Discussion Paper

CeDEx

Centre for Decision Research and Experimental Economics

Discussion Paper Series

ISSN 1749-3293

CeDEx Discussion Paper No. 2008–13

Loss Aversion and Rent-Seeking: An Experimental Study

Xiaojing Kong

October 2008

The University of Nottingham

The Centre for Decision Research and Experimental Economics was founded in 2000, and is based in the School of Economics at the University of Nottingham.

The focus for the Centre is research into individual and strategic decision-making using a combination of theoretical and experimental methods. On the theory side, members of the Centre investigate individual choice under uncertainty, cooperative and non-cooperative game theory, as well as theories of psychology, bounded rationality and evolutionary game theory. Members of the Centre have applied experimental methods in the fields of Public Economics, Individual Choice under Risk and Uncertainty, Strategic Interaction, and the performance of auctions, markets and other economic institutions. Much of the Centre's research involves collaborative projects with researchers from other departments in the UK and overseas.

Please visit http://www.nottingham.ac.uk/economics/cedex/ for more information about the Centre or contact

Karina Whitehead
Centre for Decision Research and Experimental Economics
School of Economics
University of Nottingham
University Park
Nottingham
NG7 2RD
Tel: +44 (0) 115 95 15620
Fax: +44 (0) 115 95 14159
karina.whitehead@nottingham.ac.uk

The full list of CeDEx Discussion Papers is available at

http://www.nottingham.ac.uk/economics/cedex/papers/index.html

Loss Aversion and Rent-Seeking: An Experimental Study*

Abstract: We report an experiment designed to evaluate the impact of loss aversion on rent-seeking contests. We find, as theoretically predicted, a negative relationship between rent-seeking expenditures and loss aversion. However, for any degree of loss aversion, levels of rent-seeking expenditure are higher than predicted. Moreover, we find that the effect of loss aversion becomes weaker with repetition of the contest.

* I am indebted to my supervisors Martin Sefton, Klaus Abbink, Bouwe Dijkstra and Richard Cornes for their incredible support and valuable comments; their remarks influenced this study considerably. In addition, I am especially grateful to Chris Starmer for very useful suggestions on the experimental design. Thanks also to Ping Zhang, Xianghua Zhang and Bin Xiao for assistance in conducting the experiments. Funding of the experiments by the Centre for Decision Making and Experimental Research (CeDEx) of the University of Nottingham is gratefully acknowledged. I wish to thank Simon Gachter, Alex Possajennikov, Robin Cubitt and Daniel Seidmann, as well as participants at the CREED-CeDEx Workshop, Nottingham, 2005, and the Economic Science Association Asia-Pacific Regional Meeting, Hong Kong, 2006, for helpful and encouraging comments. Any errors remain my own.

1. Introduction

The term “rent-reeking” was initially coined by Krueger (1974) to describe the contest of lobbying to obtain a monopoly rent from the government. Since then it has been applied to many economic and social settings in which individuals expend resources or efforts in attempts to win something of value. Standard examples of rent-seeking behavior include political candidates’ competition for an office, firms expending R&D resources to secure a patent, and periodic contests among cities and countries to host Olympic Games. Resources spent in rent-seeking are generally considered a pure social waste, because the resources are not used productively. Therefore, an important question raised in the theory of rent-seeking concerns the extent of rent dissipation, i.e. the amount of resources spent as a fraction of the prize.

Most theoretical accounts of rent-seeking study the interaction of expected utility maximizers. Useful reviews of this literature can be found in Nitzan (1994) and Hillman (2003, Chapter 6). There is, however, a growing body of evidence that many individuals systematically deviate from expected utility maximization. For example, there is considerable evidence of “loss aversion”: starting from a given level of initial wealth, the aggravation people experience in losses looms larger than the pleasure associated with gains of identical magnitude (Kahneman and Tversky 1979). Recently Cornes and Hartley (2003) have shown theoretically that loss aversion reduces rent dissipation. In this paper we use experimental methods to ask whether loss aversion in fact affects rent-seeking.

The experiment utilises the basic model for analyzing rent-seeking contests introduced by Tullock (1980). This model describes the rent-seeking process as a lottery, where rent seekers invest resources competing for an exogenous indivisible prize. Specifically, we examine three-person contests where player i wins the prize with probability $x_i / \sum_{j=1}^{3} x_j$, where x_j denotes the expenditure of player j.

Ours is not the first experiment to study the Tullock rent-seeking model. Most of the earlier studies have found observed dissipated rates to be higher than theoretically predicted. The first experiment to study the Tullock model was conducted by Millner and Pratt (1989), who found dissipation rates were significantly higher than predicted. In a further experiment (Millner and Pratt 1991) they investigated the effect of risk aversion on rent dissipation. They found that more risk-averse subjects spend less on rent-seeking.[1] Davis and Reilly (1998) and Potters et al. (1998) also find over-dissipation in their experiments. More recently, Schmidt et al. (2003) compare rent-seeking behavior across three different mechanisms. In their mechanism corresponding to the Tullock model they observe *lower* levels of rent dissipation than predicted. In their experiment, subjects play a one-shot game, the rent prize is set at $72, and each subject is only given an endowment of $20; this may account for lower rent-seeking expenditures than the theoretical predictions. The only experiment which finds dissipation of rent consistent with the theoretical prediction is by Shogren and Baik (1991), who provide subjects with a complete payoff matrix showing the expected payoff of all possible choices made by a subject and her opponent.

Our experiment is the first (as far as we are aware) to examine the impact of loss aversion on rent-seeking. We first elicited measures of each subjects' loss aversion, and then divided our subjects into "more loss-averse" and "less loss-averse" sub-samples. We then compared the rent-seeking behavior of the two sub-samples. We find, as predicted, that expenditures on rent-seeking are lower in the more loss-averse sub-sample. However, for any degree of loss aversion, levels of rent-seeking expenditure are higher than predicted. Thus, although loss aversion can reduce the extent of rent dissipation in rent-seeking contests, we observe (as in previous experiments) over-dissipation. Moreover, we also find that the difference in rent-seeking expenditures between the two sub-samples diminishes as subjects accumulate experience with the contest.

The remainder of the paper is organized as follows. In the next Section we present Cornes and Hartley's (2003) extended rent-seeking model, its equilibrium prediction and comparative static properties. Section 3 describes the experimental design and procedures. Section 4 presents the experimental results. Section 5 concludes.

2. The Model

2.1 The Value Function and Loss Aversion

Loss aversion is a central feature of Kahneman and Tversky's (1979) prospect theory,

[1] They found that the rent dissipation rate of the more risk-averse subjects was consistent with the Cournot-Nash risk-neutral prediction, while the less risk-averse subjects spent more than risk-neutral predictions.

in which a value function is defined over gains and losses relative to some reference point, rather than absolute levels of wealth. The specific finding known as loss aversion is that the value function is steeper in the domain of losses than in the domain of gains.

In order to focus on the implication of loss aversion, we confine our attention to a piecewise linear value function

$$v_i(w) = \begin{cases} w & if \quad w \geq 0 \\ \lambda_i \cdot w & if \quad w < 0 \end{cases}, \qquad (*)$$

where w denotes a change in wealth, $\lambda_i \geq 0$ denotes player i 's *index of loss aversion*, and we take the reference point to be player *i*'s initial wealth, W_i.[2] Player i is strictly loss-averse if $\lambda_i >$ 1, is loss-neutral if $\lambda_i =$ 1 and is loss-seeking if $\lambda_i <$ 1. The higher is λ_i, the more loss-averse is player i.

2.2 Rent-seeking with Loss-averse Players

Consider n ($n \geq 2$) players contesting an exogenous indivisible prize *R*. Player i has an initial wealth level W_i and chooses to spend the level of resources x_i in an attempt to win the prize. We assume that player i 's probability of winning the prize is $x_i / X = x_i / (x_i + X_{-i})$, where X denotes the total resources spent by all the players, $X = \sum_{j=1}^{n} x_j$, and X_{-i} is the sum of resources spent by all players except player *i*. This is a simple form of Tullock's rent-seeking model (1980) in which the odds of a player winning the prize is linear in her expenditure.

Cornes and Hartley (2003) incorporate loss aversion into this model. Without loss of generality, restrict $x_i \leq R$, so that if player *i* wins the prize she will gain $R - x_i$; otherwise, she will suffer a loss of $-x_i$. Using value function (*), and assuming linear probability weighting, player *i*'s payoff function can be written as

$$\pi_i(x_{i,} X_{-i}) = \frac{x_i}{x_i + X_{-i}}(R - x_i) + (1 - \frac{x_i}{x_i + X_{-i}})\lambda_i(-x_i),$$

which can be rearranged as

[2] Prospect theory also allows for curvature in the value function in the loss and gain domains. The theory also allows for non-linear probability weighting. In what follows, and again in order to focus on pure loss aversion, we will assume a linear probability weighting function.

$$\pi_i(.) = \frac{x_i}{x_i + X_{-i}}[R + (\lambda_i - 1)x_i] - \lambda_i\ x_i .$$

If R $\le \lambda_i X_{-i}$, then

$$\pi_i(.) \le \frac{x_i}{x_i + X_{-i}}[\lambda_i X_{-i} + (\lambda_i - 1)x_i] - \lambda_i\ x_i = -\frac{x_i^{\ 2}}{x_i + X_{-i}} \le 0 .$$

Since choosing $x_i = 0$ gives a payoff of 0, the optimal choice when R $\le \lambda_i X_{-i}$ is $x_i = 0$.

