CBESS Discussion Paper 13-08

Inequality and Effort: An Experiment on Competition Between Teams

By Shaun P. Hargreaves Heap*, Abhijit Ramalingam* Siddharth Ramalingam** and Brock V. Stoddard***

* School of Economics and Centre for Behavioural and Experimental Social Science, University of East Anglia
** Cambridge Economic Policy Associates
*** Department of Economics, Indiana University

Abstract
At least since Adam Smith, economists have recognized the beneficial effects of competition in markets. The possible positive influence of competition between teams on the free rider problem within teams is a more recent discovery. It is important because the free rider problem exists to some degree in most teams and because many outcomes in economic and social life depend on competition between teams. However, teams are rarely endowed equally and we do not know much about how such inequality affects the influence of competition on free riding. We address this question with an experiment. It is important not only because of the connections sketched above, but also because this is an overlooked aspect of how inequality impacts on society. We find that there is less free riding within teams when there is competition, that this is robust to moderate degrees of inequality but disappears when inequality is high.

JEL classification codes
C91, C92, D63, H41

Centre for Behavioural and Experimental Social Science
University of East Anglia
Norwich Research Park
Norwich NR4 7TJ
United Kingdom
www.uea.ac.uk/ssf/cbess

INEQUALITY AND EFFORT: AN EXPERIMENT ON COMPETITION BETWEEN TEAMS*

Shaun P. Hargreaves Heap (corresponding author)
School of Economics and Centre for Behavioural and Experimental Social Science,
University of East Anglia, Norwich NR4 7TJ, U.K.
s.hargreavesheap@uea.ac.uk, Ph: +44-1603-593422, Fax: +44-1603-456259.

Abhijit Ramalingam
School of Economics and Centre for Behavioural and Experimental Social Science,
University of East Anglia, Norwich NR4 7TJ, U.K.
a.ramalingam@uea.ac.uk, Ph: +44-1603-597382, Fax: +44-1603-456259.

Siddharth Ramalingam
Cambridge Economic Policy Associates, Green Park, New Delhi 110016, India.
siddharth.ramalingam@cepa.co.uk, Ph: +91-11-41012279, Fax: +44-2074054699.

Brock V. Stoddard
Department of Economics, Indiana University, 100 S. Woodlawn, Wylie Hall 105,
Bloomington, IN 47405, U.S.A.
brvstod@indiana.edu, Ph: +1-812-855-1021, Fax: +1-812-855-3736.

Abstract

At least since Adam Smith, economists have recognized the beneficial effects of competition in markets. The possible positive influence of competition between teams on the free rider problem within teams is a more recent discovery. It is important because the free rider problem exists to some degree in most teams and because many outcomes in economic and social life depend on competition between teams. However, teams are rarely endowed equally and we do not know much about how such inequality affects the influence of competition on free riding. We address this question with an experiment. It is important not only because of the connections sketched above, but also because this is an overlooked aspect of how inequality impacts on society. We find that there is less free riding within teams when there is competition, that this is robust to moderate degrees of inequality but disappears when inequality is high.

JEL Codes: C91, C92, D63, H41

Word count : 7862

1. Introduction

Many economic and social outcomes depend on competition between teams. Sporting contests are one example. Companies that compete in the market are another: like sports' teams, they are formed by groups of people whose combined efforts influence the likelihood of their success. How does inequality between team resources in such competitions affect efforts within each team? This is the question that we address with an experiment. It is important because competitions between teams are not only ubiquitous, they are invariably characterised by some degree of inequality between the teams and little is known about the effect of such inequality on individual effort within each team.[1]

This is not only an overlooked aspect of how inequality could impact on society, it is also one where there are liable to be conflicting intuitions. For instance, individuals in the 'poor' team might expend less effort when pitched against a team that is much better resourced than their own because the result can appear like a foregone conclusion---'what is the point of trying?' might be an understandable reaction. Alternatively, the disadvantage could spur extra effort among the poorly endowed team, as happens sometimes when the numbers on a sporting team are reduced through injury or a sending-off.

The possible link we consider between inequality and outcomes is obviously important for the design of sporting contests where it is often argued that their entertainment value is likely to fall when teams are unequally endowed. This is

[1] There are experiments that consider how individual effort in a contest with another individual is affected by inequality (e.g. see Calsamiglia, Franke and Rey-Biel, 2013) and there are experiments that examine how individual efforts in teams are influenced when there is a contest between teams (e.g. see Guntthorsdottir and Rapoport, 2006). But so far as we know there is only one experiment where the effect of differences between the teams in such a contest between teams has been examined and this is Erev, Bornstein and Galili (1993). Their teams, in a quasi field experiment, compete over orange picking and they have different orange picking abilities. These differences in ability are, however, not common knowledge and so although they detect some effect from these differences in ability, their results are difficult to interpret.

usually because differences in endowment seem likely to produce more predictable results. But inequality could as easily detract from entertainment if team members respond to differences in resource by expending less effort. Such worries have led some sporting leagues to introduce equalizing arrangements like the ‘draft’ in North American Football. But is there reason to fear an effort effect from inequality? The same question applies for companies and other organisations. Should a small potential entrant company fear that its workers will be demoralised if they enter a market dominated by large companies? Is it only sensible for a manager to set up internal competitions to motivate the various teams within his or her company when the teams are equally resourced? In these and other ways, the question is quite general and with conflicting intuitions over how inequality might work in such cases, the question is well suited for experimental investigation.

We focus for this purpose on one aspect of individual effort within the team: efforts that are subject to a free rider problem. In part, this is because, given monitoring difficulties, there is always likely to be some individual effort in a collective enterprise like a company or sports’ team that is subject to this problem. It is also because there is an argument, and some evidence, that this free rider problem within teams can be attenuated by the existence of competition between teams (see Bowles and Gintis, 2011, Tan and Bolle, 2007, Guntthorsdottir and Rapoport, 2006, and Marino and Zábojník, 2004). This is a relatively new and potentially important argument because it is different to the standard one connecting competition with efficiency. In effect, our paper provides an experimental test of this new argument and its robustness to inequality.

The design of the experiment is simple. We capture this aspect of the individual effort decision via a public goods contribution problem and we examine the influence of competition between teams on these public good decisions by making a team's contribution to its public good affect its chances of success in a Tullock contest.

