Rent Seeking in Groups*

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Abstract

Rent-seeking contests between groups involve conflicts of interests at the levels of individuals, groups, and the society as a whole. We conduct a series of economic experiments to study the behavior of groups and individuals competing against each other in rent-seeking contests. We find substantial over-contribution to rent-seeking relative to the equilibrium predictions of standard models regardless whether individuals compete against other individuals, groups compete against other groups, or individuals compete against groups.
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1 Introduction

"Rent-Seeking" is a common activity in which individuals, firms, cities and states compete to obtain some benefit from a governmental or quasi governmental source that range from monopoly rights for operating a cable franchise, a contract for building airplanes for the armed forces, to protectionist tariffs levied on foreign competitors. Many rent-seeking contests involve individuals competing against individuals but others involve competition between groups including situations in which groups compete against individuals. As an example, in the spectrum license auctions conducted by the Federal Communications Commission, multiple companies often form partnerships or consortia to pool their resources and compete against other consortia as well as individual firms.

When groups are involved in a rent seeking contest this adds some interesting elements of a public goods game but with some interesting differences. In a classic public goods game, there is a conflict between individual self-interest and social welfare such that individuals seeking to maximize their own self-interest would generate low contributions while maximizing social welfare requires higher contributions. The conflicts are more complicated in the

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rent seeking context. When only individuals are competing there is still a conflict between individual optimality and social welfare but in the opposite direction of the public goods case. Individuals wish to contribute high enough to secure the prize while society is actually best off with low or even no contributions. When teams are competing to win the prize there is a standard public goods dilemma inside of each group but then there is also the social welfare concern at the level of the entire society. Specifically, individual self interest in this case suggests contributing little and free-riding on group members. Group interest suggests contributing high so your group wins, while maximizing social interest would involve neither group expending resources in the competition. This leads to an interesting difference from the standard public goods dilemma because now the incentives for maximizing individual self-interest and social welfare are actually aligned, though imperfectly.[1] Examining how social welfare changes based upon rent seeking competitions occurring between individuals versus between groups then may demonstrate substantially different properties. This study will use economic experiments to examine this issue of how individuals respond to differing group sizes and how this effects overall social welfare. We are particularly interested in the cases in which competing groups are of different sizes. Game theoretic analyses show that, other things being equal, the smaller group is advantaged against a larger group in the sense that the smaller group induces more aggregate rent-seeking efforts from its members. However, this has never been tested in controlled experiment.

The standard rent seeking game was first discussed by Tullock (1967) and then given a fuller theoretical exposition in Rogerson (1982).[2] Several more recent studies have extended these models to examine the impact of within-group sharing rules on the level of rent-seeking with a general conclusion that even when groups use sharing rules that encourage contributions for group rent-seeking, the overall level of rent-seeking is lower in group competition than in individual competition. See for example Lee (1995), Baik and Lee (1997), Lee and Kang (1998), Gürtler (2005) and Baik, , and Shogren (1995). Our experimental setup is most closely associated with Nitzan (1991) which extends the standard rent seeking model to allow for competition between asymmetrically sized groups.

There are several early experimental studies examining predictions of rent seeking models in laboratory experiments such as Millner and Pratt (1989), Millner and Pratt (1991), Shogren and Baik (1991) and Davis and Reilly (2000). These generally focus on the degree and conditions for rent-dissipation. Most of the extant experimental literature has looked at the individual, rather than a group, as the economic actor in rent-seeking contests but there is a literature on group interaction. Davis and Reilly (2000) utilizes groups of rent defenders competing against individual rent-seekers and Abbink, Brandts, Herrmann, and Orzen (2007) examines the effects of intra-group punishment options.

Social-psychologists have conducted various types of experiments of group competition utilizing matrix form games, see for example Bornstein and Ben-Yossef (1994), Insko et al. (1992) and Insko et al. (1994), and generally find a 'discontinuity effect' in which group are more competitive than individuals. Among them, Bornstein, Winter, and Goren (1996) and

[1] Bornstein (2003) provides an excellent review of the interest alignment between individuals, groups and the larger society in diverse game settings. The group size asymmetry of interest in our study is not discussed.

[2] We note that Krueger (1974) first used the term "rent-seeking" to refer to these socially wasteful activities.

Gunnthorsdottir and Rapoport (2006) present perhaps the most similar approaches to ours but Gunnthorsdottir and Rapoport (2006) focusses on examining equal vs. proportional sharing rules while Bornstein, Winter, and Goren (1996) utilizes a substantially simpler environment which lacks some of the richness allowed in our more general framework.

There is also a literature on behavior of individuals and groups in tournaments as well as in auctions such as Fonseca (2009), Cox and Hayne (2006), Hayne and Cox (2005), Nalbantian and Schotter (1997), Bull, Schotter, and Weigelt (1987), Orrison, Schotter, and Weigelt (2004) and Sutter, Kocher, and Strauß (2009). Tournament games are mathematically the same as rent seeking games though they typically have different motivations. Several of the above mentioned research features groups competing against groups, but none except, Davis and Reilly (2000) studies competition among asymmetrically sized groups. The current paper contributes by studying group dynamics in rent-seeking competition by varying the size of the group as well as including the competition between groups of different sizes.

Our focus will be explicitly on the group dynamics, i.e., how the individuals' choices vary in response to different configurations of their own and their rival group. We compare individual contests, group contests, and mixed contests in which a single player competes against a group of five players. We compare the behavior players in these contests against equilibrium game-theoretic predictions, socially optimal benchmarks, and against more informal disequilibrium conjectures which can be derived from years of observation of behavior in public goods experiments.

An important part of our story as it unfolds is the necessity for individuals to deal with a dual level strategic problem: each individual must not only consider the "game" being played by members of his own group, but also the "game" being played by members of the other rent-seeking rival groups.

2 Theory

We will construct a standard model of rent seeking between groups of potentially uneven sizes which is similar to that of Nitzan (1991).[3] Let R be the value of the franchise or prize that the two groups are competing to win. We will use G_i to indicate the group that player i is in and g_i the size of that group. G_{-i} will refer to the rival group for player i. All individuals in both groups will simultaneously choose some amount to contribute towards the rent seeking endeavor, $x_i \in [0, \overline{X}]$. The probability of winning for the group of player i is simply the ratio of the total contributions of their group to the total from both groups, or $p_i = \sum_{j \in G_i} x_j / \left(\sum_{j \in G_i} x_j + \sum_{j \in G_{-i}} x_j \right)$. We will assume that the prize will be divided evenly among all members of the winning group. Consequently the problem for each individual is given by equation 1.