If R $> \lambda_i X_{-i}$, then the first order condition for maximizing the payoff π_i is[3]

$$\frac{\partial \pi}{\partial x_i} = \frac{(x_i + X_{-i})\left[R + 2(\lambda_i - 1)x_i\right] - x_i\left[R + (\lambda_i - 1)x_i\right]}{\left(x_i + X_{-i}\right)^2} - \lambda_i = 0 .$$

After some rearrangement, the first order condition can be written as

$$x_i^{\ 2} + 2x_i X_{-i} + \lambda_i X_{-i}^{\ 2} - RX_{-i} = 0 .$$

This can be solved to give the optimal x_i as a function of X_{-i}:

$$x_i = -X_{-i} + \sqrt{(1-\lambda_i)X_{-i}^{\ 2} + RX_{-i}} .$$

Thus, player *i*'s best response function is:

$$\hat{x}_i = \begin{cases} -X_{-i} + \sqrt{(1-\lambda_i)X_{-i}^{\ 2} + RX_{-i}} & \text{if } R > \lambda_i X_{-i} \\ 0 & \text{if } R \le \lambda_i X_{-i} \end{cases} .$$

Figure 1 shows the graph of best response functions with different indices of loss aversion.[4] It shows that given a total amount of expenditure by her rivals, X_{-i}, player *i* will spend less the more loss-averse she is.

--- Figure 1 about here ---

Cornes and Hartley (2003) examine properties of equilibria under the assumption that all players have the same index of loss aversion, i.e. $\lambda_i = \lambda$ for all *i*. If players are not extremely loss-averse ($\lambda \le 2$),[5] they show that there is a unique Nash equilibrium of the

---

[3] The second order condition is $\frac{\partial^2 \pi}{\partial x_i^{\ 2}} = \frac{2X_{-i}\left[(\lambda_i - 1)X_{-i} - R\right]}{(x_i + X_{-i})^3} < 0$, which is satisfied since R $> \lambda_i X_{-i}$.

[4] Strictly speaking, the best response is not defined when $X_{-i} = 0$, since in that case player *i* would want to minimize x_i, subject to $x_i > 0$. This does not affect the existence or properties of equilibrium.

[5] When players are very sensitive to loss ($\lambda > 2$), although there is a unique symmetric equilibrium, there may exist

rent-seeking contest, at which the expenditure of each player is

$$\hat{x} = \frac{R\,(n-1)}{(\lambda-1)(n-1)^2 + n^2}\,.$$

This expression shows a negative relationship between equilibrium expenditure ($\hat{x}$) and the index of loss aversion (λ).

Thus, an increase in players' aversion to loss decreases equilibrium expenditure at both the individual and the aggregate levels. This comparative static property of Cornes and Hartley's model is the basis for our experimental design, which will be described in more detail in the next section.

3. Experimental Design and Procedure

The experiment was conducted in May 2005 at the CeDEx laboratory at the University of Nottingham. Subjects were recruited by e-mail from a university-wide pool of students to take part in a two-session experiment. The sessions were conducted two days apart. In the first session, we ran a pre-test to assess subjects' individual attitudes to loss and divided them into two categories, one relatively more loss-averse than the other. In the second session, subjects classified in the same loss category played rent-seeking contests within fixed three-person groups for 30 rounds.[6]

3.1 Eliciting Measures of Loss Aversion

Kahneman et al. (1990) applied a simple method to derive an estimate of subjects' loss aversion on average. They randomly assigned subjects to two conditions: sellers and buyers. Each seller was given a coffee mug and was asked the minimum offer she would accept in exchange for it (WTA - willingness to accept). Buyers were given nothing and asked the maximum price they would be willing to pay for the mug (WTP - willingness to

---

additional asymmetric equilibria. More discussion can be found in Cornes and Hartley (2003). In our experiment, only 2 out of 73 subjects had an estimated λ higher than 2.

[6] The instructions for both sessions are included as an appendix. Both sessions were computerized using the software package z-tree (Fischbacher, 1999). For technical reasons the 30 rounds of rent-seeking games consisted of 3 sets of 10 rounds, with two-minute breaks at the end of rounds 10 and 20 rounds to reset software; during the breaks subjects were not allowed to talk or leave their seats. We examined our data for restart effects and failed to find any.

pay). In their experiment, the observed ratio between the median value of WTA among sellers and WTP among buyers was about 2. They used loss aversion to explain this disparity and took the ratio of median WTA to WTP as a measure of loss aversion.

For our experiment, we modified the method used by Kahneman et al. (1990) in order to elicit individual-specific measures of loss aversion. In our first session, subjects were required to answer 120 binary choice decision-making questions. At the beginning of the session, subjects received instructions that explained the decision tasks and the mechanism used to determine their earnings. Each subject knew that one of the 120 decision questions, to be drawn randomly by computer at the end of the session, would be for real and the final payoff for this session depended on her answer to this randomly selected question.

The 120 questions were divided into two sets of 60 questions. Questions in the first set were designed to elicit each subject's WTA valuations on three different goods: a box of chocolates, a notebook and a coffee mug that were normally sold at £2.50, £1.99 and £3.25 respectively in the Students' Union Shop.[7] After inspecting samples of the three goods, subjects had to answer the first set of questions. The questions were structured as "Suppose you have *Good A*, would you like to sell it for *£X* ? " , where *Good A* was one of the three items listed above and the range of *£X* was between £1.50 and £7.20, with a variation of £0.30. Accordingly, we had 60 questions in the first set, which were programmed to display on computer screen in a random order. A subject could see 10 questions per screen and she had to complete all the questions shown on the screen before moving on to the next screen.

A consistent subject would refuse to sell a good at all prices below her WTA and would agree to sell at any price higher than her WTA. For example, if a subject gives negative answers to questions "Suppose you have the mug, would you like to sell it for *£X* ? " until the amount of *£X* exceeds £4.50 and afterwards her responses are always positive, then we estimate her WTA for the mug to be £4.50. When all our subjects had given their answers to the first 60 questions, we calculated each one's WTA valuations for the three goods. At the same time a questionnaire was handed out to each subject to fill in.[8]

[7] The reason we chose these three items in our experiment is that we expected most of our subjects to be familiar with them, so that they could easily place their own valuation on them. Subjects may also have been aware of the market price of these goods; Bateman et al. (1997) shows that whether or not subjects know the market price of a good does not affect the psychological impact of loss aversion for it.

[8] The questionnaire included questions about students' familiarity with the goods. It was mainly intended as a "filler task", to give subjects something to do while the experimenter calculated each subject's WTA for the three goods.

About ten minutes later, we gave a second set of 60 questions, which were aimed to derive subjects' WTP for the same goods. Questions in this set had the following form: "If you have *£M* in cash, would you like to pay *£Y* to buy *Good B* ? " *Good B* was one of the three goods that appeared in the first set of questions and *£Y* ranged from £1.50 to £7.20. Given a subject's answers to the second set of questions, we used the same method as before to derive her WTP valuations for the three goods.

A novel aspect of our experimental design is that the amount appearing in the second set of questions, *£M*, was the estimate of each subject's WTA for *Good A*. For instance, from the first set of questions, if a subject's WTA valuations were judged as £6.30, £5.40 and £4.80 for the mug, chocolates and notebook respectively, then the questions created to her in the second set would be: "If you have £6.30 (/£5.40/£4.80), would you like to pay *£Y* to buy the mug (/the box of chocolates/the note book)?" Therefore, different subjects may have different settings of *£M* for the same good. This design allows us to control the effects of income and the elasticity of substitution which Hanemann (1991) suggested may account for some of the divergences between WTA and WTP.

In the first set of questions, a subject starts from the reference point R (see Figure 2), where she owns *Good A* without any money. If *£M* is the minimum offer she would accept in exchange for *Good A*, then point R and M produce the same utility to her from the reference point R, and the estimation of her WTA for *Good A* is *£M*. In the second set of questions, we set subject's reference point at point M, where she doesn't own *Good A* but is endowed with *£M*, the same amount as her WTA for *Good A*. Starting from the reference point M, if *£Y* is the maximum price she is willing to pay for *Good A*, then point M and P produce the same utility to her, *£Y* is our estimation of her WTP. The difference between her WTA (*£M*) and WTP (*£Y*) can be easily explained by loss aversion: since *Good A* is valued as a loss from the initial reference point R but a gain from the reference point M, the difference between *£M* and *£Y* reveals that the disutility of giving up *Good A* is greater then the utility of receiving it. Loss aversion is incompatible with the neoclassical theory of consumer choice, as shown by the indifference curves RM and MP that intersect at M.

However, in the second set of questions, if the subject's endowment is not exactly equal to her WTA (*£M*), the disparity between WTA and WTP could be consistent with neoclassical theory. For example, if in the second set of questions, the subject is endowed with *£M'*, because the indifference curves RM and QM' do not intersect, the shape of the indifference curve, rather than loss aversion, could explain the difference between *£M* and *£Y'*.

--- Figure 2 about here ---

Based on the estimates of subjects' WTA and WTP valuations, we calculated the average WTA/WTP ratio over the three goods for each subject. We used this ratio as an estimate of a subject's index of loss aversion, and using these estimates we divided our subjects into two categories, one relatively more loss-averse than the other.

