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An experimental examination of rational rent-seeking

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Abstract

The theoretical literature exploring various ramifications and applications of Tullock's (1980) rent-seeking model is extensive and rapidly growing. In contrast, there exist as yet only a few experimental evaluations of this model, with ambiguous results. Moreover, these studies focus on one particular case (proportional probabilities) and use a problematic experimental design. With an appropriate design we investigate the extreme cases of proportional probabilities and perfect discrimination, which offer the starkest contrast in theoretical predictions. We find substantial evidence for the predictive power of the rent-seeking model, particularly if one allows for the fact that people sometimes make mistakes or are confused about what to do. © 1998 Elsevier Science B.V. All rights reserved.

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1. Introduction

In remarkable contrast to the extensive and rapidly growing theoretical literature on rent seeking (see Nitzan, 1994), there are as yet only very few experimental evaluations of this theory. This is unfortunate, because the method of laboratory experimentation appears particularly useful here. The basic rent-seeking model due to Tullock (1980) lends itself readily to experimental implementation, which offers the possibility of a controlled and replicable investigation of the model's properties. Moreover, direct empirical evidence on rent seeking is hard to come by, due to the very nature of the lobbying process. Hence the importance of laboratory work.

The basic model involves two competing agents expending resources to influence the probability of acquiring a given rent. The probability that agent 1 gets the rent with expenditure x, given that agent's 2 expenditure is y, follows from the exogenous choice of R in the function: $P\{1 \text{ wins with } x \mid 2 \text{ spends } y\} = x^R/(x^R + y^R)$, with $P = 0.5$ if $x = y = 0$. The higher is R, the more discriminatory the game becomes. In fact, taking $\lim_{R\to\infty}$ of P it shows that P becomes 0 (1) if $x < (>)\ y$, in which case the contest has become perfectly discriminatory ($P = 0.5$ if $x = y$). Solutions to the game with $R < 2$, and $R = \infty$ are known from Tullock (1980) and Hillman and Samet (1987), respectively. Only recently the solution to the case $2 < R < \infty$ has been characterized (Baye et al., 1994). When $R \leq 2$ there is a pure strategy Nash equilibrium, when $R > 2$ the equilibrium is necessarily in mixed strategies. The rent-seeking literature is not only concerned with the existence of Nash equilibria, however, but also with its characterization and ''in particular, with the relationship between total rent-seeking outlays in equilibrium and the value of the contested rent'' (Nitzan, 1994). In this context, the following definitions are helpful. Let the expected rate of dissipation (ERD) be defined by the ratio of the expected sum of the rent-seeking expenditures and the value of the rent. Moreover, define the expected rate of overdissipation (ERO) as ERO = ERD-1. Furthermore, let the expected incidence of overdissipation (EIO) be defined as the expected frequency by which the sum of the expenditures exceed the value of the rent. For a continuous strategy space, if $R < 2$ it turns out that ERO < 0 and EIO $= 0$, whereas if $R = \infty$ it follows that ERO $= 0$ and EIO > 0. For the intermediate cases, $2 < R < \infty$, we have that ERO ≤ 0 and EIO > 0. Consequently, the starkest contrast in terms of these dissipation ratios is between the cases $R = 1$ (proportional probabilities) and $R = \infty$ (perfect discrimination).

As of today there exist only four related experimental investigations of the basic rent-seeking model. Millner and Pratt (1989) investigate the cases $R = 1$ and $R = 3$. However, instead of using an appropriate, simultaneous single decision design, they allowed sequential decisions within a given time interval. Moreover, they mistakenly arrived at a pure strategy solution for $R = 3$, leading to a wrong evaluation of the results for this case. Later, Millner and Pratt (1991) have argued that the discrepancy between the theoretical prediction for $R = 1$ and their experimental results, showing dissipation in excess of the Nash prediction, can be explained by risk aversion. Shogren and Baik (1991) re-examined the case $R=1$ with a new experimental design utilizing an explicit expected payoff matrix. [1] The matrix, provided to the subjects, shows the expected outcome of all alternative choices (expenditure levels) given the opponent's choice. Their results seem consistent with the theoretical predictions. Unfortunately, by having subjects repeatedly play against the same opponent, their design too is not in line with the theoretical model. In a repeated game cooperation through lower expenditure is facilitated, and this may partly explain their results. [2] Davis and Reilly (1998), finally, investigate the effects of rent defending buyer behavior as in Ellingsen (1991). Their base cases are, however, without the rent defending activity and concern $R=1$ and $R=\infty$. [3] They find that dissipation is indeed significantly larger for the latter case, but for both cases persistently and substantially above the Nash prediction. Moreover, there appears to be no significant difference in behavior between experienced and inexperienced subjects. Their design is problematic, though, for the following reasons. First of all, their experimental setup is such that agents are cash constrained. This affects the equilibrium spending behavior (see Che and Gale, 1997). Furthermore, they have four agents participating in the rent-seeking game. With more than two competing agents there are multiple Nash equilibria (see Baye et al., 1996), so that straight-forward behavioral predictions cannot be obtained from the theory. Moreover, their base cases were run together with other treatments in two-sequence sessions, with only half of the relevant sessions having the base case first in the sequence. Because of the small number of sessions, their analysis uses aggregate results and may, therefore, be affected by a sequence effect.