We find that the existence of the Tullock contest does boost contributions to the public good as compared with the level of contributions when there is no contest. In this sense, competition between teams does mitigate the free rider problem within a team and so promotes efficiency. We also find that this boost is sensitive to the level of inequality between the teams. The boost occurs under equality and for moderate levels of inequality, but disappears when there is more extreme inequality. The magic of competition in this respect, so to speak, vanishes when organizations in the competition are highly unequal. In our experiment, this adverse effect of high inequality on effort is most pronounced in the poorer team and this has further implications for the political economy of redistribution. Section I explains the design of the experiment in more detail, II gives the results which we discuss in III. We conclude the paper in section IV.

2. Experimental design.

2.1 Overview

We follow closely the design of Guntthorsdottir and Rapoport's (2006) experiment on team competition. They have a standard public goods decision that individuals in each team must make. Each player i in group k composed of m players receives an endowment of $e_k > 0$ and must decide how much to invest $0 \leq x_{ik} \leq e_k$ in a public good. The remainder, $(e_k - x_{ik})$, is automatically invested in a private good. The return from the private good is 1 while the return from the public good depends on the total contribution to the public good in group k, denoted by $X_k = \sum_i x_{ik}$. Each player in group k receives a fraction, g ($0 < g < 1$ and $mg > 1$), of X_k, i.e., the marginal per-capita return (MPCR) from the public good is g.

Thus the payoff to player i in group k is given by

$$V_{ik} = (e_k - x_{ik}) + g\, X_k. \qquad \ldots\ldots.(1)$$

The Nash equilibrium in this game is for each player to contribute nothing to the public good. However, this public goods game is connected to a team competition. Two groups compete for a prize in a standard Tullock contest where the probability of success depends on relative contributions to their public goods; and this changes the equilibrium. In particular, with two groups, k and l, competing for a prize S that is split equally amongst its m members and where each group wins the prize with a probability determined by a Tullock Contest Success Function given by (2), the pay-off to each individual is now given by (3).

$$\text{Prob (Group } k \text{ wins the prize)} = X_k / (X_k + X_l) \text{ if } X_k > 0, = 0.5 \text{ if } X_k = X_l = 0, \text{ and } = 0 \text{ otherwise} \quad \ldots\ldots\ldots\ldots(2)$$

$$V_{ik} = (e_k - x_{ik}) + g\, X_k. + [X_k / (X_k + X_l)].(S/m) \quad \ldots\ldots\ldots(3)$$

The first-order condition for player i in group k and player j in group l are respectively (4) and (5).

$$-1 + g + [X_l / (X_k + X_l)^2].(S/m) = 0 \ \ldots\ldots..(4)$$

$$-1 + g + [X_k / (X_k + X_l)^2].(S/m) = 0 \ \ldots\ldots\ldots.(5)$$

The two-first order conditions imply that, in equilibrium the aggregate contribution to the public good must be the same: $X_k = X_l$. As long as both groups have sufficient endowments, in an interior equilibrium we have[2]

$$X_k^* = X_l^* = S / [4m\,(1 - g)] > 0 \text{ ……… } (6)$$

Without further assumptions, such as symmetry, we cannot solve for individual contribution levels. In equilibrium, they should sum to the value given by (6) but since this can be generated by a variety of individual contributions, there are multiple equilibria. Nevertheless, it is clear that the competition for a prize has the potential to raise the equilibrium contributions of groups above zero which is the equilibrium group contribution in the standard public goods game.

Note that as long as both groups have "sufficient funds", the equilibrium group allocation is independent of the endowments of both groups. In other words, the equilibrium analysis of the interaction suggests that inequality will have no effect on the public goods contributions. Nevertheless, there is an intuition that inequality could have an effect. In particular, it seems possible that the greater the inequality, the more likely both sets of team members are likely to feel that the result is a foregone conclusion and so expend less effort. It is this conjecture that we aim to test.

Towards this end we make two changes to the Guntthorsdottir and Rapoport (2006) sketched above. They have equal endowments and play the public good-cum-contest game 80 times. In our treatments, we change the endowment of the teams to produce varying degrees of inequality and we repeat the interaction 20 times. The

[2] There can exist another equilibrium where both groups contribute zero to the public good. See Chowdhury and Sheremeta (2011).

latter is closer to what is common in the experimental literature on repeated public goods games. The former is to test for any effect of inequality on effort.

2.2 Design details

There were 19 experimental sessions conducted at the University of East Anglia (UEA). For each session, 12 subjects were recruited from the student body at UEA. Subjects were anonymously and randomly assigned to three-person groups (m = 3). The composition of these groups remained the same throughout each session, i.e., all sessions used partner matching.

At the beginning of each session, instructions were read out by an experimenter. Subjects also had a copy that they could refer to at any time during the experiment. Subjects then took a quiz to ensure understanding. They could not proceed until all questions were answered correctly. Once the experiment began, subjects made decisions privately at their computer terminals. The experiment was programmed in z-Tree (Fischbacher 2007). A session lasted 50 minutes on average and each subject earned between £10 and £11 on average including a £2 show-up fee.

In our control treatment, subjects played a linear public goods game, using the Voluntary Contributions Mechanism (VCM), in groups of three. Each subject received an endowment of 50 tokens which could be allocated to either a private account or a group account. Subjects earned one token for each token allocated to the private account. For each token allocated to the group account, each member of the three-person group earned 0.5 tokens, i.e., MPCR = g = 0.5. Once all subjects had made their contribution decisions, each subject was informed of his/her group's total contribution to the public good in that round and his/her individual earning from his/her private account and the group account.

This decision setting was repeated for 20 rounds. Earnings from a round could not be carried forward to future rounds. In each round, each subject received a fresh endowment. Further, all members of a group received the same endowment each period. At the end of a session, tokens were converted to cash at the rate of 150 tokens to £1. We ran 3 sessions of the VCM control.

We also ran four treatments where each otherwise similarly set up group also competed in a Tullock contest with another group for a prize of S = 120 tokens in a second stage in each round. We chose S = 120 so that we would have at least one case each where the individual prize (40 tokens per group member) would be higher than, equal to and lower than the individual endowment (see below). The competitors in each Tullock contest were chosen randomly at the beginning and then kept fixed throughout a session. Subjects could not identify the subjects in their group or those they compete with in the Tullock contest at any time.

In this second stage, each group was informed of their total allocation to the group account, the allocation to the group account of the competing group, the winning probabilities for each group and the winning group (one's own group or the other group) in the round. Winning probabilities were determined using a Tullock contest success function as above: i.e. Prob(Group k Winning) = Group account of group k / (Group account of group k + Group account of group l), $k \neq l$.