Seventy-three subjects participated in the first session, which lasted about 40 minutes. Of these, 13 seemed just to give their answers casually without any serious consideration. For example, for questions "Suppose you have a mug, would you like to sell it for £1.50/£2.70/£4.20/£5.40/£6.90?", a subject gave her answers as "No/Yes/No/Yes/No". It is difficult for us to judge her WTA or her index of loss aversion. For that reason, we excluded these inconsistent subjects from our second session. The remaining 60 subjects gave consistent responses and took part in our second session.

For the 60 consistent subjects, the median index of loss aversion (WTA/WTP) was 1.14 and only 3 subjects had their WTA/WTP ratios less than 1. The thirty subjects with their WTA/WTP ratios higher than 1.14 were classified as more loss-averse. The other thirty subjects with WTA/WTP ratios lower than 1.14 were classified as being less loss-averse. On average, both categories of subjects who took part in the second session of the experiment were loss-averse, as the mean WTA/WTP ratios were 1.52 and 1.03 for the more and less loss-averse categories respectively.

3.2 The Rent-Seeking Session

A total of 30 less loss-averse and 30 more loss-averse subjects took part in the second session, where they played 30 rounds of rent-seeking game within fixed three-player groups. This part of the experiment consisted of four sub-sessions with 15 subjects each and subjects in the same sub-session were taken from the same loss-averse category. Altogether we had 10 groups with more loss-averse subjects and 10 groups with less loss-averse subjects.

In this session, all expenditures, prizes and earnings in the game were stated in terms of 'taler', an experimental currency. At the end of the experiment, the total amount of talers subjects earned throughout the 30 rounds was converted to British pounds at an exchange rate of 1000 talers to £1 and paid to subjects anonymously in cash. Each sub-session lasted between 40 and 55 minutes and subject earnings ranged from £7.53 to £11.01. Average earnings were £9.30 for subjects in the more loss-averse category and £8.92 for subjects in the less loss-averse category; the former was significantly higher than the latter (Wilcoxon Rank Sum test, one-sided p-value = 0.029).

In each sub-session, before the rent-seeking game started, written instructions were handed out and read aloud to subjects. These instructions provided comprehensive descriptions of the experimental procedure and the payoff structure. At the beginning of the first round, each subject was randomly assigned to a three-player group which remained fixed throughout the session and knew that two of the other fourteen people in the room were in her group, but had no idea which two. In each round, subjects were given an initial endowment of 300 talers, which they could use to buy lottery tickets costing one taler apiece to compete for a prize of 200 talers with the other two players in their groups. Subjects were informed how their winning probabilities and round payoffs were calculated and they were also aware that when all group competitors had made decisions on how many tickets to buy, one ticket within a group would be randomly drawn by the computer to decide the winner. Feedback was displayed on subjects' screens at the end of each round and included information about the winner of the group, the number of tickets purchased and the round payoff of each group member. Subjects were also kept updated on their accumulated payoffs before every new round began.

With this design, the comparison of expenditures between our two sub-samples allows us to test our primary hypothesis that rent-seeking expenditures will be higher in the less loss-averse sub-sample. In addition, the repetition of the rent-seeking task in our design enables us to examine the role played by learning in rent-seeking contests. The initial behavior of subjects may plausibly depend on their expectations about others' behavior. Whereas in equilibrium these expectations are assumed to be correct, in our experiment we do not expect this to be necessarily the case. Thus the equilibrium expressions in Section 2 may predict subject behavior more closely in later rounds, after subjects have had a chance to learn about the behavior of others.

4. Experimental Results

4.1 Early Round Behavior: Rounds 1-10

In the very first round we observe a clear relationship between rent-seeking expenditures and loss aversion. Figure 3 presents a scatter-plot of individual expenditures in round one against the measure of loss aversion taken from the elicitation session. Also shown is an OLS regression line where the coefficient on loss aversion is negative and significant ($t = -2.34$, one-sided p-value = 0.012). Non-parametric analysis of the data yields the same conclusion: the correlation between individual expenditures in round one and individual indices of loss aversion is negative and significant (Spearman Rank-Order Correlation Coefficient = –0.28, one-sided p-value = 0.016).[9]

--- Figure 3 about here ---

This pattern holds beyond the first round. Because individuals interact in fixed groups with no information passing between groups, we base inferences on group-level data. For each group we measure loss aversion as the average of each group member's index of loss aversion, and compare this with average group expenditures. Figure 4 presents a scatter-plot of average group expenditure over the first ten rounds against the measure of loss aversion (thus, each point in the scatter-plot corresponds to a three-person group). Also shown is an OLS regression line, which again displays a negative and significant coefficient on loss aversion ($t = -2.53$, one-sided p-value = 0.011). Again, non-parametric test supports this conclusion: the average group expenditure over the first ten rounds is negatively and significantly correlated with the measure of loss aversion (Spearman Rank-Order Correlation Coefficient = –0.43, one-sided p-value = 0.029).

--- Figure 4 about here ---

Given these data, it should not be surprising that when we compare the more loss-averse and less loss-averse sub-samples the comparative static predictions of Section 2 are borne out. Table 1(a) shows the average expenditure of groups in the first ten rounds. Expenditures by less loss-averse groups are 35% higher than expenditures by more loss-averse groups. The difference is significant, based on a Wilcoxon Rank Sum test (one-sided p-value = 0.021), and strongly confirms the hypothesis that more loss-averse

[9] One-sided tests are appropriate in our context as the theoretical considerations of Section 2 suggest a directional alternative to the null hypothesis of no relationship between expenditure and loss aversion.

expenditures will be closer to equilibrium in the second ten rounds. Similarly we test whether group expenditures in the last ten rounds are closer to equilibrium than group expenditures in the second ten rounds.

Note that in the first 10 rounds, 9 out of 10 less loss-averse groups invested more than the amount of the prize (200 talers) in rent-seeking (see Table 1(a)). Realizing their group expenditures were too high, even higher than the prize itself, all of these groups learned their lessons fast and lowered their expenditures in rounds 11-20. As a result there is a significant tendency for group expenditures by less loss-averse groups to move closer to the loss-neutral prediction between the first and second thirds of the session (Wilcoxon Signed-Rank test, one-sided p-value = 0.005). However, we observe no such learning effect after the second 10 rounds (Wilcoxon Signed-Rank test, one-sided p-value = 0.930). This is despite the fact that in the second 10 rounds average group expenditures are 180.9 talers per group per round, still higher than loss-neutral equilibrium (though somewhat less than the prize). For more loss-averse groups, no such learning effect was found throughout the whole session (Wilcoxon Signed-Rank test, one-sided p-values = 0.361 and 0.807 after the first and second 10 rounds respectively).

These tests suggest that subjects reduce their spending when group expenditure exceeds the amount of the prize, but they fail to adjust expenditures further, even though this leaves expenditures still higher than predicted. This suggestion is supported by Figure 8 which depicts each individual's average expenditure over the three sets of 10 rounds, with data from the less and more loss-averse sub-samples presented in Panels (a) and (b). Also shown are average best response functions (based on indices of loss aversion $\lambda = 1.03$ and 1.52, each corresponding to the average WTA/WTP ratio for the relevant sub-samples), plotted as solid lines. The Figure also shows dashed lines along which group expenditure is exactly equal to the prize; from the dashed line, group expenditure increases northeasterly and decreases southwesterly. Comparing the first ten rounds with the second ten it is clear that many individuals find themselves in groups where expenditures exceed the prize in the first ten rounds, and then learn to reduce expenditures in the second ten rounds. However, a comparison of the third ten rounds with the second ten shows that this process does not converge to the equilibrium. Neither more nor less loss-averse groups learned to decrease their expenditure to the equilibrium predicted level.

--- Figure 8 about here ---

The analysis above is supported by further analysis using individual-level data. We examined how subjects adjusted their expenditures from round to round. We first examine whether subjects adjust their expenditure in the direction of the best response. In our rent-seeking session, subjects received feedback at the end of each round about the number of tickets purchased by each group member and the earnings of each group member. In principle, subjects could have evaluated what decision would have maximized their expected earnings, taking as given other subjects' decisions. For example, if a subject has an index of loss aversion of 1.56, and the total expenditure by her rivals in round t is 100 talers, her best response function suggests her optimal expenditure to be 20 talers. Suppose her actual expenditure in round t is 55 talers, then if she decreases her expenditure in round $t+1$, she moves in the direction of what her own best-response suggested; otherwise, she does not adjust her expenditure in the direction of her best response.

Assuming subjects evaluate outcomes in this way, then out of 29 rounds, the average number of expenditure adjustments made by subjects in the best-response suggested direction should be significantly higher than 14.5, the number of adjustments in this direction that would be expected when adjustments were purely random. However, our results show that the average number of expenditure adjustments in the predicted direction is 14.5 and 11.9 for less and more loss-averse subjects respectively. Therefore, subjects do not have a systematic tendency to move in the direction of best responses to opponents' previous round choices.