[3] We do note that Abbink, Brandts, Herrmann, and Orzen (2007) uses a model virtually identical to ours and the one developed in Nitzan (1991) which leads them to a base experimental design quite similar to ours. Their main interest though was in the tendency of subjects to utilize a punishment option and how this effects contributions thus the focus of the analysis in the two papers is different.

$$\max_{x_i} \frac{R}{g_i}\left(\frac{\sum_{j\in G_i} x_j}{\sum_{j\in G_i} x_j + \sum_{j\in G_{-i}} x_j}\right) - x_i \tag{1}$$
$$st \qquad x_i \leq \overline{X}$$

There will be many asymmetric and mixed strategy equilibria in this game, but for the purposes of establishing a benchmark equilibrium, we will consider only symmetric pure strategy equilibria in which all members of a group contribute the same amount, x_i^*, and the members of the rival group also contribute (a perhaps different) common amount, x_{-i}^*. This gives rise to the solution shown in equations 2 and 3.

$$x_i^* = R\left(\frac{g_{-i}}{g_i(g_i+g_{-i})^2}\right) \tag{2}$$
$$x_{-i}^* = R\left(\frac{g_i}{g_{-i}(g_i+g_{-i})^2}\right) \tag{3}$$

Note that in this setting contributions to rent-seeking represent purely wasteful activity from a social standpoint. Consequently, social welfare is trivially maximized when there are no contributions assuming prize is still awarded. As equations 2 and 3 show, the equilibrium contributions among the members of a group are strictly positive unless if the rival group has 0 members. Thus, some level of social waste due to rent-seeking is always expected in rent-seeking contests.

Based upon these equilibrium contribution levels, it is useful to note a few comparative static results. An obvious one is that contributions are decreasing in own group size as shown in equation 4. A more interesting effect is that not only do the contributions of individual group members decrease as the number of members increase but the sum of contributions by the group decreases as the group size increases as shown by equation 5. This shows the public good aspect of team contributions. Were all individuals to consider the team itself as a single entity then they would just divide the contribution level for a group of size one among themselves. Instead, they drop their contributions by even more than that amount showing a standard free-rider effect. The final comparative static concerns an individual's reaction to a change in group size by the rival group. This is shown in equation 6 and the sign of it is indeterminate. If the size of i's group is larger than the rival group then contributions increase as the rival group size increases. If, however, the rival group is already larger then as that rival gets even larger i decreases his contributions.

$$\frac{\partial x_i^*}{\partial g_i} = \frac{-g_{-i}R\left(3g_i+g_{-i}\right)}{g_i^2(g_i+g_{-i})^3} < 0 \tag{4}$$
$$\frac{\partial (g_i x_i^*)}{\partial g_i} = \frac{-2g_{-i}R}{(g_i+g_{-i})^3} < 0 \tag{5}$$
$$\frac{\partial x_i^*}{\partial g_{-i}} = \frac{R(g_i-g_{-i})}{(g_i+g_{-i})^3\, g_i} < 0 \text{ if } g_i < g_{-i} \tag{6}$$

	Sessions	Subjects Per Session	Total Subjects	Indep Groups	Phase 1	Phase 2
Baseline	2	16	32	8	1V1	1V1
AG	3	18	54	9	1V1	1V5
SG	4	20	80	8	1V1	5V5
RAG	2	18	36	6	1V5	1V1
Total	11	–	202	31	-	-

Table 1: Details on sessions conducted.

3 Experiment Design

Our experiments are designed as a test of the predictions of the model outlined above. Our main interest is in the comparative statics regarding how subjects shift behavior when the size of their group changes and when the size of their rival group changes. What we are particularly interested in is whether group members will be able to solve their in-group social dilemma by contributing above the Nash equilibrium or whether the paired rival groups will be able to overcome their social dilemma by tacitly agreeing to decrease rent-seeking levels below the equilibrium benchmarks.

Towards this end, we have conducted a set of experiments with four treatments. Each treatment has two phases. In the first phase of three of the four treatments, each subject competes against another individual. This first phase lasts for 15 periods. In the second phase of our Baseline treatment, subjects are re-matched to another subject and they again play the rent seeking game for 15 rounds. In the Symmetric Groups (SG) treatment, subjects are placed in groups of five and then matched with another group of five to play the rent seeking game for 15 periods. In the Asymmetric Groups (AG) treatment, one group consists of five members and they compete against a single individual for 15 rounds. The idea behind these treatments is that they allow us to clearly assess how contributions change moving from the base 1V1 condition to either a restart of that condition or to cases in which groups sizes adjust in a symmetric or asymmetric manner. Our fourth treatment reversed the Asymmetric Groups treatment (RAG) and so the experiments began with subjects playing 1V5 games for 15 rounds and were then switched to 1V1 games for the final 15 rounds. Table 1 shows the numbers of sessions, subjects and independent groups we have for each treatment.

A key component of the experiment design is in how the groupings were dealt with between phases. Inside of a phase, groupings and pairings were held constant as a parallel of the classic Public Goods literature. Our intention was to examine which (if either) social dilemma groups would solve and so the fixed groupings/pairings was essential. Re-assignments of groups and re-pairing of rival groups was done to maximize the number of independent samples we were able to achieve. In the Baseline treatment, you can imagine us splitting each session into 4, 4-person cells. For the first 15 rounds subjects were matched inside those 4-person cells and then for the second 15 rounds, subjects were re-matched with someone else inside of that 4-person cell (e.g. subject pairings might be (1,2) and (3,4) for the first phase and then (1,4) and (2,3) for the second). Since we conducted 2 sessions with 16 subjects each, that gives us a total of 8 completely independent cells or groups

	1V1	1V5		5V5
		Small	Big	
Individual Contributions	250	139	5.6	10
Group Total	250	139	28	50
Probability of Winning	50%	83%	17%	50%
Total Contributions	500	167		100
Rent Dissipation	50%	16.7%		10%