The four treatments with the additional Tullock contest were distinguished by the distribution of the endowment levels across the competing groups. In our Equality treatment, each group member (in one's own group and in the competing group) received an endowment of 50 tokens each round. In our Low Inequality treatment, members of one of the groups in a competing pair received a per-period endowment of 45 tokens each while members of the other group received a per-period endowment of 55 tokens each. In our Medium Inequality treatment, members of one of the groups in a pair received a per-period endowment of 40 tokens each while members of the other group received a per-period endowment of 60 tokens each. In our High Inequality treatment, members of one of the groups in a pair received a per-period endowment of 20 tokens each while members of the other group received a per-period endowment of 80 tokens each. In all cases, the endowments were known by all participants.

The endowment values were chosen such that the total combined resources of both competing groups were the same in all treatments, i.e., 300 tokens.[3] To keep earnings comparable to those in the control treatment, final token earnings were converted to cash at the rate of 200 tokens to £1 in these 4 treatments.

Due to the potential effects of competition on the decisions of both groups in a pair, each comparison pair forms an independent unit of observation. We thus have data on two independent pairs each session. We ran four sessions each of the four competition treatments, thus leading to 16 groups and 8 competing pairs in each. Table 1 summarises our treatments and lists the number of sessions and observations for each treatment.

[Table 1]

[3] Further, given our parameters, the equilibrium remains unchanged in all competition treatments. See below.

In the no competition VCM treatments, zero contribution is the unique sub game perfect equilibrium in each round. Figure 1 shows the reaction functions of the two groups in the competition treatments. Two things to note from this are that a) the equilibrium group contribution is 20 tokens in all competition treatments (and this is feasible for all groups in our experiment, even the poorest in 20-80, as their group endowment is 60); and b) there is no incentive for one group to 'overbid' because the other group has contributed more than 20.

[Figure 1]

3. Results

3.1 Effects of competition

We begin by comparing average group public good provision in the VCM and in the competition treatments. Figure 2 presents the average group contributions over time by independent groups (12 groups) in the VCM and by competing pairs of groups (8 pairs each) in the competition treatments. We observe the usual pattern of contributions in the VCM (see, for instance, Fehr and Gächter 2000): they start high (here, about two-thirds of the endowment) and collapse by round 20 to about one-fifth of the group's endowment (about 30 tokens). This collapse is particularly evident in the last 5 rounds of the game.

[Figure 2]

Contributions in the competition treatments start at similar levels to the VCM and evolve in the same way until about round 15. Thereafter, it seems the average contributions show less of deterioration with competition than in the VCM and all groups contribute more than the equilibrium prediction of 20 tokens.

Table 2 presents summary statistics on average group contributions by groups in the VCM and competing pairs in all the competition treatments combined. The data is disaggregated across rounds, by the initial five rounds, the middle 10 rounds, the last 5 rounds, and it is presented for all rounds combined. While the contribution level is higher with competition in almost all rounds, there is no statistically significant difference between contributions levels in the first 5 rounds (p = 0.5015) and the middle 10 rounds (p = 0.4215). The statistically significant differences in contributions appear in the last 5 rounds (p = 0.0148). Table 3 reports on the proportion of free riders (in the sense of zero contributors) in the VCM and under competition, as this can be crucial in influencing public goods contributions when there is reciprocating behaviour. There is a significantly lower level of free riding in all periods with competition and the difference becomes particularly pronounced in the last 5 periods when free riding increases greatly in the VCM and only slightly with competition. This suggests that there is an influence on behaviour from competition in all rounds, it does not yield a statistically significant difference in average contributions in the first 15 rounds but as free riding jumps and contributions drop during the last 5 rounds of the VCM, the difference with respect to contributions when there is competition does become significant.

[Table 2]

[Table 3]

Result 1: *Competition reduces free riding as compared with the VCM, this is most marked in the last 5 rounds with the result that average contributions to public goods are also higher with competition in the last 5 rounds.* [4]

3.2 The influence of inequality

Table 4 reproduces the data from Table 2 but distinguishes now between each of the competition treatments (i.e. by the degree of inequality). Competition between equal groups (50-50) and between groups that face a low level of inequality (45-55) does increase contributions relative to the VCM in the last 5 rounds but only at the 10% level of significance (p = 0.0641 for 50-50 and p = 0.0697 for 45-55). Competition between groups faced with medium inequality (40-60) increases contributions over the VCM by a greater amount compared to the other competition treatments and this difference over the VCM is significant at the 5% level (p = 0.0449). Finally, while contributions by groups in the high inequality competition treatment (20-80) are higher than those of groups in the VCM, they are not significantly different (p = 0.1427). In other words, while there is reasonable confidence that contributions are higher under competition when inequality is no more than moderate, there is no confidence that this boost from competition survives when inequality is high.[5]

[Table 4]

[4] There is supporting evidence that these differences in behaviour under competition are due to competition in the sense that individual behaviour under competition seems to be sensitive to a feature of the competition. In a regression reported in the appendix in Table A1 we find that individual contribution levels are related to the proportion of wins experienced so far in the competition.

[5] In the appendix, we report in Table A2 on the proportion of free riders by Treatment. As in Table 3, this suggests sharper differences in behavior in all rounds than is evident in the data on average contributions. It also seems that free riding, unlike average contributions, remains significantly lower under high inequality than the VCM. Nevertheless, free riding is always higher under high inequality than under equality and more moderate levels of inequality, again suggesting that high inequality tends to offset the boost from competition.

We check for these Treatment differences in the last 5 rounds at the level of individual behaviour by running regressions on individual contributions with demographic controls and Treatment dummies. In particular, we present two sets of panel (individual level) random effects regressions with clustered standard errors in Table 5: one for the absolute individual contribution and the other on the contribution as a % of individual endowment. With same total endowment in each Treatment, there is no difference between these measures when applied, as in the earlier analysis, to average group contribution in a Treatment. However, for individuals there are differences in endowment and so the two measures are not the same. In particular, if there are wealth effects or if behavioural norms develop over % contributions, then the differences in behaviour that are due to inequality will be better captured by % than absolute individual contributions.

[Table 5]

The individual regressions largely complement the results on the Treatment differences with respect to average contributions. Individual contributions, measured absolutely, are higher under all competition treatments except when the inequality is high. While the same is largely true for % individual contributions, there is one further inequality treatment, the low one, where the difference is on the borderline of significance at the 10% level (p= 0.105).