There are of course other ways in which subjects could evaluate outcomes. For example, it seems obvious that if group expenditures exceed the prize then the group as a whole is losing money and should, from a group perspective, decrease expenditures. In fact, even from an individual perspective a subject earns more if she reduces expenditures in this case.[10] On the other hand, if group expenditures are below the value of the prize, it may not be so obvious to a subject why she should reduce expenditures. Indeed, suppose individual expenditures do not exceed the prize (i.e. $x_i \leq R$ for all i). Then the subject who

[10] This is because the marginal earnings from an additional unit of expenditure is $\partial\pi / \partial x_i = X_{-i}R / X^2 - 1$. This is clearly less than $XR / X^2 - 1 = R / X - 1$. In turn this expression is negative if $X > R$.

wins the prize will always earn the most money. The winner of the prize is most likely to be the subject who spent the most. Thus if subjects imitate the choices of the most successful player there will be a tendency to increase expenditures. More formally, an "imitate the best" dynamic converges to full dissipation in the long-run.[11]

In order to examine how group expenditures adjusted relative to the full dissipation level, we tested formally whether there is a systematic tendency for groups to reduce their expenditure when their total expenditure is higher than the prize, and increase it when their total expenditure is lower than the prize. Out of 29 rounds, the average number of the changes in group expenditure in the direction towards 200 talers is 19.5 and 17.3 for less and more loss-averse subjects respectively; both of them are significantly higher than the 14.5, the number of adjustments in this direction that would be expected when adjustments were purely random (Wilcoxon Signed-Rank test, one-sided p-values = 0.003 and 0.020 for less and more loss-averse groups respectively). Thus, dynamic adjustments of rent-seeking expenditures appear to move groups in the direction of full dissipation, rather than in the direction of the Nash equilibrium.

5. Conclusion

The results of our experiment show a clear negative relationship between loss-aversion and initial rent-seeking expenditures. In the early rounds of the rent-seeking experiment groups composed of more loss-averse subjects spend significantly less than groups composed of less loss-averse subjects. This confirms one of the suggestions from Cornes and Hartley's (2003) model: the existence of loss aversion can reduce rent dissipation in rent-seeking contests. However, we also observed higher levels of rent-seeking expenditure than predicted for both more and less loss-averse sub-samples. Thus, although loss aversion can reduce the extent of rent dissipation in rent-seeking contests, we still observe over-dissipation. Moreover, the effect weakens with repetition. The difference between the expenditures of our two sub-samples is only significant for the first 10 rounds; it is not significant for the later rounds.

Further analysis of adjustments in rent-seeking expenditures showed some strong

[11] Evolutionary game theory also suggests convergence toward full dissipation. For example, in this rent-seeking game Nash equilibrium strategies are not evolutionary stable, and the unique evolutionary stable strategy is for a player to spend one n^{th} of the prize, leading to full dissipation by the n-member group (see Hehenkamp, Leininger and Possajennikov, 2004).

--- Figure 8 about here ---

The analysis above is supported by further analysis using individual-level data. We examined how subjects adjusted their expenditures from round to round. We first examine whether subjects adjust their expenditure in the direction of the best response. In our rent-seeking session, subjects received feedback at the end of each round about the number of tickets purchased by each group member and the earnings of each group member. In principle, subjects could have evaluated what decision would have maximized their expected earnings, taking as given other subjects' decisions. For example, if a subject has an index of loss aversion of 1.56, and the total expenditure by her rivals in round *t* is 100 talers, her best response function suggests her optimal expenditure to be 20 talers. Suppose her actual expenditure in round *t* is 55 talers, then if she decreases her expenditure in round *t+1*, she moves in the direction of what her own best-response suggested; otherwise, she does not adjust her expenditure in the direction of her best response.

Assuming subjects evaluate outcomes in this way, then out of 29 rounds, the average number of expenditure adjustments made by subjects in the best-response suggested direction should be significantly higher than 14.5, the number of adjustments in this direction that would be expected when adjustments were purely random. However, our results show that the average number of expenditure adjustments in the predicted direction is 14.5 and 11.9 for less and more loss-averse subjects respectively. Therefore, subjects do not have a systematic tendency to move in the direction of best responses to opponents' previous round choices.

There are of course other ways in which subjects could evaluate outcomes. For example, it seems obvious that if group expenditures exceed the prize then the group as a whole is losing money and should, from a group perspective, decrease expenditures. In fact, even from an individual perspective a subject earns more if she reduces expenditures in this case.[10] On the other hand, if group expenditures are below the value of the prize, it may not be so obvious to a subject why she should reduce expenditures. Indeed, suppose individual expenditures do not exceed the prize (i.e. $x_i \leq R$ for all i). Then the subject who

[10] This is because the marginal earnings from an additional unit of expenditure is $\partial\pi/\partial x_i = X_{-i}R/X^2 - 1$. This is clearly less than $XR/X^2 - 1 = R/X - 1$. In turn this expression is negative if $X > R$.

wins the prize will always earn the most money. The winner of the prize is most likely to be the subject who spent the most. Thus if subjects imitate the choices of the most successful player there will be a tendency to increase expenditures. More formally, an "imitate the best" dynamic converges to full dissipation in the long-run.[11]

In order to examine how group expenditures adjusted relative to the full dissipation level, we tested formally whether there is a systematic tendency for groups to reduce their expenditure when their total expenditure is higher than the prize, and increase it when their total expenditure is lower than the prize. Out of 29 rounds, the average number of the changes in group expenditure in the direction towards 200 talers is 19.5 and 17.3 for less and more loss-averse subjects respectively; both of them are significantly higher than the 14.5, the number of adjustments in this direction that would be expected when adjustments were purely random (Wilcoxon Signed-Rank test, one-sided p-values = 0.003 and 0.020 for less and more loss-averse groups respectively). Thus, dynamic adjustments of rent-seeking expenditures appear to move groups in the direction of full dissipation, rather than in the direction of the Nash equilibrium.

5. Conclusion

The results of our experiment show a clear negative relationship between loss-aversion and initial rent-seeking expenditures. In the early rounds of the rent-seeking experiment groups composed of more loss-averse subjects spend significantly less than groups composed of less loss-averse subjects. This confirms one of the suggestions from Cornes and Hartley's (2003) model: the existence of loss aversion can reduce rent dissipation in rent-seeking contests. However, we also observed higher levels of rent-seeking expenditure than predicted for both more and less loss-averse sub-samples. Thus, although loss aversion can reduce the extent of rent dissipation in rent-seeking contests, we still observe over-dissipation. Moreover, the effect weakens with repetition. The difference between the expenditures of our two sub-samples is only significant for the first 10 rounds; it is not significant for the later rounds.

Further analysis of adjustments in rent-seeking expenditures showed some strong

[11] Evolutionary game theory also suggests convergence toward full dissipation. For example, in this rent-seeking game Nash equilibrium strategies are not evolutionary stable, and the unique evolutionary stable strategy is for a player to spend one n^{th} of the prize, leading to full dissipation by the n-member group (see Hehenkamp, Leininger and Possajennikov, 2004).

similarities between the adjustment patterns of the two sub-samples. Subjects in both sub-samples react to situations of over-dissipation by reducing expenditure. However, they do not reduce expenditure all the way to the Nash equilibrium. Once the reduction is sufficient to help them escape group losses, they show no systematic tendency to further reduce expenditures. Rather, groups appear to move systematically in the direction of full dissipation. The convergence in behavior of less and more loss-averse groups reflects this pattern. In early rounds it was the less loss-averse groups that tended to spend more on rent-seeking than the value of the prize. These groups learned to reduce their expenditures in later rounds, and this brought their expenditures in line with the more loss-averse groups.

One reason why the effect of loss aversion on rent-seeking behavior weakens over time may be that attitudes to loss aversion may change over time. One possibility is that the degree of loss aversion may change across rounds as subjects accumulate earnings in the experiment. Note that the more loss averse groups spend less on rent seeking in early rounds, and so we would expect that these groups to be wealthier (relative to the less loss averse groups) in later rounds. If wealthier people are less loss averse, we would expect the differences in the attitudes toward loss aversion between the two sub-samples to weaken. However, the only evidence of which we are aware linking loss aversion to wealth is a study by Johnson et al. (2006), who find that wealthier people are *more* sensitive to losses. Similarly Barkan and Busemeyer (1999) find that subjects' risk preferences tend to switch towards risk aversion after experiencing a gain, and towards risk seeking after experiencing a loss. [12] A similar pattern in our data (i.e. less loss averse after experiencing a loss) would amplify, not erode, the difference between sub-samples.

More fundamentally, loss aversion itself may be a transient phenomenon, only displayed by inexperienced subjects. Indeed, List (2003) suggests market experience can eliminate the WTA/WTP disparity, and thus, loss aversion is limited to inexperienced subjects. Since repetition of our rent-seeking game allows subjects to gain experience, it may be that repetition makes both groups effectively loss-neutral in later rounds, and this eliminates the original distinction between our two sub-samples.

---

[12] A similar argument that losses lead to more aggressive behavior in has been made in the context of real-world contests. In an empirical study of twentieth century battles, Bauer and Rotte (1997) suggest that "the experience of losses contributes positively to the preparedness to continue fighting, up to a point where casualties clearly outweigh any direct utility drawn from ordinary expected-utility theory."

We find it intriguing that even among subjects in our more loss-averse category, rent-seeking expenditures substantially exceed equilibrium predictions, and that this substantial level of over-dissipation persists into later rounds. This over-dissipation is consistent with other laboratory rent-seeking experiments. This appears to be a form of anomalous behavior that is *not* eliminated by experience. Our experiment was not designed to investigate the reasons for such over-dissipation, and we leave this topic open for future research.