Table 2: Benchmark equilibrium predictions from one-shot game.

for statistical purposes. In the other treatments, subjects were divided into similar cells of either 10 or 6 subjects in which all pairings/groupings were contained. This means that each 10 or 6 person cell in those treatments were independent from the other subjects in those sessions. All subjects were identified anonymously and subjects were only informed that their pairings/groupings would be constant inside of a phase and be changed for the second phase. This segmenting of the population was not explained and they would for example have no way of knowing or determining that their rival from the first phase was now a group member in the second phase or vice versa.[4]

In the experiment, we used a fixed size of the prize of 1000 ECUs in all rounds. Assuming this value for R and plugging in the appropriate group sizes to equations 2 and 3, we can derive our benchmark equilibrium predictions for the stage game played each round for each of the three configurations.[5] These values can be found in table 2 and a graphical overview of the comparative statics derived formally in equations 4-6 can be found in figure 1. Note that in all cases the social optimum would be for all subjects to contribute 0 since the prize was awarded randomly with each group having equal probability of winning in that case. Alternatively, the group optima would involve the five person groups to contribute such that the total group contribution level matched that of the single person group contribution level of 250. That would break down to 50 per subject were they to divide it evenly. Since the phases are repeated for a finite and known period of time these stage game equilibria can also be supported by appropriately defined strategies in the repeated game. While we do note again that there will be other asymmetric equilibria, mixed strategy equilibria and other equilibria which could be derived based on the repeated game structure, we will use these stage game symmetric equilibria as our benchmark predictions as a means of organizing and interpreting the contribution levels we see in the data.

Because of the fact that subjects would almost certainly make losses in at least some periods we started all subjects with an initial balance of 2500 ECUs. Due to the possibility that subjects might sustain enough losses so as to have negative overall earnings we had to enforce some rules regarding how to deal with bankruptcies. The rule we used is that subjects whose earnings went negative once were reset to a new balance of 2500 ECUs while the second time a subject went bankrupt they were removed from the experiment and would

[4] A complete set of instructions can be found in an Appendix.

[5] In all treatments and rounds we did implement a maximum contribution of 2000 ECUs which is twice the size of the prize. This should not have limited any intentional choices by the subjects but was used to prevent accidental choices of too large a magnitude. We observed only 5 choices at this upperbound and only 12 above 1000 out of over 6000 total observations.

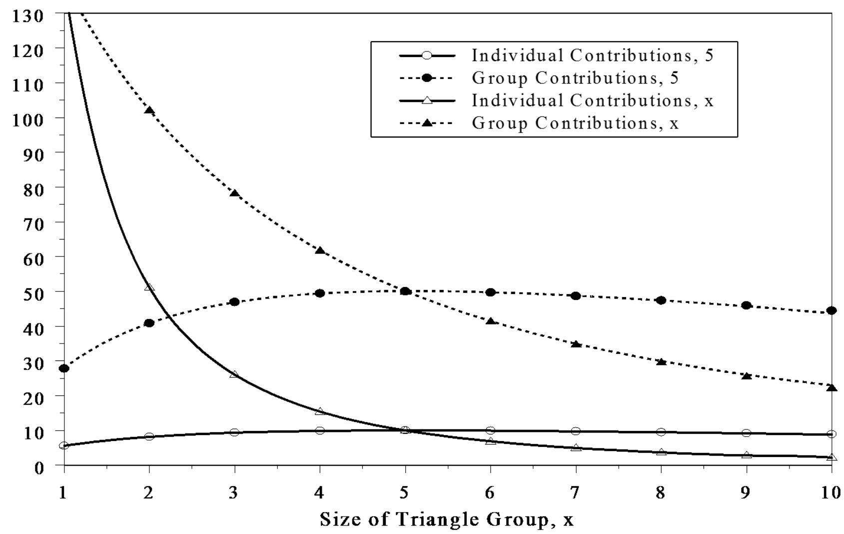

Figure 1: Individual and group equilibrium contributions assuming one group is of $n = 5$ and the other has a group size which varies along the x axis.

leave with their fee for showing up. Only one of our subjects did in fact go bankrupt twice[6] while 24 (out of 202 total subjects) went bankrupt once with 75% coming from the SG and RAG treatments. While it is possible that the rules indemnifying the first bankruptcy could have generated more aggressive contributions than we would otherwise observe, evidence will be shown in the results section suggesting that was unlikely to be the case.

The experiments were conducted using a computer interface programmed using ztree, Fischbacher (2007). After each round subjects were reminded of their own contribution, informed of the total contributions from their own and their rival group and shown how those contributions generated a probability for their group winning. They were also informed if they won or lost as well as their own net earnings for the round. Subjects received $10 for showing up on time and their earnings in ECUs translated into dollars at the rate of 4 ECUs=$0.01 making the 1000 ECU prize per round equal to $2.50. Each session lasted an hour to an hour and a half. We used a total of 202 subjects. Their total compensation including show-up fee ranged from a minimum of $10 to a maximum of around $48 with an average of approximately $25.

4 Results

In examining the outcomes from the experiments we will first examine the data using general summary statistics to determine how well the equilibrium predictions perform at that level

[6] In this case, the session continued with the bankrupt subject replaced by a randomly choosing robot. This was done to allow the other subjects to continue to accrue the rest of the money for the session. We have chosen to not only remove the data during the periods using a robot subject from the presentation but we have removed all the data from all periods/groups in which that twice bankrupt subject was included. This choice does not alter any of the results presented in the paper and we chose to present the version of the results with this data excluded.

and to examine how overall social welfare and efficiency changes with group size. We will then move on to examining the behavior on a more detailed statistical basis to generate formal results.

4.1 Summary Statistics

The general summary statistics for the key variables are shown in table 3. For the two asymmetric treatments we have separated out the subjects who will be in the big groups from the small groups during the asymmetric phase even for the 1V1 Phase to allow for a more precise demonstration of the behavioral comparative static. Although subjects were randomly assigned to these roles, given the sample size it is still possible that differences in observed behavior are due in part to some degree of individual heterogeneity. By separating these groups out it makes it easier to observe whether this appears to be the case.