Result 2: *The boost from competition to public goods contributions in the last 5 rounds disappears when there is 'high inequality'.*

3.3 "Poor" and 'Rich" groups

We now consider whether there are differences in the behaviour of the 'poor' and the 'rich' teams when there is inequality and whether this too depends on the degree of inequality. Tables 6 and 7 give the average contribution and % of endowment contribution for the poor and rich teams separately for each Treatment during the last 5 rounds. We focus on the last 5 rounds as this is where we have found significant differences between competition and the VCM and between different degrees of inequality when there is competition.

[Table 6]

[Table 7]

The results are very similar in the two tables. The boost to contributions from competition comes more frequently from the behaviour of the rich. The only case where the poor's contributions are higher than the VCM is in the 40-60 Treatment; their absolute contribution is notably lower under high inequality and neither it nor the % contribution are statistically significantly different from the corresponding amounts and rates in the VCM. The one difference between the tables is in the behaviour of the rich under high inequality. Their absolute contributions are higher than the VCM but their % contribution is not. This suggests that a wealth effect may be responsible for the high absolute contribution of the rich in this Treatment and that the distinct effect of high inequality is to remove the boost from competition for both the poor and the rich. Table 8 provides support for these inferences with regressions on individual behaviour. As in Table 5, we control for demographics and run the regressions on the 'poor' and 'rich' separately in each Treatment. In particular, neither the coefficient for the 'poor' in the absolute nor the % contribution equation under high inequality is statistically significantly different from that in the VCM, but they are with moderate inequality.

[Table 8]

Result 3: *The absence of a competition boost to contributions with high inequality is largely due to low absolute contributions by the poor.*[6]

4. Discussion

Our experiment suggests that competition between teams helps overcome the free rider problem within each team and that while this beneficial effect is robust to moderate inequality between the teams, it disappears when inequality is high. These results are important. We discuss them in turn and conclude with some welfare insights and a comment on the political economy of redistribution.

First, while the influence of competition between teams on contributions to each team's public good has been noted before, our results provide a fresh insight into its origins. The timing aspect of our result (that the benefit from competition comes in the last 5 rounds) is consistent with what has been reported in other experiments, but we are unusual in drawing attention to this and it is potentially important. For example, Nalbantian and Schotter (1997) report, in a related experiment, on the differences between remuneration schemes for the last 5 rounds, but not on differences in earlier rounds. Likewise, Erev *et al* (1993) have two observations on what is the effective contribution to the public good in their field experiment and the difference that emerges under competition is only present in the last of these

[6] Again the evidence on free riding reported in the appendix Table A3 reinforces this conclusion. The only statistically significant case where the 'poor' free ride more than the 'rich' is in the high inequality treatment.

observations. Similarly, although not part of their formal test, it would seem visually that the main difference under competition occurs in the later rounds in Guntthorsdottir and Rapoport (2006).

One reason that this is important is because it suggests that the benefits from this mechanism will be strongest in interactions that are relatively short lived: that is, the absence of an end game effect will prove more significant in the context of a shorter sequence of repeated interactions than in longer ones.

The timing of the beneficial effect may also be important for the interpretation of why the boost occurs. One view of the difference from competition might be that it comes from the change in the Nash equilibria. The Nash equilibrium on this account could be acting like a reference point that the other regarding motives build on. So, if the VCM Nash equilibrium is for a 0 contribution by each group and in the competition treatments the Nash equilibrium shifts to 20, then one might expect to get what 'other regarding' motives supply in the VCM plus 20 when there is competition. The average boost over all 20 rounds in our experiment is just over 13, so the figure is close-ish to the 20 difference in Nash. But one would expect to see this throughout on this interpretation. Instead, the boost only occurs in the last 5 rounds and it is at a higher value in these last rounds: over 30 more than the VCM. This figure is itself proportionately very similar to that quoted in the last observation by Erev *et al* (1993) where productivity is 208 compared with 120. This strongly suggests that the influence of the competition is working in a different way.

In addition, there is some direct evidence in our experiment that behaviour is being influenced by a pure feature of competition (rather than a change in the Nash equilibrium caused by the introduction of competition). In a regression that we report in the appendix in Table A1, it seems that the level of individual contribution is affected by the team's history of winning. This apparent interest in a pure feature of competition, the winning and losing, could, in turn, help explain why the clearest differences as compared with the VCM emerge in the last 5 rounds when VCM contributions fall markedly. The point is that the competition itself and the experience of winning and losing continues right up to the last round and so may plausibly distract subjects from the logic of backward induction which otherwise takes hold in the VCM.

Second, we are the first to examine how inequality between teams that is known affects the competition boost. One conjecture at the beginning was that the 'poorer' team might respond by contributing less to the public good and Erev *et al* (1993) have argued that the 'rich', too, might respond similarly because they know that they enjoy an advantage over the 'poor' and, knowing this, they need do less to win the competition. In their experiment, the difference in abilities between teams was not known by design. It is possible, since it was a field experiment and there does not seem to have been any effort to prevent communication between subjects, that subjects might nevertheless have come to know something about these differences. However one cannot be sure what they knew and this (and the heterogeneity of ability within each team) makes interpretation of their results difficult. In addition, the differences in ability effectively translate into different marginal returns from contributing to the public good and so it is not directly analogous to our difference in endowment. Nevertheless, it is interesting that they report that difference in team abilities does seem to be associated negatively with the size of the productivity boost from competition for both the relatively 'high' and 'low' ability teams. Our result is different and it is one that, through design, can be more plausibly connected causally to inequality because the inequality was common knowledge in our experiment. We find moderate inequality has no effect on the boost from competition, but high inequality can remove this beneficial effect altogether and notably among the ‘poor’. This result is similar to what has been found in experiments where there are varieties of inequality within a team. For example, Keser *et al* (2011) find that moderate inequality between individuals has no effect on their contributions when they play the standard VCM game together, but high inequality reduces contributions.