Table 1. Group expenditure per round and dissipation rate

(a) Round 1-10

Group	More Loss-averse Groups		Less Loss-averse Groups	
	Rent-seeking Expenditure (taler)	Rent Dissipation Rate	Rent-seeking Expenditure (taler)	Rent Dissipation Rate
1	138.3	0.69	292.4	1.46
2	228.2	1.14	208.2	1.04
3	109.7	0.55	235.5	1.18
4	150.2	0.75	142.1	0.71
5	255.5	1.28	302.5	1.51
6	203.0	1.02	273.0	1.37
7	292.5	1.46	240.3	1.20
8	89.5	0.45	218.7	1.09
9	221.3	1.11	275.1	1.38
10	101.5	0.51	229.5	1.15
Average	179.0	0.89	241.7	1.219
(s.e.)	(70.6)	(0.35)	(47.3)	(0.24)

(b) Round 11-20

Group	More Loss-averse Groups		Less Loss-averse Groups	
	Rent-seeking Expenditure (taler)	Rent Dissipation Rate	Rent-seeking Expenditure (taler)	Rent Dissipation Rate
1	164.7	0.82	148.9	0.74
2	195.9	0.98	196.5	0.98
3	144.8	0.72	154.0	0.77
4	41.8	0.21	157.1	0.79
5	207.6	1.04	247.6	1.24
6	148.5	0.74	175.5	0.88
7	195.0	0.98	124.4	0.62
8	106.5	0.53	183.8	0.92
9	261.0	1.31	253.9	1.27
10	51.7	0.26	167.7	0.84
Average	151.8	0.76	180.9	0.90
(s.e.)	(69.3)	(0.35)	(41.8)	(0.21)

(c) Round 21-30

Group	More Loss-averse Groups		Less Loss-averse Groups	
	Rent-seeking Expenditure (taler)	Rent Dissipation Rate	Rent-seeking Expenditure (taler)	Rent Dissipation Rate
1	185.4	0.93	179.8	0.90
2	228.3	1.14	188.0	0.94
3	105.1	0.53	210.8	1.05
4	159.1	0.80	176.5	0.88
5	245.2	1.23	273.2	1.37
6	141.0	0.71	167.5	0.84
7	238.5	1.19	181.3	0.91
8	163.0	0.82	178.4	0.89
9	265.9	1.33	215.5	1.08
10	74.9	0.37	249.5	1.25
Average	180.6	0.90	202.1	1.01
(s.e.)	(63.5)	(0.32)	(35.1)	(0.18)