There are a number of ways one might want to examine these data. The first comparison would be to the stage game equilibrium benchmarks which were shown in table 2. In the 1V1 cases, the prediction is that subjects should invest 250 ECUs each and the data show that the subjects contribute well over 300 in all cases and over 500 in the 1V1 phase of the RAG (i.e. periods 16-30). In the 5V5 phase of the SG treatment, all subjects should be contributing 10 ECUs while the data shows them contributing over 5 times that amount. This happens to coincide with the benchmark prediction of the group optimal level of contribution. In the asymmetric treatments, the subject competing as an individual should contribute 139 while the data shows them contributing 333.60 and 577.58 while members of their rival group should each only contribute 5.6 and they end up contributing over 70. Even without statistical tests (whose results will be presented later), it should be clear that there is substantial evidence of over-contribution relative to the benchmark Nash equilibrium. In the SG treatment these over-contributions are almost exactly at the level one would expect were the subjects engaged in equilibrium play and fully valuing the return on their contributions to their fellow group members. Based on the level of over-contribution in all other conditions, though, it would seem premature to conclude that this is evidence of behavior aimed at maximizing group welfare.

It would not be premature to conclude that the subjects are not behaving in a manner so as to maximize total social welfare. In a standard Public Goods game over-contribution relative to Nash levels enhances social efficiency but in this case over-contribution impairs it. In the RAG treatment, contributions go so high as to dissipate almost 100% of the rents in the asymmetric phase and most cases show rent dissipation in the 70% range. The theoretical prediction is that the most rent should be dissipated in the 1V1 arrangement and the least in the 5V5. The SG treatment does show that rent dissipation decreases from 72% to 51% in moving from the 1V1 phase to the 5V5 phase, but this is still far above the predicted values of 50% and 10%. There is also a predicted drop from 1V1 to 1V5 which is not observed. In the AG treatment, rent dissipation is 68% in the 1V1 and 67% in the 1V5 instead of 50% and 16.7% as predicted. In the RAG treatment, we find a 96% rent dissipation for the 1V5 case and then 76% for 1V1 which moves in the opposite of the predicted direction. What this means is that there are substantial welfare consequences due to the over-contribution observed in this environment.

To help compare the results across treatment and across time figures 2-4 show the

	Periods	Baseline Small	AG Small	AG Big	SG Small	SG Big	RAG Small	RAG Big
Ind	**1-15**	336.93	400.16	325.14	360.52	-	577.58	76.40
Contrib	**16-30**	348.13	333.60	67.98	-	50.79	504.76	356.49
Group	**1-15**	336.96	400.16	325.14	360.52	-	577.58	382.02
Total	**16-30**	348.13	333.60	339.92	-	253.93	504.76	356.49
Prob of	**1-15**	.50	0.55	0.45	.50	-	0.60	0.40
Win	**16-30**	.50	0.495	0.505	-	.50	0.59	0.41
Total	**1-15**	673.85	675.28		721.04		959.60	
Contrib	**16-30**	696.26	673.52		507.87		762.40	
Rent	**1-15**	0.67	0.68		0.72		0.96	
Dissip	**16-30**	0.70	0.67		0.51		0.76	

Table 3: Basic summary statistics on contributions. Note that in both asymmetric treatments there are columns for “small” and “big” which refer to the size of group those individuals are in during the asymmetric phase.

average individual contributions per period for the SG, AG and RAG treatments compared to the Baseline treatment. In the RAG and AG figures we have again separated out the data for those who will be in the groups of differing sizes even for the 1V1 phase of those sessions to help determine if there were subject specific differences which may account for the differences once they are assigned to groups of differing sizes. The clear point in the SG and AG figures is that the behavior in the 1V1 phase is equivalent across all three treatments and that in the Baseline behavior does not change much between the first 15 and last 15 periods. Further, in the AG treatment these subjects in the single person groups during the 1V5 phase do not adjust their contributions much from the 1V1 phase. In the SG treatment when subjects move to 5 person groups, the subjects show an immediate and substantial drop with a slow decay after that point and this is matched almost exactly in the members of the large groups in the 1V5 AG treatment. The RAG treatment shows substantially different behavior. Recall that in this treatment subjects began in a 1V5 phase and the small group subjects contributed substantially above the level of the Baseline 1V1 case and the small group subjects in the AG treatment. The members of the big groups, however are evidencing a roughly similar pattern to the other 5-member groups. Then in the 1V1 phase of the RAG treatment, those who were members of the small groups do not appear to drop back down to the level of other subjects in the 1V1 phase while those who were members of the large groups do converge to the standard behavior. Statistical characterization of these properties will be established in the next section.

4.2 Statistical Analysis

To provide a finer statistical characterization of the results on individual contributions we present several different regression based analyses of the choice data. The first set of regressions are aimed at identifying any effects due to treatment differences and is contained in table 4. That table contains two specifications one including all data and one limited to only the data from decisions in large groups to better isolate differences across those cases.

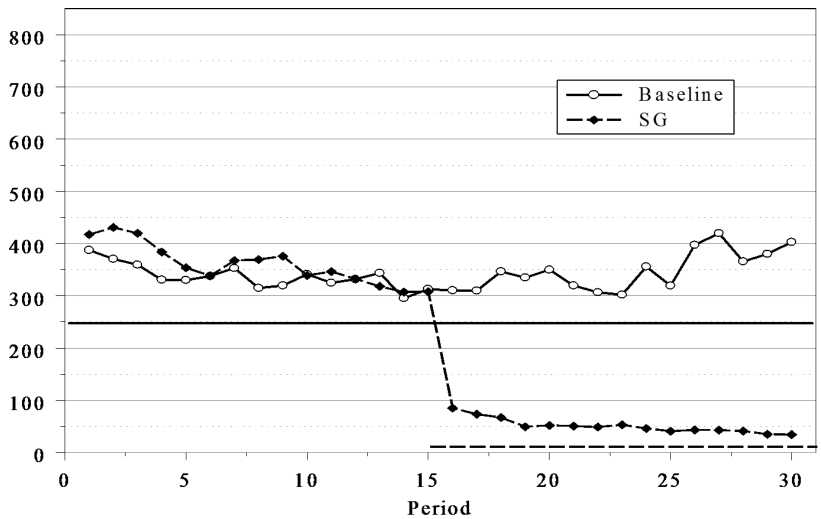

Figure 2: Average individual contributions over time in the Baseline and Symmetric Groups treatments. Solid line is equilibrium prediction for 1V1 phases while dashed line is for the 5V5 portion of the SG treatment.