Of course, the fact that we observe a difference when there is high inequality need not be because individuals perceive the result as more of a foregone conclusion and so see less point in making an effort (as we and Erev *et al* (1993) have conjectured). In experiments subjects often display a social preference for equality: i.e. their behaviour is influenced by the degree of inequality in the social interaction (see Fehr and Schmidt, 1999); and in principle this might cause behaviour to be different when there is high inequality. It could be with moderate inequality this influence is too small to register and that when there is high inequality, these inequality sensitive preferences produce significantly different behaviours. However, it is difficult to reconcile what we observe with inequality aversion. In part, this is because there is no marked difference in the response of the ‘poor’ and the ‘rich’ to high inequality (as one would expect if inequality aversion was underpinning any change in behaviour). In addition, in this Treatment (as in all the Treatments) the distribution of resources at the end of the experiment almost exactly matches the initial inequality in initial endowments (see Table A4 in the Appendix for details). If inequality aversion had been driving our results, then there should have been some change in team inequality over the course of the experiment. The absence of an apparent influence of inequality aversion on individual contributions is also what has been found when there is inequality within teams and there has been an explicit test for its influence (see Buckley and Croson, 2006).

Equally it is possible that, since the effects of high inequality are most marked for the ‘poor’, it might be argued that this is as much a consequence of being poor as a reaction to the high level of inequality. The fact that the % contribution by the ‘poor’ under high inequality is not different to that in the 50-50 or 45-55 Treatments is one bit of evidence that could suggest it is poverty *per se* and not the reaction to inequality. Against this interpretation, there is the comparison with behaviour in the VCM. The possible interaction between competition and inequality does not arise in the VCM and the endowment is 50. Thus, if the low endowment of 20 was driving the low absolute contribution of the ‘poor’ in the high inequality case (and the interaction between inequality and competition was negligible in its effect), we would expect to find that absolute contributions were higher in the VCM where there is the higher endowment. We do not.

There is another mechanism through which being poor *per se* might still be driving our result under high inequality. It could be the case that being ‘poor’ might not have provided sufficient incentive to participate actively in the experiment (and this weighed on the side of contributing less). Against this, although the poor in the 20-80 treatment do typically earn less in the experiment than those with higher endowments, they still earned on average over £5 for an experiment that lasted about 40 minutes; and this rate of pay still comfortably exceeds the minimum wage.

We draw the inference that it is more likely that high inequality undermines the benefits of competition on effort in our experiment because participants are more inclined to view the result of the competition as a foregone conclusion than that it is due to some wealth effect on the behaviour of the ‘poor’ or that our subjects were motivated by inequality averse preferences and were reacting to inequality for this reason. We proceed on this basis to consider some welfare implications.

First, we consider outcomes with respect to efficiency. We focus for this purpose on absolute average contributions under the VCM as compared with the competition treatments (and so we abstract for obvious reasons from the competition prize in these treatments). Competition is more efficient than no-competition, in the sense that average contributions are higher (in the last 5 rounds) when the competition treatments are combined and in all competition treatments taken individually except the high inequality case, where average contributions are no worse than the no-competition case. The strongest statistical difference occurs under moderate inequality and although this cannot be statistically distinguished from the no and the low inequality treatments, moderate inequality does produce the highest average level of contributions of all the treatments. The regressions on individual contributions yield exactly the same distinctions between treatments. So, competition is generally more efficient and most convincingly so under moderate inequality.

Second, we assess the outcomes using a Rawlsian standard by focussing on the absolute contributions of the ‘poor’. From this perspective, competition is only clearly better, in the sense that the non-parametric test for the average contribution of the poor is significantly higher and the treatment dummy is significantly higher in the poor individual contribution regressions, in the moderate inequality state. There is more modest statistical support for competition in the no and the low inequality treatments, but none in the high inequality one. Thus we conclude that as far as welfare is concerned, a state of competition and moderate inequality has much to commend. In comparison, competition and high inequality has no welfare advantage either in terms of efficiency or for a Rawlsian over no-competition.

Our final comment concerns the political economy of redistribution. This is more speculative because although the ‘rich’ are better off under high inequality than in any of the other competition treatments (e.g. contribution of 109.5 compared with the no-inequality contribution of 75.5) these differences are not statistically significant. Nevertheless, it is worth making, albeit tentatively because it is based on this actual difference, and it follows from the welfare analysis. The ‘poor’ have every reason to vote for a state of moderate inequality as they are better off under it than any other. The ‘rich’ in our experiment are, effectively, as well-off in the moderate inequality treatment as in low inequality and they are better off in this state than no-inequality and the no-competition treatments. The rich in our experiment are even better-off under high inequality. If we now assume that movement from one state to another depends on both the poor and the rich agreeing to this move (because it will make them better-off or at least not make them worse-off), then the moderate inequality state will likely be achieved if one starts from any state except the high inequality one. In other words, our experiment suggests that the high inequality state might not only be worrying because it is inferior in welfare terms, but it also might be more entrenched than other inferior states.

Or to put this last insight differently, if there is high inequality between teams, then it is better to organize or engage in competitions selectively between teams that are more closely matched in their resources than is generally the case. This, of course, is one reason why sporting competitions are organized into leagues.

5. Conclusion

At least since Adam Smith, economists have recognized the beneficial effects of competition in markets. The possible positive influence of competition on the free rider problem within teams is a more recent discovery (e.g. see Bornstein *et al,* 1990, and Bowles and Gintis, 2011). There are now theoretical reasons and some experimental evidence to suggest that competition between teams reduces free riding within teams. This is an important insight because the free rider problem exists to some degree in most teams and because many outcomes in economic and social life depend on competition between teams. However, teams are rarely endowed equally and, while there are conflicting intuitions about how this might affect efforts, little is actually known about the influence of inequality in this context. This is the question we have addressed with an experiment.

We find that there is a boost to public goods contributions within a team when there is competition with other teams and it is plausibly related to the fact of competition rather than the operation of some social preference in the interaction. We also find that the gain largely arises because the endgame drop-off in contributions is much less marked when there is competition. This is not so surprising if it is the fact of competition *per se* that is driving the difference in behaviour because, with competition occurring in every period, this interest in competition will be tending to offset or distract from the logic of backward induction that seems to take hold in the last rounds of such interactions when there is no-competition.

We also find that this boost to cooperativeness is not diminished by moderate levels of inequality between teams, indeed it might be enhanced, but it disappears when inequality is high. This is largely due to the way that the behaviour of ‘poor’ team members, when there is high inequality, is indistinguishable from what occurs in teams when there is no competition. In other words, the magic of competition disappears with high inequality because the 'poor' appear to stop rising to its challenges. On some accounts, this is in part what being marginalized in society means: people stop behaving like others. Or to put this round the other way, when inequality is high, there may be a potential gain from moving to less unequal arrangements that is typically overlooked. The poor may become less marginalized in the sense that they become more likely to respond to the challenges of team competition in the same way as others.