Motivated by the wide use of the rent-seeking model and the problems with the few existing experimental studies, this paper investigates the results of an experimental implementation which we believe to better reflect the nature of the theoretical models. Since the starkest contrast in terms of theoretical predictions is between the cases $R=1$ and $R=\infty$, we focus on these two extremes. As in Shogren and Baik (1991), an explicit expected earnings table is used to ease the informational problem for the subjects. Section 2 presents the theoretical predictions and experimental design. Results are analyzed in Section 3, and Section 4 concludes.

[1] Shogren and Baik wrongly suggest the absence of a Nash equilibrium for $R>2$.

[2] It should be noted, furthermore, that only 10 pairs of subjects participated in their experiment.

[3] We became aware of this work after having run some pilot sessions with a somewhat different design in 1994.

2. Theory and design

Consider the simultaneous move, complete information Tullock allocation mechanism without cash constraints. We give the theoretical solutions for the cases $R=1$ and $R=\infty$, which are implemented in the experiment. The value of the rent ('prize' in the experiment) is taken to be 13. Agents can bid (buy tokens) in units of 1, starting from 0, and up to 15 (their endowment). In the experiment, the endowment, prize, and tokens were counted in 'points' with each point paying 5 Dutch cents; see the Instructions in Appendix A. Because of the discrete nature of the experiment, the theoretical solutions are given for a discrete strategy space. [4]

2.1. Case $R=1$

The expected earnings table for this case is reproduced in Appendix A as part of the instructions. From this table it is easily seen that irrespective of the choice of the opponent, it never pays to bid more than 3. Some further elimination shows that the unique Nash equilibrium is for both agents to bid 3. Expected earnings for this equilibrium are $15\text{-}3+1/2.13=18.5$. Note that this is a pure strategy equilibrium. Hence, the variance of the bids is zero. The expected dissipation equals $3+3=6$, and therefore ERD $=6/13=0.46$, ERO $=-0.54$, and EIO $=0$.

2.2. Case $R=\infty$

The expected earnings table for this case is also reproduced in Appendix A. For the continuous strategy space the unique equilibrium is for both agents to draw their bids randomly from the uniform distribution on the interval [0, 13]; see Hillman and Samet (1987) and Baye et al. (1996). In the discrete strategy space with gridsize 1, there is a unique equilibrium if the size of the rent Q is odd, and a multiplicity if it is even.; see Bouckaert et al. (1992) and Schep (1995). [5] For this reason we have chosen $Q=13$ in the experiment, to ensure that the results are not confounded by a multiplicity of equilibria. Let p_i, with $i=0,1,\dots,12$, denote the probability that a certain point in the grid is drawn. In equilibrium $p_i=1/13$ for all i; that is, bids are drawn from the discrete uniform on the interval [0, 12]. This implies an expected bid of 6, and a variance of the bids equal to 14.0 and hence a standard deviation of 3.74. Furthermore, expected earnings equal $15\text{-}6+1/2.13=15.5$. It is immediate from the above that expected dissipation equals 12, ERD $=12/13$, and ERO $=-1/13$. The expected incidence of overdissipation,

[4] The results for a continuous strategy space can be found in, e.g., Tullock (1980), Hillman and Samet (1987) and Baye et al. (1996); these are quite similar to the discrete strategy space solutions.

[5] All equilibria are obtained in Bouckaert et al. (1992), and uniqueness was proved by Schep (1995); see also Baye et al. (1994) for a summary in English.

EIO, can be calculated as follows. For the respective bids x and y we have from Schep (1995): $P\{x+y=2Q-j\}=(j-1)/Q^2$, $j=2,\dots,Q+1$, and $P\{x+y=j\}=(j+1)/Q^2$, $j=0,\dots,Q-1$. It follows that EIO $=P\{x+y>13\}=66/169 \approx 0.39$.

The following hypotheses are generated by the theory and will be tested against the experimental data. We start out with some quantitative (point) predictions regarding the distribution of bids for $R=1$ and $R=\infty$. Since predictions concerning ERD and EIO are implied, we do not mention these explicitly.

2.3. Quantitative (point) predictions

Hypothesis 1a: With $R=1$ (proportional probabilities) the distribution of bids is concentrated on 3.

Hypothesis 1b: With $R=\infty$ (perfect discrimination) the distribution of bids is uniform on $[0,\dots,12]$, with an average bid of 6 and a standard deviation of 3.74.

