excluding skipped mazes*

	(1) Full Info, All Subjects	(2) Full Info, Top Half	(3) Full Info, Bottom Half	(4) No Info, All Subjects	(5) No Info, Top Half	(6) No Info, Bottom Half
LOW	--	--	--	--	--	--
MEDIUM	.36 (.12)***	.22 (.09)**	.51 (.28)*	.06 (.10)	.01 (.08)	.08 (.12)
HIGH	.17 (.11)	.36 (.12)***	-.09 (.18)	.05 (.08)	.04 (.08)	-.01 (.14)
Mazes fudged in Round 1	1.00 (.22)***	.08 (.04)*	1.02 (.21)***	1.64 (.26)***	.10 (.19)	1.76 (.20)***
Constant	.10 (.08)	.08 (.04)*	.14 (.14)	-.02 (.06)	.09 (.07)	-.06 (.09)
R-squared	.49	.07	.58	.78	.01	.88
# obs	216	118	98	198	108	90

The number of mazes fudged in the second round is regressed on dummies for the incentive conditions, the number of mazes fudged in the first round, and a constant term. LOW, MEDIUM, and HIGH represent dummies for the Low, Medium, and High Inequality Conditions, respectively. "Round 1" represents the number of mazes an individual fudged in Round 1. Columns 1 and 2 display results for a regression in which the sample is all participants; columns 3 and 4 display results for a regression in which the sample is all participants with first-round ranks 1 to 3 (inclusive); columns 5 and 6 displays results for a regression in which the sample is all participants with first-round ranks 4 to 6 (inclusive). The sample size is larger for the top half than the bottom half because tied scores were assigned the same rank. Robust standard errors, clustered by group, are in parentheses. *** denotes significance at the 1% level; ** denotes significance at the 5% level; * denotes significance at the 10% level.

Appendix B: Instructions (Round 1)

Each of you has been given a packet of mazes. Please do not turn this packet over until the room monitor says to start. Please write your name on the back of this packet.

"Solving" a maze means that you draw a continuous line from the place on the maze marked "Start" to the place marked "Finish," without crossing any of the walls of the maze with your line. All of the mazes in your packets have solutions. Please begin working on the first maze in the packet and work through the packet in order. Begin working on a new maze only when you have finished solving the maze that preceded it in the packet. If you work out of order and skip at least one maze, you will not be given credit in your total number of mazes for mazes you solved that follow the maze you skipped. We will check the accuracy of your solutions to the mazes.

You will have 15 minutes to solve as many mazes as you can. You will receive 20 cents for each maze you solve (on top of your guaranteed payment of $13 for showing up at the experiment). If, over the course of this session, you make stray lines on your sheet that do not lead from the start of the maze to the finish, you are not required to erase these lines during the 15-minute session itself, but you may erase them if you wish to do so.

Each of you has received a packet of mazes that is identical to the packet each other participant has received. It will not be announced at any point in the experiment which participant received which score in this session.

Please do not talk to other participants while you are solving the mazes. Also, please do not talk in the break between solving mazes in the packet you have been given and solving mazes in the next packet. Please turn off your cellular phones before the experiment begins.

If you have a question about these directions, please raise your hand now.

Instructions (read by experimenter)

Please count the number of mazes that you solved correctly in the first session, and please write this number on the front of your maze packet with a circle around it. If you skipped a maze, please do not include subsequent mazes solved in the total you report. Please raise your hand when you have finished this, so that the room monitor can collect your packet from you.

Only in the "Full Information" Treatments, Read: An experimenter will now give to each of you a list of the number of mazes each member of your group solved in the first session. The number that you solved has been circled, and the numbers that the other members of your group solved have not been circled.

Instructions (Round 2)

Each of you has been given a second packet of mazes. Please write your name on the back of this packet. Please do not turn this packet over and begin working on it until the room monitor says to start.

"Solving" a maze means that you draw a continuous line from the place on the maze marked "Start" to the place marked "Finish," without crossing any of the walls of the maze with your line. All of the mazes in your packets have solutions. Please begin working on the first maze in the packet and work through the packet in order. Begin working on a new maze only when you have finished solving the maze that preceded it in the packet. If you work out of order and skip at least one maze, you will not be given credit in your total number of mazes for mazes you solved that follow the maze you skipped. We will check the accuracy of your solutions to the mazes.

You will have 15 minutes to solve mazes in your packet.

For "No Inequality" Treatments, read:

In this session, which is the final session of the experiment, you will receive **$6**, regardless of how many mazes you solve.

For Medium Inequality Treatments, read:

In this session, which is the final session of the experiment, you will be paid based on how many mazes you solve, in comparison with how many mazes the other participants solve. If you solve the **most** mazes in this session out of the members of this group, you will receive **$15**, in addition to your show-up fee, plus what you earned in the first session. If you solve the **second-most** mazes in this session out of the members of this group, you will receive **$7**, in addition to your show-up fee, plus what you earned in the first session. If you solve the **third-most** mazes in this session out of the members of this group, you will receive **$5**, in addition to your show-up fee, plus what you earned in the first session. If you solve the **fourth-most** mazes in this session out of the members of this group, you will receive **$2**, in addition to your show-up fee, plus what you earned in the first session. If you solve the **fifth-most** mazes in this session out of the members of this group, you will receive **$1**, in addition to your show-up fee, plus what you earned in the first session. If you solve the **sixth-most** mazes in this session out of the members of this group, you will receive **only** your show-up fee, plus what you earned in the first session.

Your payment from this session (the second session) will be based **only** on how many mazes you solve in the second session. The number you solved in the first session is irrelevant to the payment you receive in this session.

For "High Inequality" Treatments:

You will have 15 minutes to solve mazes in your packet. In this session, which is the final session of the experiment, you will be paid based on how many mazes you solve, in comparison with how many mazes the other participants solve. If you solve the **most** mazes in this session out of the members of this group, you will receive **$30**, in addition to your show-up fee, plus what you earned in the first session. Everyone else will receive **only** their show-up fee, plus what they earned in the previous session.

Your payment from this session (the second session) will be based **only** on how many mazes you solve in the second session. The number you solved in the first session is irrelevant to the payment you receive in this session.

At end of each round:

Each of you has received a packet of mazes that is identical to the packet each other participant has received. It will not be announced at any point in the experiment which participant received which score in this session. Please do not talk while you are solving the mazes.

If you have a question about these directions, please raise your hand now.