References

Bornstein, G., Erev, I. and Rosen, O. (1990) "Intergroup competition as a structural solution to social dilemma", *Social Behavior*, 5, 247-260.

Bowles, S. and H. Gintis (2011) *A Cooperative Species: Human Reciprocity and its Evolution.* Princeton: Princeton University Press.

Buckley, E and R. Croson (2006) "Income and wealth heterogeneity in the voluntary provision of linear public goods", *Journal of Public Economics,* 90, 935-955.

Calsamiglia, C., J. Franke and P. Rey-Biel (2013) "The Incentive Effects of Affirmative Action in a Real Effort Tournament", *Journal of Public Economics*, forthcoming.

Chowdhury, S. M. and R. M. Sheremeta (2011) "Multiple Equilibria in Tullock Contests", *Economics Letters*, 112(2), 216-219.

Erev, I., Bornstein, G. and R. Galili (1993) "Constructive Intergroup Competition as a Solution to the Free Rider Problem: A Field Experiment", *Journal of Experimental Social Psychology*, 29(6), 463-478.

Fehr, E., and S. Gächter (2000) "Cooperation and Punishment in Public Goods Experiments", *American Economic Review*, 90(4), 980-994.

Fehr, E. and K. M. Schmidt (1999) "A Theory of Fairness, Competition and Cooperation", *Quarterly Journal of Economics*, 114(3), 817-868.

Fischbacher, U. (2007) “z-Tree: Zurich Toolbox for Ready-made Economic Experiments”, *Experimental Economics*, 10(2), 171-178.

Gunnthorsdottir, A. and A. Rapoport (2006) “Embedding social dilemmas in intergroup competition reduces free-riding”, *Organizational Behavior and Human Decision Processes*, 101(2), 184-199.

Keser, C., A. Markstädter, M. Schmidt and C. Schnitzler (2011) “Rich Man and Lazarus - Asymmetric Endowments in Public-Goods Experiments”, *Working Paper*.

Marino, A. and J. Zábojník (2004) “Internal competition for corporate resources and incentives in teams” *The Rand Journal of Economics*, 35(4), 710-727.

Nalbantian, H and A. Schotter (1997) “Productivity under Group Incentives: An Experimental Study”, *American Economic Review*, 87(3), 314-341.

Tan, J. H. W. and F. Bolle (2007) “Team competition and the public goods game”, *Economics Letters*, 96(1), 133-139.

***** The authors thank Jordi Brandts, Gary Charness, Enrique Fatas, Daniela Puzzello, Sudipta Sarangi, Bob Sugden, Steve Tucker, Ted Turocy, Jimmy Walker, Arlington Williams and seminar participants at the University of East Anglia, Indiana University and the Southern Economic Association Annual Meetings 2012 for helpful advice, comments and suggestions. Funding from the School of Economics, University of East Anglia is gratefully acknowledged.

Table 1. Summary of Treatments

Treatment	Endowments	# groups	# pairs
	Baseline - No Competition		
VCM-50	50	12	-
	Competition Treatments		
No Inequality	50-50	16	8
Low Inequality	45-55	16	8
Medium Inequality	40-60	16	8
High Inequality	20-80	16	8
Total	**-**	**76**	**32**

Figure 1. Reaction Functions of the two competing groups

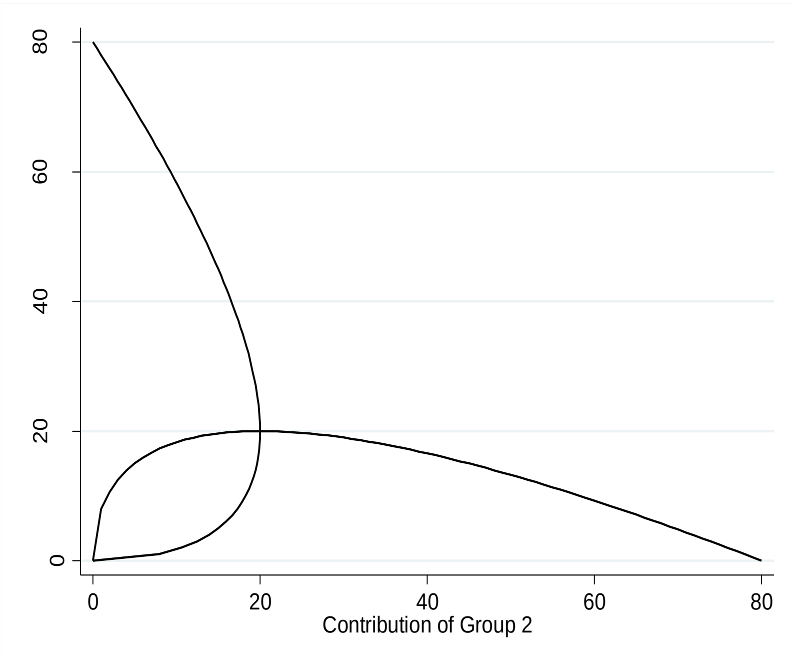

Figure 2. Average Contributions by Competing Pairs over time
(Independent Groups in VCM)