A weaker test of the theory, which may be called for due to the possible presence of factors that have not been modeled, involves the use of theoretical predictions in a qualitative (directional) sense. Assuming that the background noise caused by these omitted variables is uncorrelated with the value of R, one would at least expect to find empirical support for the following qualitative predictions.

2.4. Qualitative (directional) predictions

Hypothesis 2a: Mean bid and dissipation (D) are lower for $R=1$ than for $R=\infty$.

Hypothesis 2b: Variance of bids and dissipation are smaller for $R=1$ than for $R=\infty$.

Hypothesis 2c: Incidence of overdissipation (IO) is smaller for $R=1$ than for $R=\infty$.

The experiment was run at the computerized CREED-laboratory of the University of Amsterdam. Students were recruited through announcements on bulletin boards. In total five sessions were run with the treatment $R=1$, and four with the treatment $R=\infty$. In each session—which took about one hour—either 12 or 14 subjects participated. About 50% of the participants were undergraduate economics students, while most of the other participants studied social geography, chemistry or psychology. No subject had any prior experience with this type of experiment. Upon arrival in the reception room of the laboratory a short introduction was read, and subjects drew an envelope containing a table number before entering the lab. Once seated in the lab, at tables with partitions, the instructions were distributed and read aloud. [6] Apart from the two practice rounds (with no real

[6] Remarks made by subjects on a Remarks sheet suggest that the instructions were (extremely) clear.

Table 1
Statistics of bids

Statistic	$r=1$	$r=\infty$
Mean	5.05 (4.50)	5.96 (5.87)
Median	4.00 (4.00)	6.00 (6.00)
Mode	3.00 (3.00)	10.00 (1.00)
Standard deviation	3.30 (2.84)	3.78 (3.89)
No. bids	1980 (660)	1500 (500)

Statistics for all 30 periods. Between parentheses for the last 10 periods.

money at stake), each session consisted of 30 rounds of play. In each round subjects were first randomly matched in pairs, to retain the one-shot character of the game. Subjects then obtained an endowment of 15 points and were requested to type in how many points they wanted to spend on tokens (at 1 point per token) to win a prize of 13 points. They could use the expected earnings table in the instructions for making this decision. Subsequently, the computer determined the winner either through a lottery or by checking who spent most, depending on the treatment. Net earnings in points determined the payment for the round via the exchange rate 1 point = 5 cents. Subjects could look up the results of previous rounds in a record table on their screen, showing the number of tokens they themselves and their opponents bought, the probability of winning, the winner, and their (total) earnings. At the end of a session subjects were paid out one by one, in private. Average earnings over the one hour experiment amounted to 25.49 guilders for $R=1$ and 23.67 guilders for $R=\infty$. In US-dollars, at the time of the experiment (April 1996), these figures approximately equaled $15.35 and $14.25, respectively.

3. Results

Tables 1 and 2 present some general statistics concerning bids (number of tokens bought) and dissipation, while Figs. 1 and 2 show the frequency distribu-

Table 2
Statistics of dissipation

Statistic	$r=1$	$r=\infty$
Mean	10.10 (9.00)	11.92 (11.74)
Median	9.00 (8.50)	12.00 (12.00)
Mode	8.00 (8.00)	11.00 (12.00)
Standard deviation	4.78 (4.09)	5.39 (5.31)
Incidence of overdissipation	0.206 (0.127)	0.379 (0.348)
No. observations	990 (330)	750 (250)

Statistics for all 30 periods. Between parentheses: for the last 10 periods.

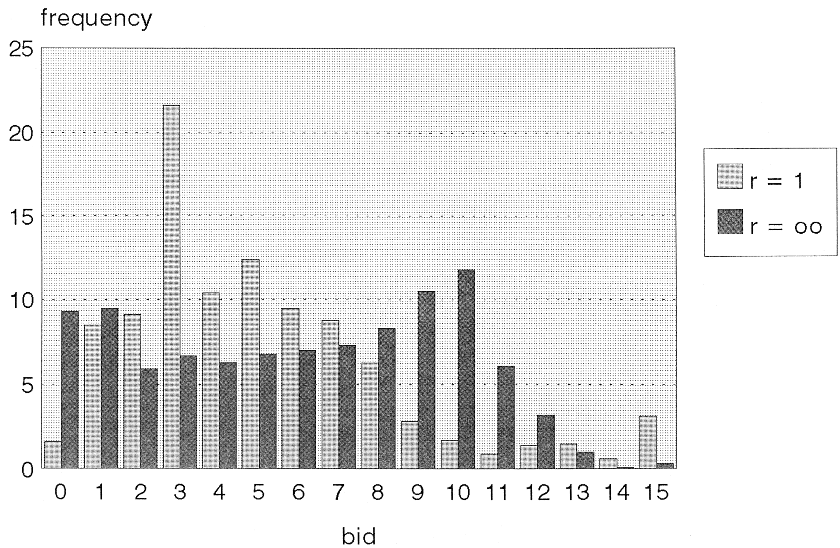

Fig. 1. Frequency distribution of bids (all rounds).