Figure 1. Best response functions with different indices of loss aversion

($\lambda_1 < \lambda_2 < \lambda_3 < \lambda_4$ **)**

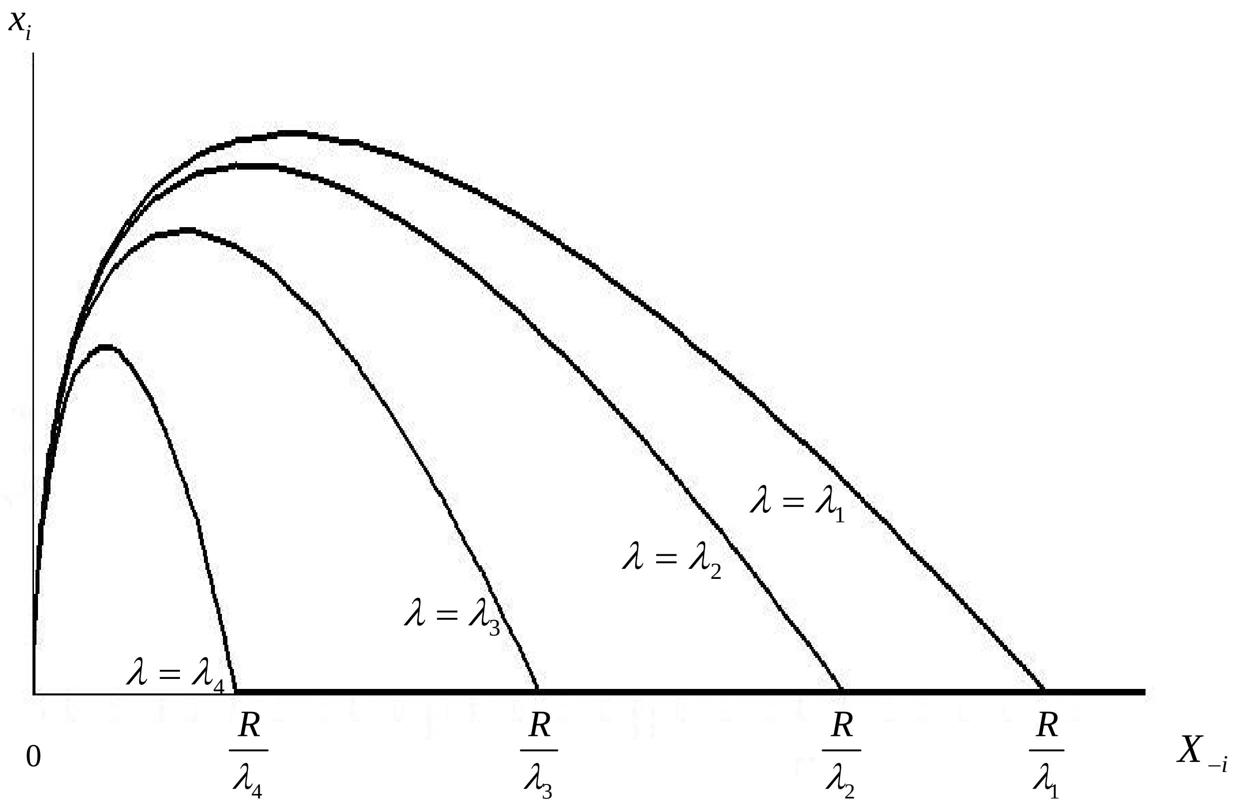


Figure 2. Indifference curves and the divergences between WTA and WTP

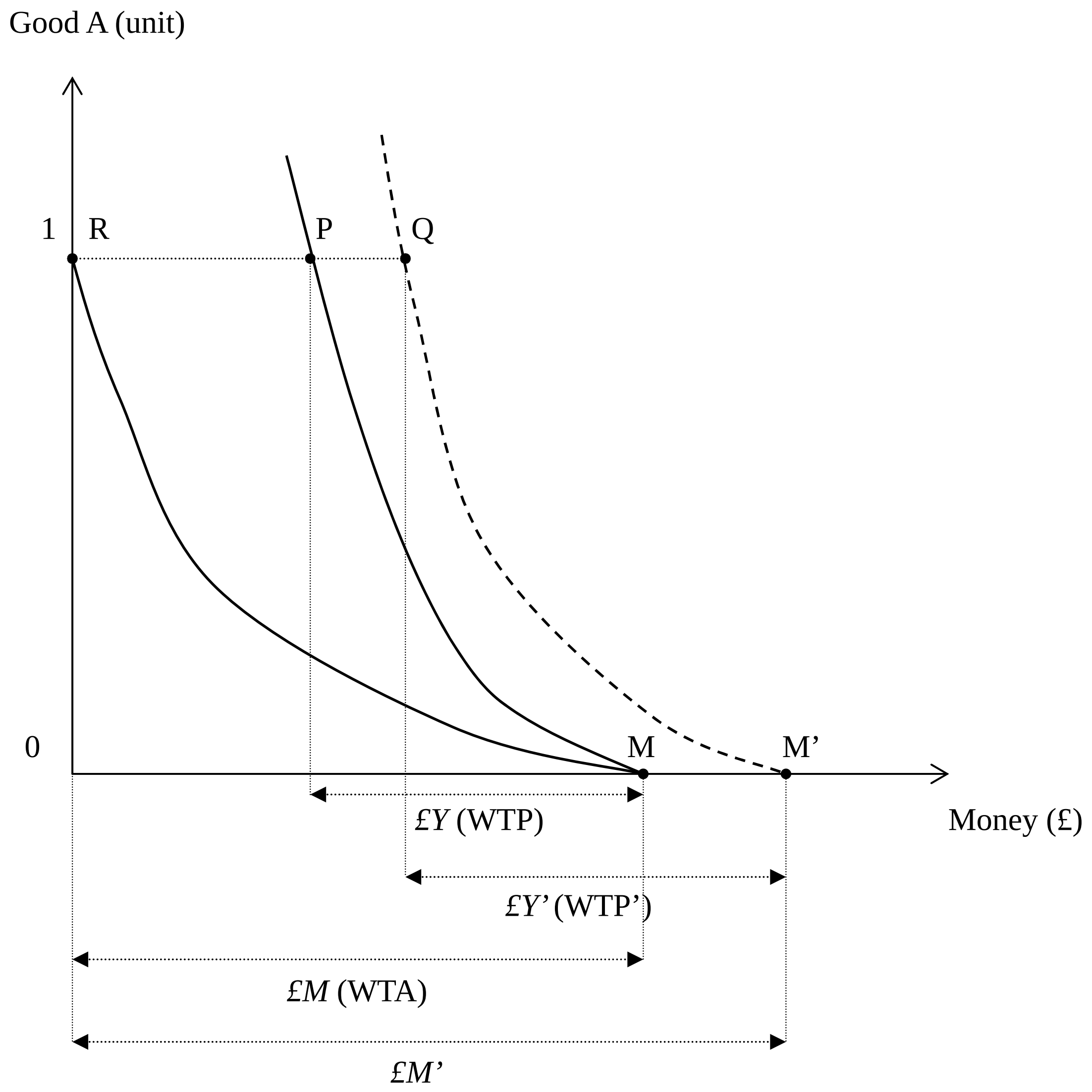


Figure 3. Individual expenditures in round one and indices of loss aversion

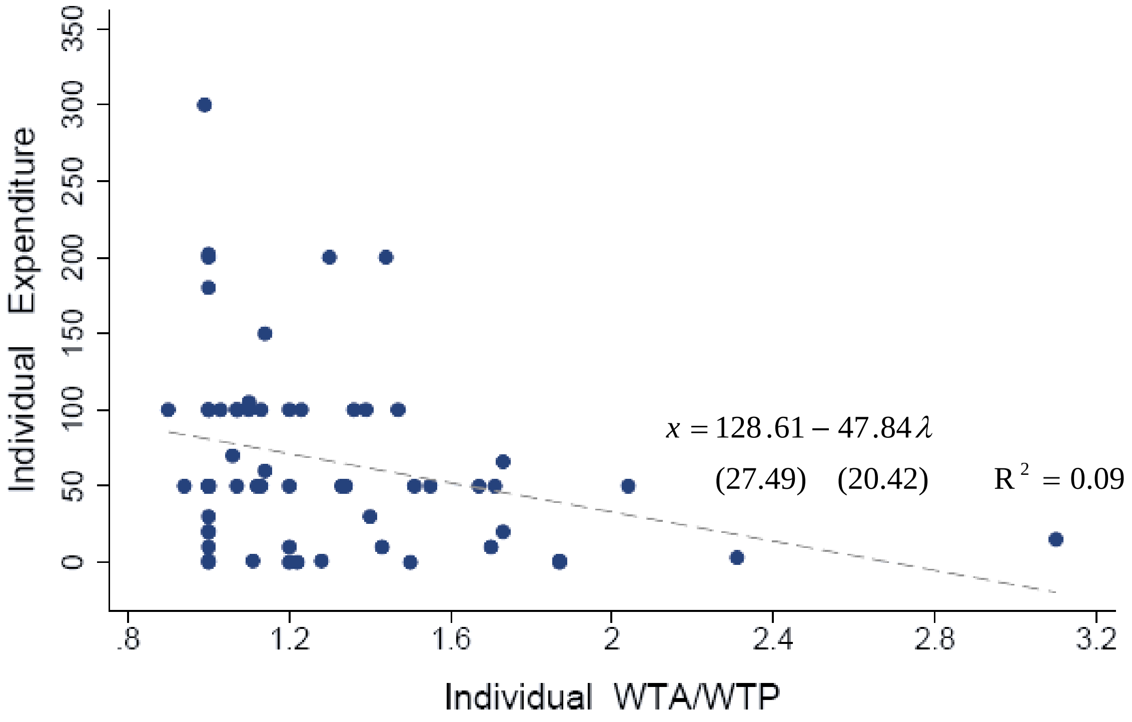


Figure 4. Group expenditures in rounds 1-10 and indices of loss aversion

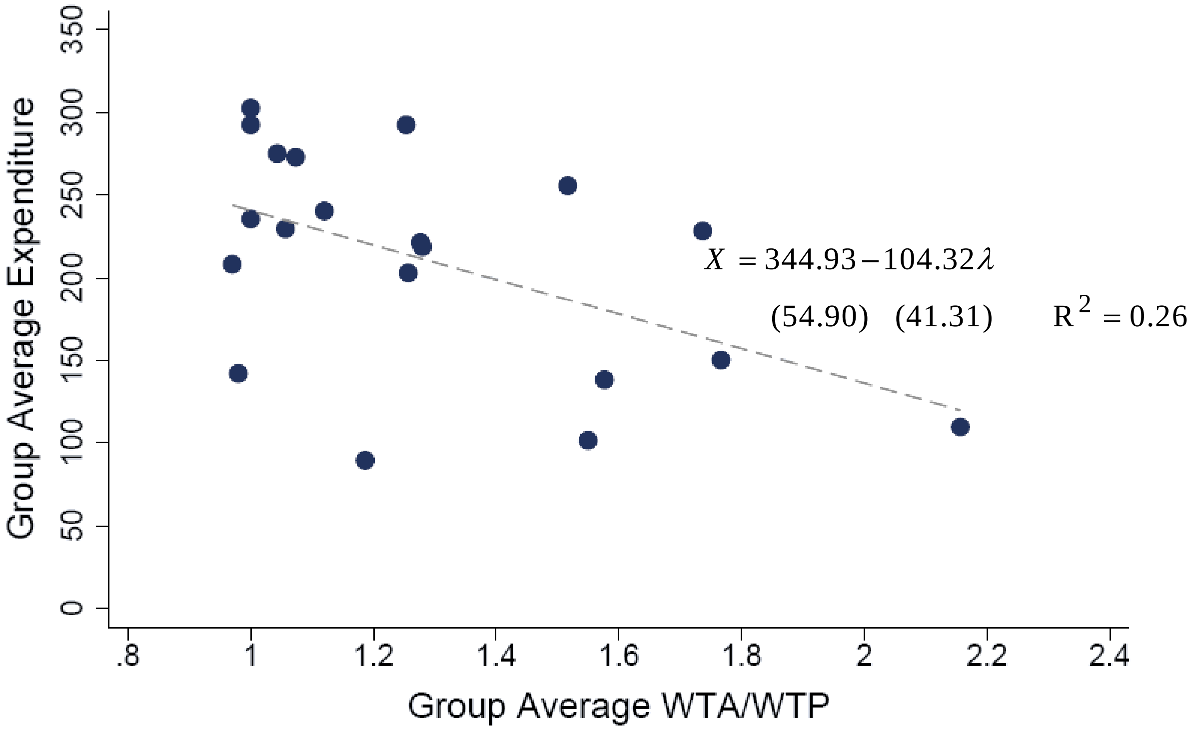


Figure 5. Average group expenditure in rounds 1-10

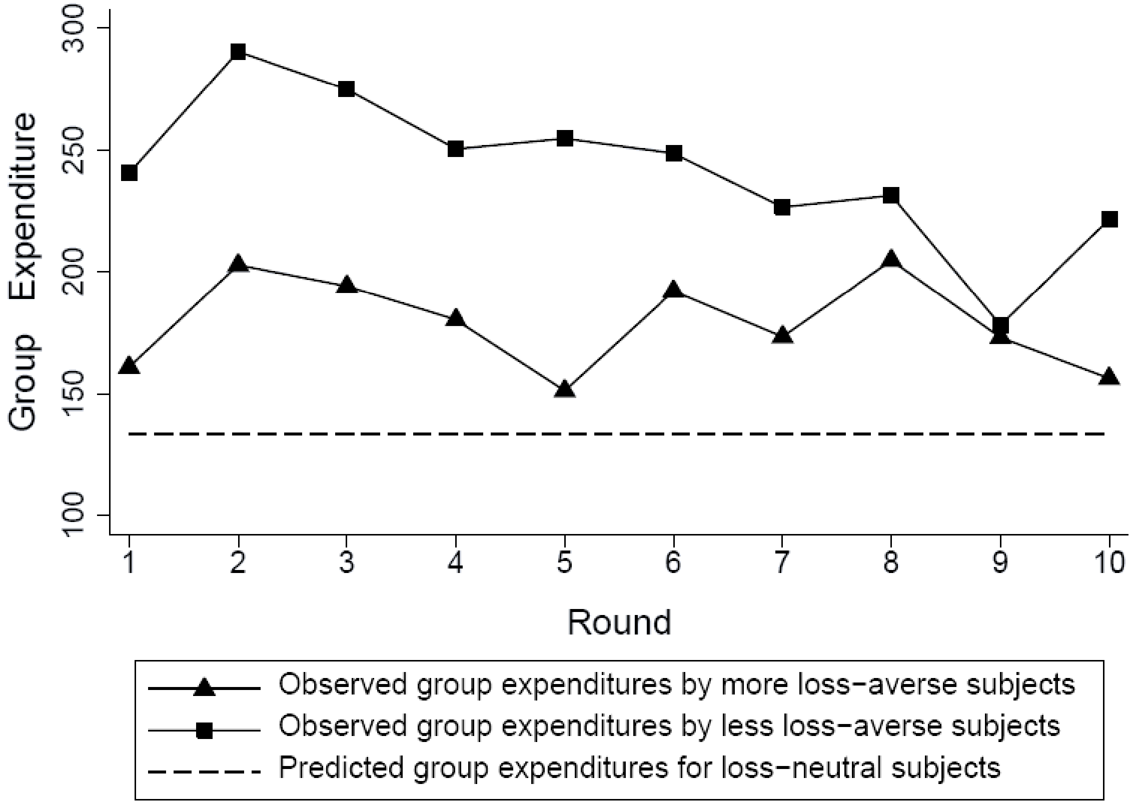