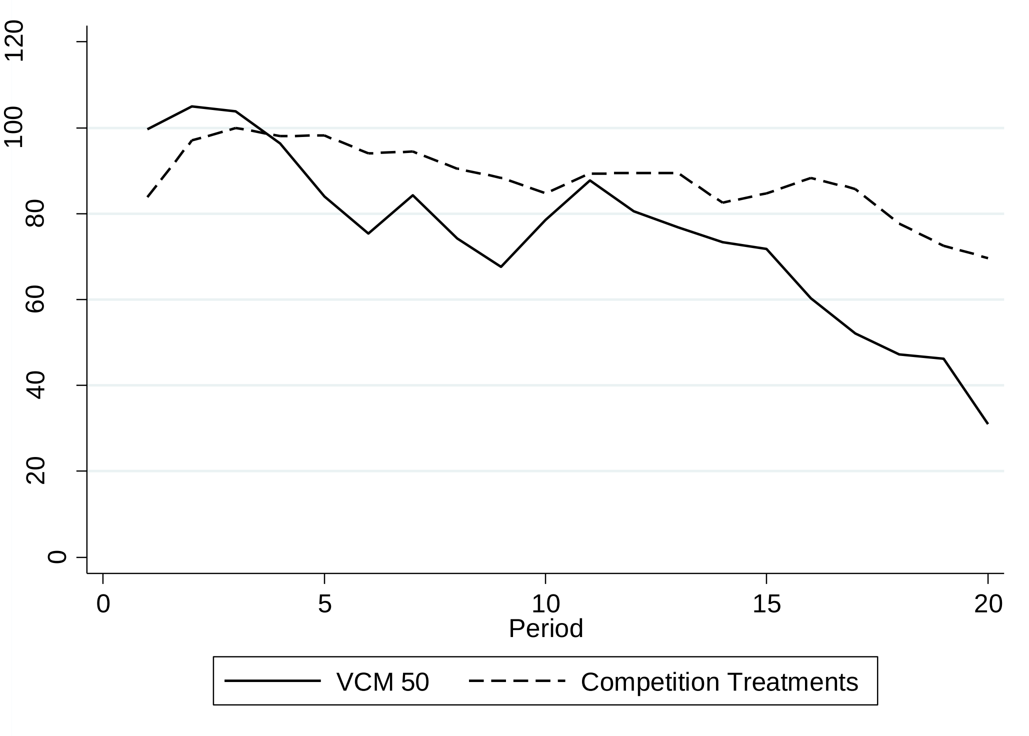

Table 2. Average Group Contributions by Competing Pairs

	Obs.	Rounds 1-5	Rounds 6-15	Rounds 16-20	All Rounds
VCM 50	12	97.73	77.03	47.33**	74.78
		(44.08)	(50.89)	(48.13)	(45.99)
Competition	32	95.42	88.76	78.79**	87.93
		(18.98)	(25.05)	(28.27)	(22.62)

Notes: Figures in parentheses are standard deviations. The unit of observation in VCM-50 is an independent group instead of a pair. A ** superscript indicates that the values are pairwise significantly different from each other at the 5% level (Wilcoxon z = -2.438, p = 0.0148).

Table 3. Proportion of Free Riders

	Rounds 1-5	Rounds 6-15	Rounds 16-20	All Rounds
VCM 50	0.20	0.31	0.53	0.34
Competition	0.13***	0.16***	0.22***	0.17***

Table 4. Average Group Contributions by Competing Pairs: By Treatment

Treatment	Obs.	Rounds 1-5	Rounds 6-15	Rounds 16-20	All Rounds
VCM 50	12	97.73	77.03	47.33	74.78
		(44.08)	(50.89)	(48.13)	(45.99)
Comp 50-50	8	93.26	89.37	75.55*	86.89
		(20.64)	(22.91)	(19.83)	(20.50)
Comp 45-55	8	95.53	88.78	82.06*	88.79
		(22.02)	(28.41)	(35.75)	(26.91)
Comp 40-60	8	102.96	99.14	87.74**	97.25
		(17.45)	(25.47)	(30.66)	(22.89)
Comp 20-80	8	89.93	77.73	69.8	78.79
		(16.59)	(23.15)	(26.86)	(20.01)

Notes: Figures in parentheses are standard deviations. The unit of observation in VCM-50 is an independent group instead of a pair. A ** superscript indicates that the value is pairwise significantly different at the 5% (* = 10%) level - Wilcoxon ranksum test - from the VCM group contribution of 47.33 tokens in the last five rounds.[7]

[7] We do not find significant differences in the aggregate contributions of pairs across competition treatments.

Table 5. Individual Regressions for all subjects: Rounds 16 – 20

	Contributions	Percentage Contributions
Comp 50-50	10.046*	19.618*
	(5.205)	(10.419)
	[0.054]	[0.060]
Comp 45-55	11.087*	19.876
	(6.139)	(12.200)
	[0.071]	[0.105]
Comp 40-60	14.139**	29.217**
	(5.865)	(11.532)
	[0.016]	[0.011]
Comp 20-80	8.235	15.006
	(6.102)	(11.818)
	[0.177]	[0.204]
Female	-2.089	-3.306
	(2.654)	(4.514)
	[0.431]	[0.464]
International	-2.989	-5.182
	(2.108)	(4.782)
	[0.156]	[0.279]
Experienced	0.285	-4.693
	(2.591)	(5.063)
	[0.912]	[0.354]
Age	0.014	0.135
	(0.183)	(0.333)
	[0.940]	[0.685]
Constant	18.069***	36.486***
	(6.600)	(13.028)
	[0.006]	[0.005]
Obs.	1140	1140
Clusters/pairs	44	44

Notes: Figures in parentheses are robust standard errors clustered on independent pairs of competing groups. Figures in brackets are p-values for the two-sided tests of significance.

Table 6. Average Group Contribution by Poor and Rich Groups: Rounds 16-20

	Obs.	"Poor"	"Rich"	Combined
VCM 50	12	-	-	47.33
				(48.13)
Comp 50-50	16	-	-	75.55*
				(39.00)
Comp 45-55	8 + 8	69.98	94.15**	82.06*
		(30.55)	(49.29)	(41.54)
Comp 40-60	8 + 8	82.08*	93.4**	87.74**
		(30.64)	(48.05)	(39.36)
Comp 20-80	8 + 8	30.1	109.5**	69.8
		(18.40)	(50.28)	(54.94)

Notes: Figures in parentheses are standard deviations. The unit of observation in VCM-50 is an independent group instead of a pair. A superscript of ** (*) indicates that the value is pairwise significantly different at the 5% (10%) level - Wilcoxon ranksum test - from the VCM group contribution of 47.33 tokens in the last five rounds

Table 7. Average Percentage Contribution by Poor and Rich Groups: Rounds 16-20

	Obs.	"Poor"	"Rich"	Combined
VCM 50	12	-	-	31.56
				(32.09)
Comp 50-50	16	-	-	50.37*
				(26.00)
Comp 45-55	8 + 8	51.83	57.06*	54.45*
		(22.63)	(29.87)	(25.75)
Comp 40-60	8 + 8	68.39**	51.89*	60.14**
		(25.53)	(26.69)	(26.63)
Comp 20-80	8 + 8	50.17	45.63	47.89
		(30.67)	(20.95)	(25.48)

Notes: Figures in parentheses are standard deviations. The unit of observation in VCM-50 is an independent group instead of a pair. A superscript of ** (*) indicates that the value is pairwise significantly different at the 5% (10%) level - Wilcoxon ranksum test - from the VCM group percentage contribution of 31.56% in the last five rounds.