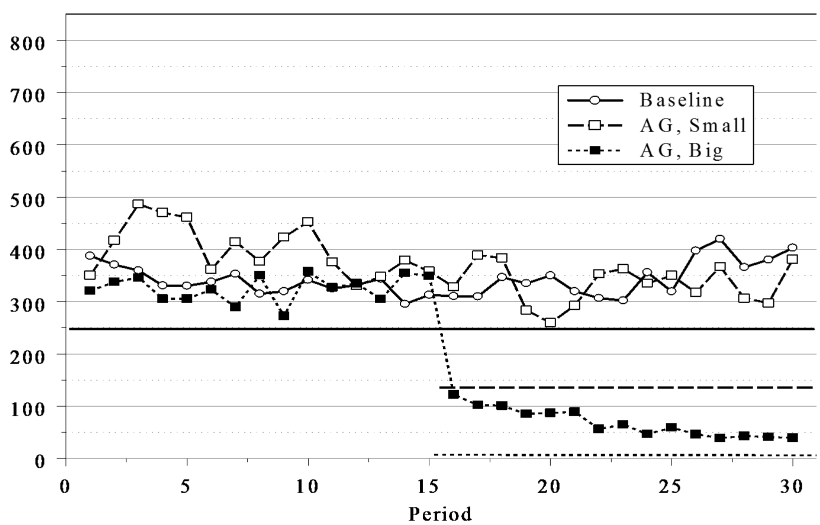

Figure 3: Average individual contributions over time in the Baseline and Asymmetric Groups treatments. Solid line is equilibrium prediction for 1V1 phases while long dashed line is the prediction for the small group in the 1V5 phase and the short dashed line is for the large group.

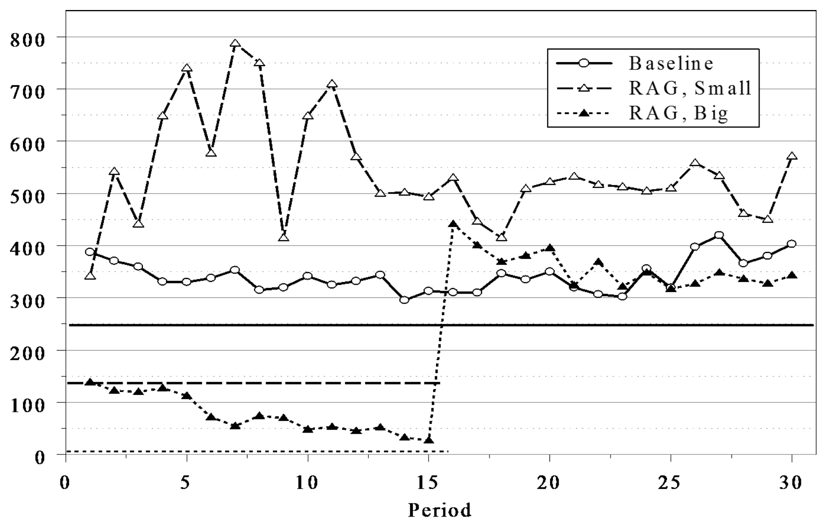

Figure 4: Average individual contributions in the Baseline and Reverse Asymmetric Groups treatments. Solid line is equilibrium prediction for 1V1 phases while long dashed line is the prediction for the small group in the 1V5 phase and the short dashed line is for the large group.

The fundamental specification is the same in both and involves regressing contributions on dummy variables that identify different treatments, phases and groups. The regressions are performed using pooled OLS with robust standard errors clustered by subject. In the regression using all data the coefficients can be interpreted as whether or not contributions in the indicated treatment/population segment differs from the contributions found in Phase 1 of the Baseline treatment. In the regression using only the data from the large groups, the baseline comparison used is the contributions in Phase 2 of the SG treatment and so coefficients can be interpreted as indicating the degree to which behavior in other treatments differs from that reference point. The interpretation of these four regressions will be explained through a series of results.

Result 1 - *There is no statistically significant difference in contributions between any of the situations in which subjects are competing as individuals except for the first phase of the RAG treatment in which the individual subjects are matched against rival groups of size 5.*

This result is supported by the coefficients for the Small Groups variables in that they are almost all not significantly different from 0. The only significant coefficient among the Small Groups set is for the RAG treatment in phase 1. Note that this is the same configuration as in the second phase of the AG treatment but the contributions in the latter do not rise as high. This suggests that having initial experience of being a single person against a group leads to higher contribution levels than if you have initial experience of rounds with competing against an individual. The other interesting point is that in the AG treatment, there is no significant difference in contributions for the people in the $n = 1$ groups in phase 2 and the phase 1 contributions in the baseline case. Thus these subjects are not adjusting their contribution level as their rival group changes from an individual in

		All Data	Large Group Data
Small Groups	Baseline Phase 2	11.20	
		(25.33)	
	AG, Phase 1	0.712	
		(32.97)	
	SG, Phase 1	23.59	
		(31.72)	
	RAG, Phase 2	44.27	
		(44.01)	
	AG, Phase 2 Small	-3.327	
		(52.75)	
	RAG, Phase 1 Small	240.7***	
		(73.50)	
Big Groups	SG, Phase 2	-286.1***	-
		(26.25)	
	AG, Phase 2 Big	-268.9***	17.20
		(27.28)	(10.48)
	RAG, Phase 1 Big	-260.5***	25.62*
		(29.47)	(15.30)
	Constant	336.9***	50.79***
		(25.73)	(5.242)
	Observations	5760	2175
	Adjusted R^2	0.350	0.011

Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

Table 4: Pooled OLS regressions of contributions on main treatment effects with robust standard errors clustered by subject. Baseline Phase 1 data is the default comparison for All Data and Phase 2 SG is the default for the Large Group Data.

Phase 1 to a group of 5 in Phase 2.