Figure 6. Group expenditures in rounds 1-30 and indices of loss aversion

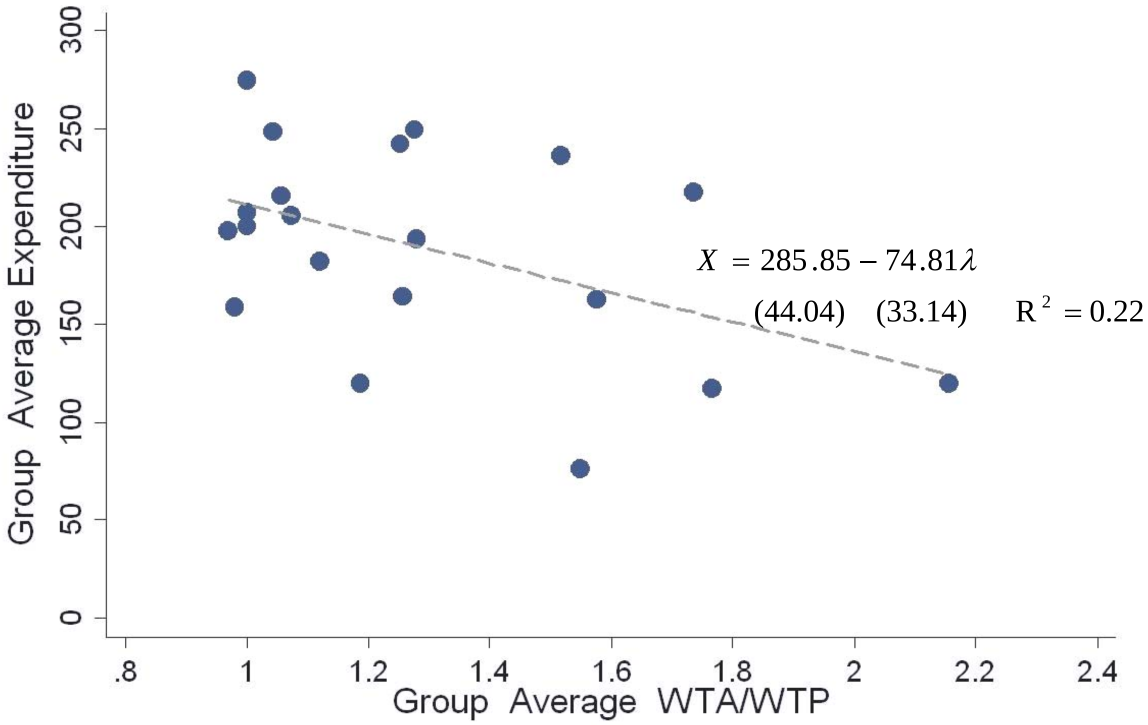


Figure 7. Average group expenditures in rounds 1-30

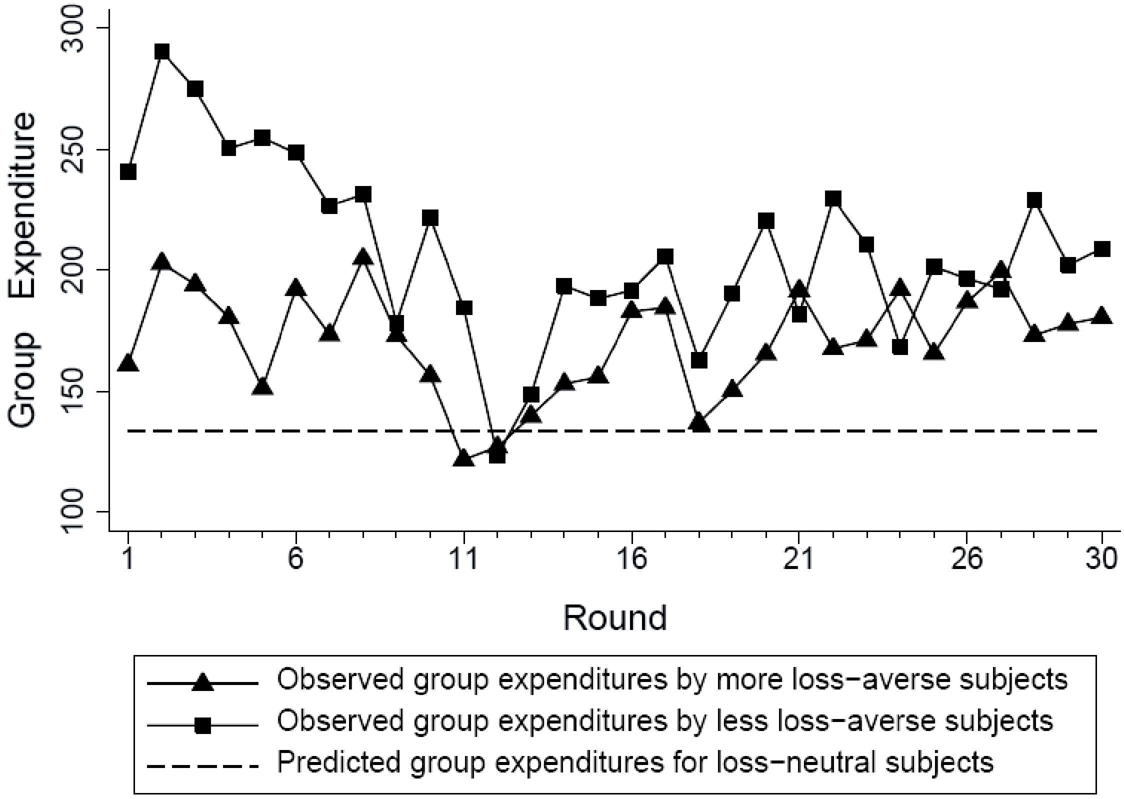
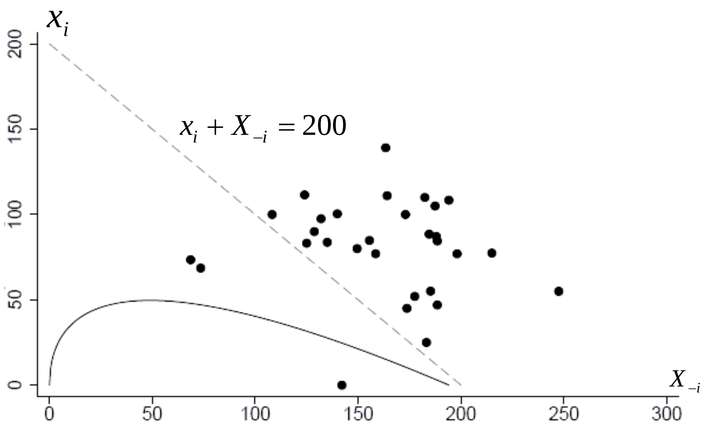


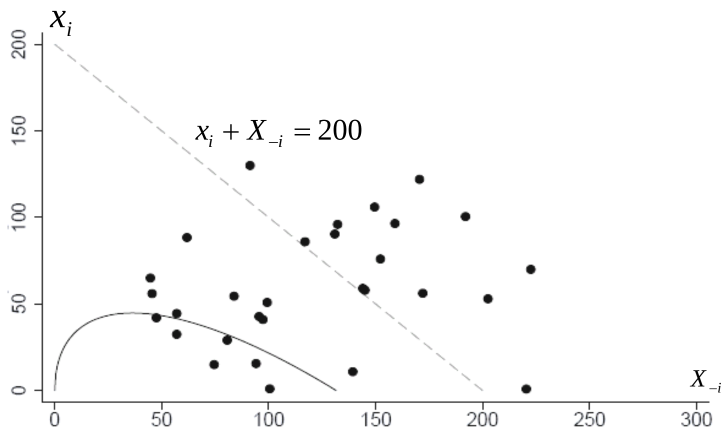
Figure 8. Average Individual Expenditure over three sets of 10 rounds (Round 1-10, Round11-20, Round 21-30)

(a) Less Loss-Averse Subjects | **(b) More Loss-Averse Subjects**

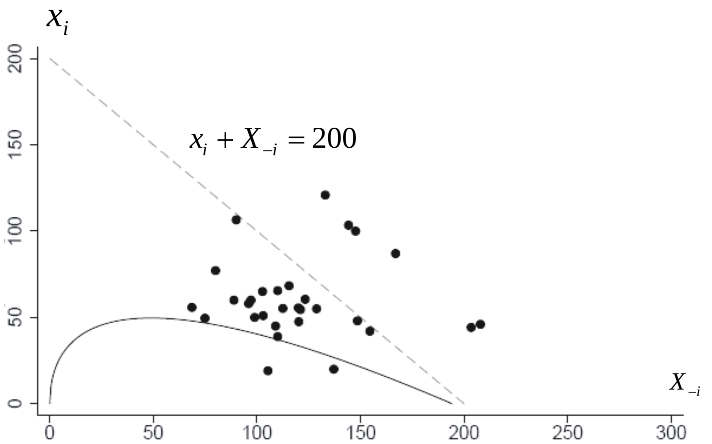
i. Round 1-10 (a)



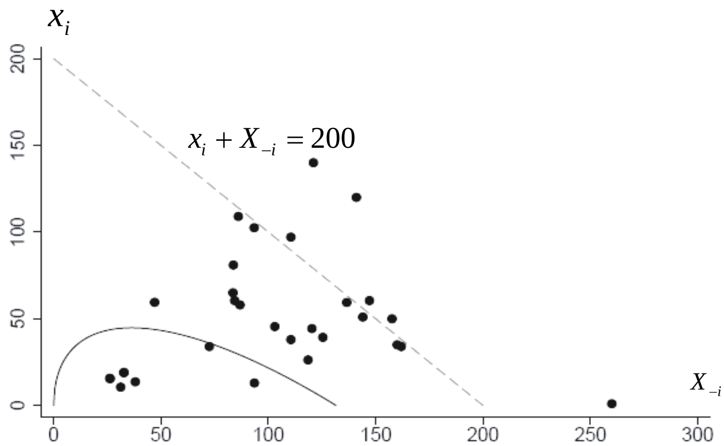
i. Round 1-10 (b)