Table 8. Individual Regressions for poor and rich subjects separately: Rounds 16 – 20

	Poor if inequality		Rich if inequality	
	Contributions	**Percentage Contributions**	**Contributions**	**Percentage Contributions**
Comp 50-50	9.924*	19.607*	9.775*	19.351*
	(5.275)	(10.618)	(5.317)	(10.598)
	[0.060]	[0.065]	[0.066]	[0.068]
Comp 45-55	4.672	14.508	14.764**	23.381*
	(5.714)	(11.854)	(6.939)	(13.076)
	[0.414]	[0.221]	[0.033]	[0.074]
Comp 40-60	11.651**	36.654***	15.629**	20.633
	(5.698)	(12.426)	(7.154)	(12.927)
	[0.041]	[0.003]	[0.029]	[0.110]
Comp 20-80	-7.725	13.200	20.697***	13.366
	(5.347)	(14.728)	(7.738)	(12.462)
	[0.149]	[0.370]	[0.007]	[0.283]
Female	-1.618	-3.164	-0.762	-0.362
	(2.152)	(4.949)	(3.071)	(5.445)
	[0.452]	[0.523]	[0.804]	[0.947]
International	-3.539	-4.989	-5.352*	-11.391**
	(2.601)	(6.082)	(3.241)	(5.637)
	[0.174]	[0.412]	[0.099]	[0.043]
Experienced	-3.779	-10.132*	0.511	1.141
	(2.595)	(5.747)	(3.265)	(6.014)
	[0.145]	[0.078]	[0.876]	[0.850]
Age	-0.156	0.053	0.019	-0.025
	(0.173)	(0.377)	(0.194)	(0.351)
	[0.928]	[0.887]	[0.923]	[0.943]
Constant	21.925***	42.194***	18.946***	39.376***
	(6.589)	(13.894)	(7.107)	(13.573)
	[0.001]	[0.002]	[0.008]	[0.004]
Obs.	780	780	780	780
Clusters/pairs	44	44	44	44

Appendix

Table A1 Individual contributions and winning history
(Panel Random Effects with standard errors clustered on independent pairs):
Excluded category: Comp 50-50

	Dependent variable	
	Contributions	**Percentage Contributions**
Lag Pct Wins	0.323***	0.656***
	(0.121)	(0.236)
	[0.008]	[0.006]
Comp 45-55	11.887	34.407*
	(9.285)	(18.378)
	[0.200]	[0.061]
Lag Pct Wins 45-55	-0.187	-0.612*
	(0.173)	(0.338)
	[0.278]	[0.070]
Comp 40-60	11.074	45.047*
	(10.610)	(23.129)
	[0.297]	[0.051]
Lag Pct Wins 40-60	-0.128	-0.686
	(0.203)	(0.426)
	[0.528]	[0.108]
Comp 20-80	-3.144	24.156
	(7.670)	(16.231)
	[0.682]	[0.137]
Lag Pct Wins 20-80	0.055	-0.512**
	(0.159)	(0.261)
	[0.729]	[0.050]
Female	-3.485	-6.294
	(2.381)	(4.528)
	[0.143]	[0.165]
International	-1.986	-1.793

	(2.129)	(5.062)
	[0.351]	[0.723]
Experienced	0.741	-3.321
	(2.718)	(5.318)
	[0.785]	[0.532]
Age	0.268	0.619**
	(0.167)	(0.315)
	[0.109]	[0.049]
Constant	5.338	9.416
	(9.231)	(18.256)
	[0.563]	[0.606]
Obs.	960	960
Clusters/pairs	32	32

Table A2 Proportion of free-riding by treatment (Poor and Rich groups combined in the inequality treatments)

Treatment	Rounds 1-5	Rounds 6-15	Rounds 16-20	All Rounds
VCM 50	0.20	0.31	0.53	0.34
Comp 50-50	0.14	0.16***	0.21***	0.17***
Comp 45-55	0.12**	0.15***	0.21***	0. 16***
Comp 40-60	0.09***	0.12***	0.22***	0.14***
Comp 20-80	0.15	0.20***	0.23***	0.19***

Table A3. Proportion of free-riding by poor and rich groups by treatment

Treatment	Rounds 1-5		Rounds 6-15		Rounds 16-20		All Rounds	
VCM 50	0.20		0.31		0.53		0.34	
Comp 50-50	0.14		0.16***		0.21***		0.17***	
Comp 45-55	0.12**	0.12**	0.18***	0.13***	0.25***	0.20***	0.18***	0.14***
	[1.0000]		[0.1250]		[0.1556]		[0.0627]	
Comp 40-60	0.08***	0.11**	0.09***	0.16***	0.15***	0.28***	0.10***	0.18***
	[0.3709]		[0.0181]		[0.0122]		[0.0005]	
Comp 20-80	0.24	0.07**	0.29	0.10***	0.28***	0.18***	0.28**	0.11***
	[0.0002]		[0.0000]		[0.0459]		[0.0000]	

Notes: In the inequality treatments, the first number in each block (i.e., column) is for the "poor" groups and the second number is for the "rich" groups. Stars indicate significance of difference from the corresponding VCM figure in that block (column). Figures in brackets are p-values for tests of differences in the proportion of free-riding between the poor and the rich in that block (column).

Table A4. Final earnings in each competing pair (excludes the show-up fee)

Pair	Poor	Rich	Share of poor (%)
Competition 45 - 55			
1	4167	5992	41.02
2	4893	5224	48.36
3	4701	5918	44.27
4	4811.5	4611	51.06
5	3697.5	6025.5	38.03
6	4377.5	6722.5	39.44
7	4787.5	5659	45.83
8	3748	6071	38.17
Average	4397.88	5777.88	43.27
Competition 40 - 60			
1	4512	5212.5	46.40
2	3722.5	6252.5	37.32
3	3529	7260	32.71
4	4252.5	6408	39.89
5	4556	5162.5	46.88
6	3905	6655	36.98
7	4617.5	6090.5	43.12
8	4875	5749	45.89
Average	4246.19	6098.75	41.15
Competition 20 - 80			
1	2208	8410	20.79
2	2022	7976	20.22
3	1618	8181.5	16.51
4	2280	8202.5	21.75
5	3080	6541.5	32.01
6	2368	7627.5	23.69
7	1276	8174	13.50
8	1992.5	7850	20.24
Average	2105.56	7870.38	21.09