tions of the bids for the two treatments. From the figures it is immediate that the theoretical predictions are rejected by the data if one were to take these in a strict sense. In case of $R=1$ all bids should be at 3, but instead they range from 1 to 15. Note that spending more than 12 can never be profitable. Similarly, for $R=\infty$

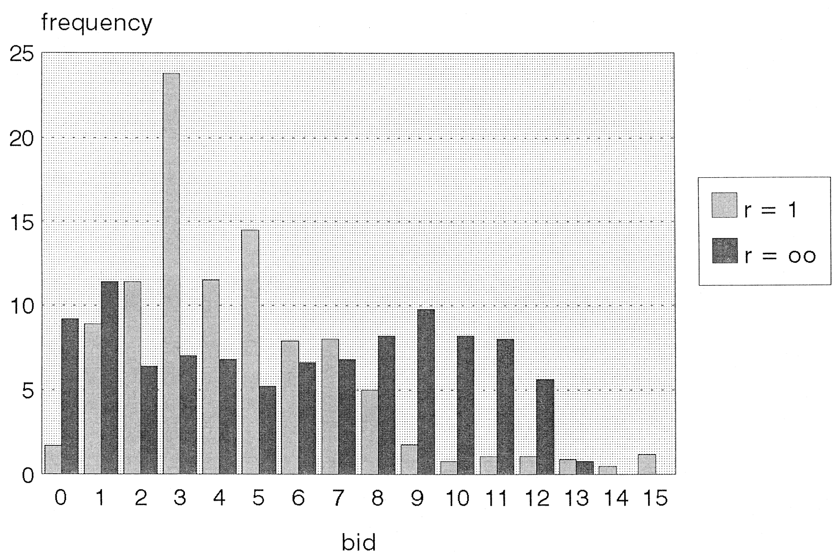

Fig. 2. Frequency distribution of bids (last 10 rounds).

no bids should be observed above 12, but individual monetary overdissipation does occur with bids of 14 and 15. Moreover, statistical tests indicate that the mean is significantly different from 3 in case of $R=1$, and that the null of a uniform distribution on [0, 12] is rejected in case of $R=\infty$, independently of whether we use all rounds or only the last ten rounds. [7] We conclude that the quantitative (point) predictions of hypotheses 1a and 1b are rejected by the data.

Before turning to the qualitative (directional) predictions we should note the following, however. First of all, we can reject the hypothesis that the observed bids for $R=1$ and $R=\infty$ are drawn from the same distribution (at $p<0.001$, using a Kolmogorov–Smirnov test). Furthermore, observe for $R=1$ from Figs. 1 and 2, and Table 1, that the mode is stable at 3 and that the distribution of bids becomes more concentrated around 3 over time. [8] Moreover, for $R=\infty$ statistical tests do not reject the hypothesis that the mean bid is 6 (using a sign test or t-test); note, furthermore, that the median is exactly 6 and that the standard deviation is very close to the predicted level. In addition, in this treatment there is no clear convergence to a unimodal distribution of bids over time. In fact, it turns out that for 3 of the 4 sessions of this treatment the observed bids become more in line with a uniform distribution when comparing the rounds 21–30 with 1–10 (that is, the z-scores of a Kolmogorov–Smirnov test decrease). Finally, note from Fig. 3, that the development of dissipation is suggestive for the predictive power of the theoretical model, at least in a qualitative comparative statics sense. For $R=\infty$ the level of dissipation fluctuates around the theoretical prediction of 12 (observe from Table 2 that the incidence of overdissipation is close to the predicted level of 0.39). For $R=1$ dissipation is persistently too high but, after the first eight periods, its development shows a clear tendency towards the predicted level of 6.

We turn now to the qualitative (directional) predictions of hypotheses 2a–c. We focus on the (independent) session aggregates for the last 10 rounds; see Table 3. [9] Using a Mann–Whitney U test, the following outcomes are obtained. Firstly, we find that the mean bid and dissipation are significantly smaller for $R=1$ than for $R=\infty$, in line with hypothesis 2a. Secondly, it appears that the variance of bids and dissipation are, as predicted, smaller for $R=1$ than for $R=\infty$, albeit the difference is only marginally significant in both cases. Thus, we find some support

[7] A conservative sign test as well as a t-test rejects the hypothesis for $R=1$ that the mean is 3 ($p<0.05$), taking session averages as observations. For $R=\infty$ we applied a Kolmogorov–Smirnov test at the treatment, sessions, and individual level. The hypothesis of a uniform distribution is rejected at $p<0.001$ for the treatment and sessions. At the individual level, the hypothesis is rejected at $p<0.05$ for all but 7 of the 50 subjects. Similarly, but with higher confidence, we find that the hypothesis of a uniform bid distribution is rejected for $R=1$.