We should note one perhaps confusing outcome which is the lack of significance in the coefficient on the RAG Phase 2 dummy variable. This is saying that on average in the 1V1 phase of the RAG treatment, subjects were not contributing differently than the 1V1 phases of the other treatments. Based on the line in figure 4 showing that the subjects who began as the single members against the large group were contributing well over the others, this might appear an odd result. The reason for the lack of significance though is that in the regression the decisions of these subjects are combined with those who began in the large groups and their behavior is not different from the other 1V1 phases and since there are more of these subjects this leads to the overall lack of significance. Were we to separate out those subjects in the RAG who began as the individuals matched against the large groups, we would find a significant difference. We refrained from presenting that specification to keep the presentation slightly more parsimonious.

Result 2 - *There is no statistically significant difference in contributions between SG Phase 2 and the members of large groups in AG phase 2 but there is a small, borderline significant increase among subjects in large groups during Phase 1 of the RAG treatment. In all cases though, individuals show decreased contribution levels when in groups of 5 rather than when playing as individuals.*

Again support for this is straightforward to find in table 4. In the regressions including all data, the dummy variables for the different $n = 5$ cases are significant, large (in absolute value) and negative indicating the drop from the baseline 1V1 condition. In the $n = 5$ data only regressions, the dummy variable for the big group members in Phase 2 of the AG is insignificant but the coefficient for the counterparts in the RAG is borderline significant (actual $p-$value=0.096). So while there may be some small increase in contributions in the RAG treatment, it is not large and in general members of the large groups behave quite similarly when facing individuals or other large groups.

For investigating behavior of the subjects at a more detailed level to understand how their behavior depends on past experience and not just the treatment alone we present another set of regressions better aimed at these questions. Table 5 provides a separate regression for each treatment with contributions regressed on various measures of prior experience of a subject. The underlying specification is pooled OLS with robust standard errors clustered by subject. The next several results will provide an interpretation of these regressions results.

Result 3 - *There are not strong temporal effects after controlling for subject responses to prior experiences.*

While the figures above do show time trends, careful regression analysis shows that these apparent time trends can be explained by forces other than simple time trends. In order to investigate these temporal effects, the regression contains a dummy variable indicating a 1 for the first five periods and another for the last 5. We find that there is no significant effect for the first five periods while in the Baseline and SG treatments there is an increase in contributions in the last few periods but this increase is not seen in the other two treatments.

Result 4 - *There is a substantial effect of inertia (or perhaps substantial individual heterogeneity) but relatively weak responses to past outcomes.*

The variables for an individual's own past contributions are included which can be thought of as measuring the inertia level in a subject's contributions or as a way of modeling individual heterogeneity. These variables turn out to be highly significant and to possess substantial coefficients indicating that subjects tend to maintain similar contribution levels from one period to the next. The other variables on prior experience have typically small and variable effects on contributions. For example, having won in the prior round has a positive effect in the Baseline treatment, negative in AG and insignificant in the other two. The effect of the contributions of a subjects fellow group members is negative in AG and RAG but positive in SG. The only consistent effect is in how an individual responds to the difference in contributions between themselves and their rival. If they are contributing less than their rival, they increase their contributions while when they were contributing more they decrease their contributions.

	Baseline	AG	SG	RAG
Phase 2	26.18***	-60.03***	-135.3***	33.85
	(8.759)	(21.63)	(16.63)	(26.50)
Own Contrib $t-1$	0.630***	0.611***	0.602***	0.712***
	(0.112)	(0.057)	(0.039)	(0.065)
Win $t-1$	31.83**	-28.80***	-1.547	-11.00
	(12.15)	(10.34)	(6.740)	(15.85)
Non-Own Team Contrib $t-1$	-	-0.127**	0.064***	-0.176***
		(0.049)	(0.022)	(0.060)
(Own) - (Opponents' Contrib) $t-1$	-0.099***	-0.071*	-0.101***	-0.142**
	(0.034)	(0.039)	(0.034)	(0.068)
(Team) - (Rival Team Contrib) $t-1$	-	0.118***	0.019	0.090**
		(0.038)	(0.022)	(0.037)
Periods 1-5	-16.03	-0.590	13.31	29.08
	(15.82)	(13.59)	(11.09)	(19.09)
Periods 26-30	50.10**	3.452	11.48***	-2.154
	(19.69)	(10.08)	(3.250)	(17.03)
Cash Balance $t-1$	-0.013***	-0.003	-0.002*	-0.010
	(0.003)	(0.003)	(0.001)	(0.006)
Bankrupt	-32.47	-19.29	-2.328	-29.03
	(24.61)	(19.03)	(11.30)	(32.15)
Constant	155.2***	160.6***	142.0***	138.7***
	(45.70)	(31.65)	(19.15)	(42.43)
Observations	928	1566	2030	1044
Adjusted R^2	0.373	0.531	0.640	0.560

Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

Table 5: Pooled OLS regressions using Contributions as the dependent variable with robust standard errors clustered by subject.

Table 5 contains two additional variables of importance which are a subject's Cash Balance at the end of the prior round and a dummy variable indicating whether or not they have previously gone bankrupt. The latter variable is insignificant in all cases indicating that subjects after a bankruptcy bid no differently from other subjects. The Cash Balance variable is one that is difficult to interpret. It is negative and significant in two treatments which might be taken as an indication that when subjects are getting close to bankruptcy they contribute more to implement that generous indemnity option included for first time bankruptcies. This effect is quite small though and is insignificant in the RAG treatment which generated the most bankruptcies while being largest in the Baseline treatment which generated only two bankruptcies. Interpreting this variable is made more difficult though by an endogeneity issue. Is it the case that a low cash balance is driving aggressive behavior or is the low cash balance due to the fact that the subject contributes aggressively? There is also another confound due to the fact that cash balance is potentially a time measure as well. Disentangling these issues is shown in Ham, Kagel, and Lehrer (2005) to be a problem in any study of this sort not designed to specifically examine the relationship between current wealth and behavior and as that was not the purpose of the present study we can not appropriately derive proper inference on this issue. We will only argue that there is reason to suspect that there is not a strong relationship between contribution behavior and wealth.