[8] Using a Kolmogorov–Smirnov test, it appears for all sessions of treatment $R=1$ that the data become less in line with a uniform distribution when comparing the rounds 21–30 with 1–10 (that is, the z-scores increase).

[9] Results are similar if we take the last 5 rounds.

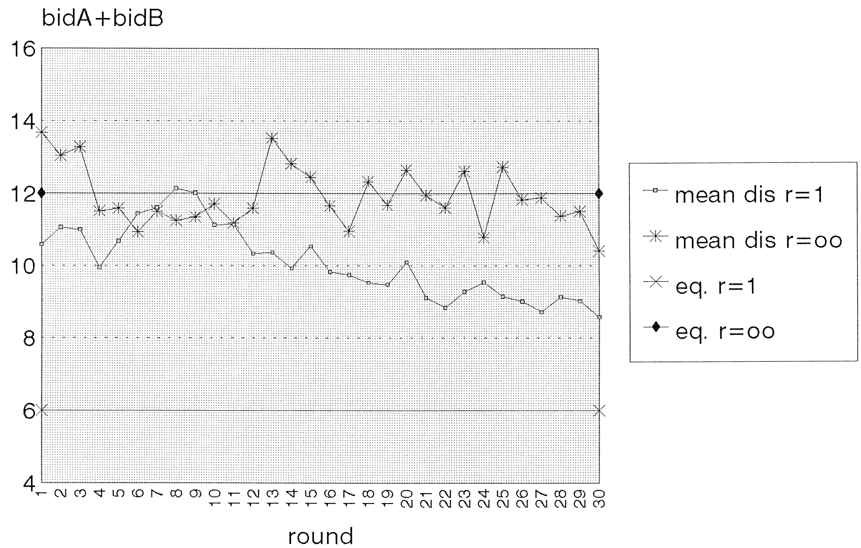

Fig. 3. Development of dissipation.

for hypothesis 2b. Finally, regarding the incidence of overdissipation, the results show that there is also support for hypothesis 2c that IO is smaller for $R=1$ than for $R=\infty$. All in all, there is clear evidence for the qualitative predictions of the rent-seeking model regarding the extreme cases of proportional probabilities and perfect discrimination.

4. Concluding discussion

Summarizing our results, we find that for $R=1$ (proportional probabilities) the mode of the bid distribution is clearly at the predicted level, and the distribution becomes more concentrated around that level during the last ten rounds. The main failure of the theoretical model is that it does not predict the persistently higher—albeit somewhat declining—level of dissipation. For $R=\infty$ (perfect discrimination) the bid distribution is strictly not uniform, but shows no clear mode or convergence towards a unimodal distribution (in fact, the distribution becomes rather more like a uniform distribution). Moreover, statistically it cannot be rejected that the mean bid and dissipation level are as predicted, while the median is exactly and the standard deviation and incidence of overdissipation are almost at the predicted levels. Finally, all qualitative (directional) predictions are supported by the data. Mean bid and dissipation, the variance of bids and dissipation, as well as the incidence of overdissipation, are all smaller for $R=1$ than for $R=\infty$, as predicted. In addition, we note that average earnings were

Table 3
Session aggregates on bids, dissipation, and incidence

	Session	All 30 rounds				Last 10 rounds			
		mean bid/D	sd bid	sd D	Inc	mean bid/D	sd bid	sd D	Inc
$r=1$	1	9.40	2.09	2.98	0.094	9.52	1.77	2.24	0.033
	2	12.78	4.80	6.68	0.500	10.67	4.60	6.45	0.400
	3	10.78	2.21	2.97	0.183	9.75	2.37	3.37	0.133
	7	9.76	3.27	4.67	0.152	8.30	2.09	3.01	0.057
	8	7.78	2.54	3.62	0.076	6.94	1.80	2.58	0.000
Average		10.10	2.98	4.18	0.201	9.04	2.52	3.53	0.125
$r=\infty$	4	11.99	3.90	5.31	0.390	13.46	4.33	5.67	0.471
	5	13.86	3.70	5.19	0.522	11.37	4.32	5.58	0.350
	6	11.25	4.11	5.76	0.328	10.45	3.53	4.87	0.233
	9	10.55	3.12	4.72	0.272	11.40	3.04	4.45	0.317
Average		11.91	3.71	5.25	0.378	11.67	3.81	5.14	0.343
Diff. $r=1$ vs. $r=\infty$ Mann–Whitney U (one-tailed sign.)		4 (0.096)	5 (0.143)	4 (0.096)	3 (0.056)	1 (0.016)	4 (0.096)	4 (0.096)	3 (0.056)

D stands for dissipation, sd for standard deviation, and Inc for incidence of overdissipation.

rather close to the Nash-equilibrium predictions, particularly for the perfect discrimination treatment: 25.49 vs. 27.75 guilders for $R=1$, and 23.67 vs. 23.25 guilders for $R=\infty$. [10]