The statistical characterization of the individual behavior is useful for understanding how individuals respond to the different group arrangements, but it is also important to understand how the overall contributions adjust and ultimately the impact on social welfare. Table 6 presents a pair of regressions to determine how these variables change under the different treatments. The first regression uses the total production of each group per period as the dependent variable while the second uses the percentage of total welfare dissipated by period. The independent variables are all just dummy variables indicating the phase and treatment. For the group production regressions, there are separate variables in the asymmetric phases for the small and large groups to allow us to compare the group totals. The default comparison group is phase 1 of the Baseline treatment. We will present the interpretation of these regressions in an additional two results.

Result 5 - *The only two group configurations that lead to differences in total contributions are the symmetric 5-member groups and the individuals in the asymmetric phase of the RAG treatment. All other groups generate total contributions that are not significantly different.*

This result demonstrates an intriguing property of the data. While it should not be a surprise that none of the individuals (except in phase 1 of the RAG treatment) generate different contributions based upon result 1, it is perhaps more surprising that the 5-member groups in the AG treatment generate on average the same level of total contributions as the individuals. This shows that the individuals do not respond to the change in the size of their rival group and that the members of that rival group on average simply divide the average individual contribution by 5 to arrive at their contributions toward their group's chances of winning. Perhaps this is an indication that the subjects are not falling victim to the free-rider problem in this situation. On the other hand, we do see a small drop in total group contributions in the 5V5 arrangement in the SG treatment. While the individual contributions in the SG treatment do not differ statistically from the 5-member groups in the AG treatment, once those individual contributions are added up the difference becomes

	Group Production	**Dissipated Social Welfare**
Phase 2 Baseline, 1V1	11.20	0.022
	(26.187)	(0.052)
AG Phase 1, 1V1	0.712	0.001
	(35.300)	(0.071)
SG Phase 1, 1V1	23.591	0.047
	(41.657)	(0.083)
RAG Phase 2, 1V1	44.271	0.089
	(51.961)	(0.104)
AG Phase 2, 1V5 $n = 1$	-3.327	-
	(54.491)	
AG Phase 2, 1V5 $m = 5$	2.991	-
	(45.976)	
AG Phase 2, 1V5 ALL	-	-0.0003
		(0.073)
SG Phase 2, 5V5	-82.994**	-0.166**
	(37.035)	(0.074)
RAG Phase 1, 1V5 $n = 1$	240.651***	-
	(75.108)	
RAG Phase 1, 1v5 $m = 5$	45.095	-
	(67.301)	
RAG Phase 1, ALL	-	0.286***
		(0.098)
Constant	336.927***	0.674***
	(28.400)	(0.057)
Observations	4020	2010
Adjusted R^2	0.032	0.040

Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

Table 6: Pooled OLS regressions using Group Contributions or the total percentage of surplus dissipated as the dependent variable. Phase 1 of the Baseline is the comparison treatment.

large enough to be significant at the 10% level. Again, the only substantial difference in behavior is found in the first phase of the RAG treatment with the members of the single group massively out contributing all other group arrangements.

This results allows us to better interpret result 1 which showed that individuals did not alter their contributions based upon being matched with individuals or five member groups despite the theoretical prediction that they should. Result 5 helps to explain why this was perhaps perfectly reasonable behavior. It is easy to see that an individual should best respond to the total contributions of the rival group regardless of the makeup of that group. Consequently, if the five member groups are contributing at the same level as individuals by themselves, then those individuals matched with the five member groups should in fact not alter their behavior. Alternatively, given the contribution level of the individuals, those in the big groups should still best respond by lowering their contributions. Consequently the key deviation from the equilibrium predictions is by the five member groups and not the fact that the individuals do not appear to respond to facing groups of different size.

Result 6 - *The symmetric 5-member group configuration yields the least rent dissipation while the asymmetric phase of the RAG treatment yields the most. All other arrangements yield on average the same level of rent dissipation.*

This result is of course heavily foreshadowed by result 5 but the second regression in table 6 provides the verification of the point. Most of the treatments yield a base level of rent dissipation of about 67% while the 5V5 arrangement drops this by about 20 percentage points and the asymmetric phase of the RAG increases it by 29 percentage points. The overall levels are all greater than the theoretical predictions and only the comparative static prediction of the shift between the 1V1 or 1V5 and the 5V5 configuration is validated. The predicted drop between the 1V1 and 1V5 is not borne out in the data.

5 Conclusion

The motivation of this study was to examine how the conflict among individual, group and social concerns would net out in rent seeking games. In general we find strong over-contribution relative to Nash levels which leads to an overall level of social welfare which is not only lower than the social optimum benchmark but also much lower than the equilibrium benchmark. Our result matches with the over-contribution found in investigations of all-pay auctions such as Noussair and Silver (2006) as well as some of the previously cited work on rent seeking and tournament contests.

Explaining the degree of over contribution is more difficult. Baharad and Nitzan (2008) attempt to understand deviations from Nash behavior assuming that participants mis-perceive the true probability of winning according to a standard S-shape which overweights low probabilities and under-weights high probabilities. They find that they predict under-dissipation for numbers of contestants examined here and only find over-dissipation when a large number of groups are competing for the prize. Salmon and Iachini (2007) provides a model of attentional bias in which decision makers place less weight on undesirable states than they should, which is able to explain overbidding in all-pay auctions. Applications of that model to this environment can not generate over-contribution to the degree observed here for reasonable parameterizations.

Perhaps more surprising results emerge when we examine group behavior. In the treatment with individuals matched against five member groups, equilibrium analysis suggests that the large group should suffer from under-contributions due to free riding and the small group should anticipate this and reduce their contributions accordingly. What we find instead is that the large groups do not reduce their contributions by as much as expected leaving their overall total contributions to be the same as the individuals and so the individuals best respond by keeping their contributions constant.[7]

We also find that, contrary to the equilibrium prediction, the overall contribution levels do not decrease as substantially as predicted when two large groups are competing compared to when two individuals are competing. Consequently, at least in our results we find that the larger groups are not suffering from a public good or free-rider problem as much as one would expect. The cause of this phenomenon is an open question and is a prime area for further research. Our experimental results appear to eliminate at least two possible explanations. First, the high level of contribution is not an effort to maximize overall social welfare. High levels of contribution in the standard public goods games may be interpreted as attempts to raise social welfare. In our experiment, however, in-group contributions for rent-seeking actually decrease social welfare and, thus, the observed over-contribution is inconsistent with a motivation to maximize overall social welfare. Secondly, we investigated whether the result could be an artifact of sequencing, and found that this explanation was not satisfactory. One other simple explanation might be the relatively small decrease in expected monetary payoff when an individual belonging to a large group over-contributes. The fact that we see similar over-contributions by the individual players not belonging to a group, for whom over-contribution is quite costly, suggests that this should not be the main explanation either. Further research with more elaborate experimental design will be necessary to exactly identify the reasons for the over-contribution in group rent-seeking games.

References

Abbink, K., J. Brandts, B. Herrmann, and H. Orzen (2007). Inter-Group Conflict and Intra-Group Punishment in an Experimental Contest Game. CeDEc Discussion Paper No. 2007-15.

Baharad, E. and S. Nitzan (2008). Contest Efforts in Light of Behavioral Considerations. *The Economic Journal 118*, 2057–2059.

Baik, K. B. and S. Lee (1997, February). Collective rent seeking with endogenous group sizes. *European Journal of Political Economy 13*(1), 121–130.

Baik, K. H., , and J. F. Shogren (1995). Competitive-share group formation in rent-seeking contests. *Public Choice 83*, 113–126.

[7] Abbink, Brandts, Herrmann, and Orzen (2007) use an experimental design similar to ours and find in their no-punishment control series the 4-person teams behaved identically whenever they faced teams or individuals. Also single person groups appeared to be similarly unaffected by whether they faced groups or other individuals.

Bornstein, G. (2003). Intergroup conflict: Individual, group and collective interests. *Personality and Social Psychology Review 7*(2), 129–145.

Bornstein, G. and M. Ben-Yossef (1994). Cooperation in intergroup and single-group social dilemmas. *Journal of Experimental Social Psychology 30*(11), 52–67.

Bornstein, G., E. Winter, and H. Goren (1996). Experimental Study of Repeated Team-Games. *European Journal of Political Economy 12*, 629–639.

Bull, C., A. Schotter, and K. Weigelt (1987). Tournaments and Piece rates: An Experimental Study. *Journal of Political Economy 95*(1), 1–33.

Cox, J. C. and S. C. Hayne (2006). Barking up the right tree: Are small groups rational agents? *Experimental Economics 9*(3), 209–222.

Davis, D. D. and R. J. Reilly (2000). Multiple Buyers, Rent-Defending and the Observed Social Costs of Monopoly. *Pacific Economic Review 5*, 389–410.

Fischbacher, U. (2007). z-Tree: Zurich Toolbox For Readymade Economic Experiments. *Experimental Economics 10*(2), 171–178.

Fonseca, M. (2009). An experimental investigation of asymmetric contests. *International Journal of Industrial Organization ??*, ??

Gunnthorsdottir, A. and A. Rapoport (2006). Embedding Social Dilemmas in Intergroup Competition Reduces Free-Riding. *Organizational Behavior and Human Decision Processes 101*, 184–199.

Gürtler, O. (2005). Collective contests with externalities: Corrigendum. *European Journal of Political Economy 21*(2), 533–536.

Ham, J., J. Kagel, and S. Lehrer (2005, March-April). Randomization, Endogeniety and Laboroatory Experiments: The Role of Cash Balances in Private Value Auctions. *Journal of Econometrics 125*(1-2), 175–205.

Hayne, S. C. and J. C. Cox (2005). When does an incentive for free riding promote rational bidding? In *Experimental Business Research*, pp. 133–149. Springer US.

Insko, C. A., J. Schopler, K. A. Graetz, S. M. Drigotas, D. P. Currey, S. L. Smith, D. Brazil, and G. Bornstein (1994). Interindividual-intergroup discontinuity in the prisoner's dilemma game. *Journal of Conflict Resolution 38*(1), 87–116.

Insko, C. A., J. Schopler, J. F. Kennedy, K. Dahl, K. A. Graetz, and S. M. Drigotas (1992). Individual-group discontinuity from the differing perspectives of campbell's realistic group conflict theory and tajfel and turner's social identity theory. *Social Psychology Quarterly 55*(3), 272–291.

Krueger, A. O. (1974). The Political Economy of the Rent-Seeking Society. *American Economic Review 64*(3), 291–303.

Lee, S. (1995, October). Endogenous sharing rules in collective-group rent-seeking. *Public Choice 85*(1/2), 31–44.

Lee, S. and J. H. Kang (1998, November). Collective contests with externalities. *European Journal of Political Economy 14*(4), 727–738.

Millner, E. L. and M. D. Pratt (1989). An Experimental Investigation of Efficient Rent-Seeking. *Public Choice 62*(2), 139–151.

Millner, E. L. and M. D. Pratt (1991). Risk Aversion and Rent Seeking: An Extension and Some Experimental Evidence. *Public Choice 69*(1), 81–92.

Nalbantian, H. R. and A. Schotter (1997). Productivity Under Group Incentives: An Experimental Study. *American Economic Review 87*(3), 314–340.

Nitzan, S. (1991). Collective rent dissipation. *Economic Journal 101*, 1522–1534.

Noussair, C. and J. Silver (2006). Behavior in All-Pay auctions with Incomplete Information. *Games and Economic Behavior 55*(1), 189–206.

Orrison, A., A. Schotter, and K. Weigelt (2004). Multiperson Tournaments: An Experimental Examination. *Management Science 50*(2), 268–279.

Rogerson, W. P. (1982). The social costs of monopoly and regulation: A game theoretic analysis. *The Bell Journal of Economics 13*, 391–401.

Salmon, T. C. and M. Iachini (2007). Continuous Ascending Vs. Pooled Multiple Unit Auctions. *Games and Economic Behavior 61*(1), 64–85.

Shogren, J. F. and K. H. Baik (1991). Re-examining Efficient Rent-Seeking in Laboratory Markets. *Public Choice 69*, 69–97.

Sutter, M., M. G. Kocher, and S. Strauß (2009). Individuals and teams in auctions. *Oxford Economic Papers 61*(2), 380–394.

Tullock, G. (1967). The Welfare Costs of Tariffs, Monopolies and Theft. *Western Economic Journal 5*, 224–32.