So, why this 'excessive' dissipation under proportional probabilities, whereas dissipation is as predicted under perfect discrimination? First, observe that the suggestion of Millner and Pratt (1991) that the deviation may be due to risk-aversion is not supported by our data. In that case we should have found a lower (than the Nash equilibrium) dissipation level for $R=\infty$. [11] The outcome for this treatment rather suggests that subjects were almost risk-neutral. Suppose, however, that subjects make mistakes or search randomly if they are not sure about their analysis of the problem. This can be modeled by adding uniformly distributed noise to the Nash solution. Observe that this would affect the $R=1$ case, but not the $R=\infty$ solution. For $R=1$ fewer bids can be selected below the predicted level of 3 than above that level, whereas for $R=\infty$ the support is symmetric around the predicted average of 6. Consequently, this would affect the results precisely in the direction found, with a median and mean above the equilibrium prediction for the former case and at the predicted level for the latter.

A similar reasoning has been applied to explain observed 'excessive' contributions in public good experiments, where often contributing nothing is theoretically a dominant strategy (e.g., Andreoni, 1995). Apart from confusion, this literature has also pointed to altruistic or cooperative motives for the observed behavior (see Ledyard, 1995). In our case these alternative explanations are not very helpful, since they would lead to lower instead of higher bids. They also would affect the equilibrium predictions for both of our treatments similarly, counter to what we observe in our experiment. For the same reason, envy or spite cannot explain our results either.

Our conclusion is that the rent-seeking model has predictive power, particularly if one allows for the fact that people sometimes make mistakes or are confused about what to do. Remarks left by participants on their Remark sheets suggest that there are three categories of subjects. The first type behaves as 'gamesmen'; they appear to understand the strategic nature of the game and behave accordingly. The second type is confused and basically randomizes, whereas the third type adapts to the outcomes of earlier rounds. The third type seems to constitute a substantial

[10] The Pareto-efficient (cooperative) outcome, implying the purchase of zero tokens and a probability of $1/2$ of winning the prize, would have led to earnings of 32.25 guilders.

[11] This result is independent of the sign of the third derivative of the utility function. Incidentally, Millner and Pratt have to assume that this derivative is negative to explain their results for $R=1$, which runs counter to the implied assumption for the usual classes of utility functions (e.g., CARA, CRRA, and also DARA). The stable mode at 3 and the development of dissipation in the direction of 6 in our experiment also plead against this explanation.

group, making recent research efforts to model this type of behavior (see, e.g., Roth and Erev, 1995) of interest and importance for the future study of rent-seeking behavior.

Acknowledgements

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Appendix A. Instructions (translated in English)

The instructions concern the treatment $R = 1$, with adaptations for $R = \infty$ in bold brackets [.].

A.1. Introduction

This is an experimental study of decision making. Various research institutions have financially contributed to this study. The instructions are simple. If you follow them carefully you can earn a substantial amount of money. All the money you earn is for you to keep. Your earnings will be paid to you in cash, privately and confidentially, immediately after the experiment. We will first go through the instructions. Subsequently, you will get the opportunity to raise questions.

A.2. Decisions and earnings

The experiment consists of thirty rounds. In each round you will be matched with one other participant.

In each round a lottery decides which one of you two will win a *prize*. The probability that you win the prize is dependent on the *number of tokens* that you buy and the number of tokens that the other participant buys. More precisely, the probability that you win the prize equals the ratio of the number of tokens that you buy and the sum of the tokens that you and the other participant buy. If you buy X tokens and the participant to whom you are matched with buys Y tokens, then the probability that you win the prize equals $X/(X+Y)$, while the probability that the other participant wins the prize equals $Y/(X+Y)$. Suppose, for example, that you buy the same number of tokens as the other participant. In that case $X=Y$ and the probability that you win the prize equals $1/2$, while the probability that the other participant wins the prize is also $1/2$. (For the sake of completeness, a probability of $1/2$ also holds if neither of you buys any tokens, so that $X=Y=0$.) Note that the probabilities sum up to 1. Consequently, always one of you will win the prize.

[In each round one of you will win a *prize*. Which one of you will win the prize depends on the *number of tokens* that you buy and the number of tokens that the other participant buys. More precisely, the one who has bought more tokens than the other participant to whom he or she is matched with in a round wins the prize. Thus, if you buy X tokens and the participant you are matched with buys Y tokens, then you will win the prize if X is larger than Y, while the other participant wins the prize if X is smaller than Y. In case you buy the same number of tokens as the other participant ($X=Y$), the computer will perform a lottery in which the probability that you win the prize equals $1/2$, and the probability that the other participant wins the prize is also equal to $1/2$. (For the sake of completeness, a probability of $1/2$ also holds if neither of you buys any tokens, so that $X=Y=0$.) Note that the probabilities sum up to 1. Consequently, always one of you will win the prize.]

You will not actually receive the tokens you buy. In each round the computer will record the decisions of all participants and for each pair perform a drawing (lottery) in accordance with the number of tokens bought. [... and for each pair determine who has won the prize.] When you make your decision you will not know the decision of the other participant. Once the round is over, you will be informed about the number of tokens the other participant bought and the winner of the prize. You will not know the participant whom you are matched with in a round. Furthermore, in each round the participant with whom you are paired with will change. The matching scheme has been randomly determined by us in advance.

Earnings in a round are in *points*. At the end of the experiment you will be paid 5 cents for each point you have earned. At the start of each round each participant will get an *endowment* of 15 points. Then, everyone decides how many tokens to buy, at a cost of 1 point per token. Winning the prize will earn you 13 points. If you win the prize your earnings in points equal: the endowment of 15 points minus the number of tokens you bought plus the prize of 13 points. If the participant whom you are paired with wins the prize your earnings equal: the endowment of 15 points minus the number of tokens you bought. The endowment (15 points), the prize (13 points), and the cost per token (1 point) will stay the same in each round.

To help you in making your decisions we have added a table to these instructions showing *your expected earnings (in points)*. We ask you now to look at this table. Your expected earnings are equal to the endowment minus the number of tokens you buy, plus the probability of winning times the prize. To determine your expected earnings in case of a particular number of tokens bought by yourself and a particular number of tokens bought by the other participant, you have to look up first the row in the table showing the number of ‘tokens you bought’ and then look for the column to the right showing the number of ‘tokens bought by other participant’. [In case you buy the same number of tokens as the other participant it is taken into account that you win the prize with a probability of 1/2.] As mentioned before, the expected earnings are determined by taking into account the probability that you win the prize. Your actual earnings (in points) are, of course, dependent on the outcome of the lottery determining the winner. [Your actual earnings (in points) are, of course, dependent on whether you win the prize.]

As indicated before, you will be paid *5 cents* for *each point* you earn. The total amount of money that will be paid to you after the experiment will, thus, be determined by your total earnings over all (thirty) rounds times 5 cent.

A.3. Use of the computer

On your computer you can now see the screen that will be visible during the whole experiment. We will explain this screen and the procedures to you by going through a practice round. *Only type something if you are requested to do so.*

In the upper left-hand corner of the screen you see that the current ‘round’ and ‘your role’ are indicated. Your role can be either A or B. If you have role A, then the participant whom you are matched with in that round has role B, and reversely. Sometimes your role will change from one round to another, on other occasions it will stay the same. Your role (A or B) will only be used to ease the registration of the results and has no further meaning. Furthermore, observe that for both roles the prize (13 points) and the endowment (15 points) are indicated. Prize and endowment are equal for both roles, and will not change over the rounds.

In the upper right-hand corner of the screen you can see how you have to enter the number of tokens that you want to buy in a period. You type in the number and press the Enter-key. After having entered the number you will have to wait until all participants have entered a number. Once every participant has done so, you will be immediately informed about whether you have won the prize and your earnings for that round.To illustrate the procedure you are now asked to type in a number and to press the Enter-key. The number that you enter must not be larger than the endowment. ⟨*Type in a number and press the Enter-key*⟩. Immediately after everyone has entered the number of tokens, for each pair a lottery will be performed by the computer in accordance with the tokens that are bought. [..., for each pair the computer will determine who has won the prize.] The result is presented on your screen. This procedure will be followed in each round.

The lower part of the screen offers a results-table. This table gives the results of all previous rounds. The first column of the table indicates the round. The second column shows your role, A or B, in the respective round. The third column gives the numbers of tokens that you and the other participant bought, indicated via the role A or B. Column four shows the probabilities with which the prize is won by you and the other participant, given the numbers of tokens that are bought. The second to last column indicates who has won the prize. [Column four shows who has won the prize.] The last column presents the earnings (in points) for the round. Note that your role is always indicated in white. In the lower right-hand corner of the table your total earnings over the rounds are recorded. Your total earnings determine the money that will eventually be paid to you, since each point earns you 5 cents. Finally, you can see below the table that you can look up the results of, respectively, previous and later rounds by using the arrow keys (up/down) or the PageUp and PageDown keys.

A.4. Summary

In each round you will be randomly matched with one other participant. The person whom you are paired with changes each round. In each round you have to decide how many tokens to buy. The numbers of tokens you and the other participant buy determine the probability with which you will win the prize. In accordance with these probabilities the computer performs a drawing (lottery) determining the winner of the prize. [The one who buys more tokens than the other wins the prize. If both of you buy the same number of tokens then you have an equal probability of 1/2 of winning the prize.] Your earnings in points in a round are determined by the endowment, the number of tokens that you buy, and the outcome of the drawing. Endowment (15 points) and prize (13 points) are the same for everyone, and stay the same for all rounds. Each point that you earn gives you a payoff of 5 cents when the experiment is over. The total amount of money that will be paid to you is determined by your total earnings times 5 cents, therefore.

A.5. Final remarks

At the end of today’s session you will be called, one by one, by your table number to receive your payment in cash in the reception room, privately and confidentially. Your payment is only your business; you do not have to talk about it with anyone.

It is not allowed to talk or communicate in any way with other participants during the experiment. Please, raise your hand if you have a question. I will then come to your table. In case you have any remarks concerning the experiment or your decisions, you are requested to use the form labeled ‘REMARKS’, which is on your table. Shortly, there will be an opportunity to raise questions. Subsequently, there will be two practice rounds to make you fully at ease with the procedures. Your earnings in these rounds do not count for final payment.D stands for dissipation, sd for standard deviation, and Inc for incidence of overdissipation.

Your expected earnings (in points) [Appendix: R = 1] (= endowment − number of tokens you bought + probability of winning × price)

Tokens you bought	Tokens bought by other participant															
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
0	21.5	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0
1	27.0	20.5	18.3	17.3	16.6	16.2	15.9	15.6	15.4	15.3	15.2	15.1	15.0	14.9	14.9	14.8
2	26.0	21.7	19.5	18.2	17.3	16.7	16.3	15.9	15.6	15.4	15.2	15.0	14.9	14.7	14.6	14.5
3	25.0	21.8	19.8	18.5	17.6	16.9	16.3	15.9	15.5	15.3	15.0	14.8	14.6	14.4	14.3	14.2
4	24.0	21.4	19.7	18.4	17.5	16.8	16.2	15.7	15.3	15.0	14.7	14.5	14.3	14.1	13.9	13.7
5	23.0	20.8	19.3	18.1	17.2	16.5	15.9	15.4	15.0	14.6	14.3	14.1	13.8	13.6	13.4	13.3
6	22.0	20.1	18.8	17.7	16.8	16.1	15.5	15.0	14.6	14.2	13.9	13.6	13.3	13.1	12.9	12.7
7	21.0	19.4	18.1	17.1	16.3	15.6	15.0	14.5	14.1	13.7	13.4	13.1	12.8	12.6	12.3	12.1
8	20.0	18.6	17.4	16.5	15.7	15.0	14.4	13.9	13.5	13.1	12.8	12.5	12.2	12.0	11.7	11.5
9	19.0	17.7	16.6	15.8	15.0	14.4	13.8	13.3	12.9	12.5	12.2	11.9	11.6	11.3	11.1	10.9
10	18.0	16.8	15.8	15.0	14.3	13.7	13.1	12.6	12.2	11.8	11.5	11.2	10.9	10.7	10.4	10.2
11	17.0	15.9	15.0	14.2	13.5	12.9	12.4	11.9	11.5	11.2	10.8	10.5	10.2	10.0	9.7	9.5
12	16.0	15.0	14.1	13.4	12.8	12.2	11.7	11.2	10.8	10.4	10.1	9.8	9.5	9.2	9.0	8.8
13	15.0	14.1	13.3	12.6	11.9	11.4	10.9	10.5	10.0	9.7	9.3	9.0	8.8	8.5	8.3	8.0
14	14.0	13.1	12.4	11.7	11.1	10.6	10.1	9.7	9.3	8.9	8.6	8.3	8.0	7.7	7.5	7.3
15	13.0	12.2	11.5	10.8	10.3	9.8	9.3	8.9	8.5	8.1	7.8	7.5	7.2	7.0	6.7	6.5

Your expected earnings (in points) [Appendix: R = ∞] (= endowment − number of tokens you bought + probability of winning × price)

Tokens you bought	Tokens bought by other participant															
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
0	21.5	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15
1	27	20.5	14	14	14	14	14	14	14	14	14	14	14	14	14	14
2	26	26	19.5	13	13	13	13	13	13	13	13	13	13	13	13	13
3	25	25	25	18.5	12	12	12	12	12	12	12	12	12	12	12	12
4	24	24	24	24	17.5	11	11	11	11	11	11	11	11	11	11	11
5	23	23	23	23	23	16.5	10	10	10	10	10	10	10	10	10	10
6	22	22	22	22	22	22	15.5	9	9	9	9	9	9	9	9	9
7	21	21	21	21	21	21	21	14.5	8	8	8	8	8	8	8	8
8	20	20	20	20	20	20	20	20	13.5	7	7	7	7	7	7	7
9	19	19	19	19	19	19	19	19	19	12.5	6	6	6	6	6	6
10	18	18	18	18	18	18	18	18	18	18	11.5	5	5	5	5	5
11	17	17	17	17	17	17	17	17	17	17	17	10.5	4	4	4	4
12	16	16	16	16	16	16	16	16	16	16	16	16	9.5	3	3	3
13	15	15	15	15	15	15	15	15	15	15	15	15	15	8.5	2	2
14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	7.5	1
15	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	6.5

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