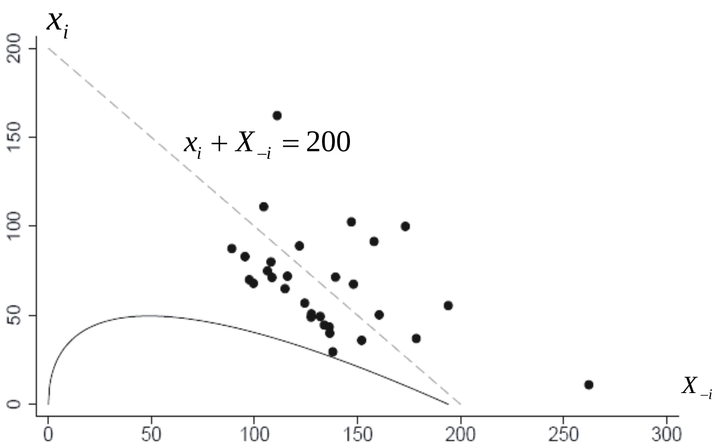
ii. Round 11-20 (a)



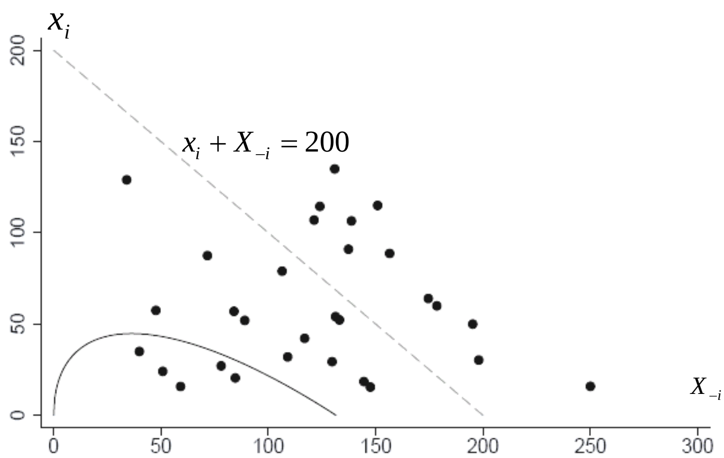
ii. Round 11-20 (b)



iii. Round 21-30 (a)



iii. Round 21-30 (b)



X_{-i} **-Average total expenditure by the other two group member of each 10 rounds**

x_i **- Average individual expenditure of each 10 rounds**

Appendix. Experimental Instructions

General Instructions

Thank you for coming to our experiment. This experiment consists of **2 sessions**. Today we are going to run the first session and **the second one will be run on this Thursday (12th of May).** We'll write an email to inform you the precise time to come for the second session by 2pm this Wednesday.

The purpose of this experiment is to study how people make decisions in a particular situation. During the experiment it is not permitted to talk or communicate with other participants. If you have any question, please raise your hand and one of us will come to your table to answer it. During the sessions you will earn money and maybe some good as well (such as chocolates, notebook etc). **At the end of the first session you will receive a statement signed in acknowledgement of your earnings; And at the end of the second session, the total amount you have earned from both two sessions will be paid to you *together***. Payments are confidential, we will not inform any other participant of the amount you have earned.

Please keep the statement signed in acknowledgement of your earnings from the first session safely and bring it with you when you come to the second session this Thursday (12th of May).

And **please make sure that you would come and participate the second session of this experiment at the time you informed.** Your absence from the second session could result in our experiments breaking down, therefore you will be unqualified to claim what you have earned from the first session.

Thanks for your participation.

Instructions (for Session A)

This session consists of 120 binary choice decision making problems for you to answer. The session is divided into 2 parts: After every participant has completed the first 60 questions, there is a questionnaire for you to fill in; then participants begin to answer the other 60 questions.

There are two types of questions in the session:
Questions from 01 to 60 are like:
Suppose you have ***Good A***, would you like to sell it for ***X pounds***? (Yes or No)
Questions from 61 to 120 are like:
If you have ***M pounds***, would you like to pay ***Y pounds*** to buy ***Good B***? (Yes or No)

At the end of this session, the computer will randomly draw one question among all the 120 questions in the survey. Your final payoff for this session depends on the answer you have made to this randomly selected question.

If the randomly selected question is **one out of question 01-60**, ***Good A*** will be handed to you first. Then, if the answer you have given is '**yes**', we would **buy (take) Good A from you and pay you X pounds as your final payoff** for this session; if the answer you have given is '**no**', **you would keep Good A as your final payoff** for this session.

If the randomly selected question is **one out of question 61-120**, you will be given **M pounds as your credit** first. Then, if the answer you have given is '**yes**', we would **sell (give) Good B to you at a price of Y pounds and your final payoff for this session is: M pounds- Y pounds +Good B**; if the answer you have given is '**no**', **you would keep that M pounds as your final payoff** for this session.

During the session, you are not allowed to talk or communicate. If you have any question, please raise your hand and one of us will come to your desk to answer it.

Instructions (for Second Session)

Thank you for coming to the second session of our experiment. The purpose of this experiment is to study how people make decisions in a particular situation. During the experiment it is not permitted to talk or communicate with other participants. If you have any question, please raise your hand and one of us will come to your table to answer it.

Payment
During the session you will earn money, at the end of the session, the total amount you have earned will be paid to you by cash. The unit of payoff shown in the instructions and the computer screens are in ***talers***, which is the experimental currency used in this session. At the end of the session your total payoff will be converted into sterling at an exchange rate of 1 pound for each 1000 talers. Payments are confidential; we will not inform any other participant of the amount you have earned.

This session consists of 30 rounds. At the beginning of the first round, you will be randomly assigned to a group consisting of you and two other participants and your group members will be the same during the session.

Rules of the decision situation in each round:

In each round, you are competing for a prize of 200 talers with the other two players in your group by purchasing lottery tickets. One of the three players in your group will win the prize and the probability that you win the prize depends on your own decision and the decisions made by the other two players in your group.

We will begin every round by giving you 300 talers as an initial endowment, which you can use to buy the lottery tickets. Each ticket costs you 1 taler, so you will be able to buy up to 300 tickets every round.

Each player will separately make a decision on the number of lottery tickets he/she wish to buy. When the decision has been made, please enter the number into the computer.

Your probability of winning the prize depends on the number of tickets you buy and the number of tickets purchased by the other two players in your group. More precisely, the probability that you win the prize equals the ratio of the number of tickets you buy and the total number of the tickets bought by all the 3 players in your group:

$$\text{Probability of you winning the prize} = \frac{\text{Number of tickets you buy}}{\text{Total number of tickets bought by your group}}$$

If none of the players buys a ticket, each player will have an equal chance (1/3) of winning the prize.

After every player has made his/her decision, the computer will randomly draw one ticket among all the purchased tickets to decide who the winner is.

<u>If you are the winner</u>, your round payoff will be:
Payoff = 300 (initial endowment) – the money you spent to buy lottery tickets
+ 200 (the prize of the lottery)

<u>If you are not the winner</u>, your round payoff will be:
Payoff = 300 (initial endowment) – the money you spent to buy lottery tickets

At the end of each round you will be informed about the winner of the lottery and the round payoff of yourself and your competitors. In addition, you will also be able to see the result of previous round and your updated total payoff.

Payment:
The payoffs shown in both the instructions and the computer screens are in ***talers***, which is the experimental currency used in this session. At the end of the session your total payoff will be converted into sterling at the exchange rate of 1 pound for each 1000 talers.

References

Barkan, R. and Busemeyer, J.R. (1999) Changing Plans: Dynamic Inconsistency and the Effect of Experience on the Reference Point. *Psychonomic Bulletin & Review* 6: 547-554.

Bauer, T. and Rotte, R. (1997) Prospect Theory Goes to War: Loss-aversion and the Duration of Military Combat. *Working Paper*, Sonderforschungsbereich 386, Paper 97.

Cornes, R. and Hartley, R. (2003) Loss Aversion and the Tullock Paradox. *Working Paper*, School of Economics, University of Nottingham.

Davis, D.D and Reilly, R.J. (1998) Do Too Many Cooks Always Spoil the Stew? An Experimental Analysis of Rent-seeking and the Role of a Strategic Buyer. *Public Choice* 95: 89-115.

Fischbacher, Urs (1999) *Z*-Tree. Toolbox for Readymade Economic Experiments, *IEW Working Paper* 21, University of Zurich.

Hanemann, W.M. (1991) Willingness to Pay and Willingness to Accept: How Much Can They Differ? *American Economic Review* 81: 635-647.

Hehenkamp, B., Leininger, W. and Possajennikov, A. (2004) Evolutionary Equilibrium in Tullock Contests: Spite and Overdissipation. *European Journal of Political Economy* 20: 1045-1057.

Hillman, A.L. (2003) Public Finance and Public Policy: Responsibilities and Limitations of Government. Cambridge University Press.

Johnson, E.J., Gaechter, S. and Herrmann, A. (2006) Exploring the Nature of Loss Aversion. *IAZ Discussion Paper*, No. 2015.

Kahneman, D. and Tversky, A. (1979) Prospect Theory: An Analysis of Decision under Rrisk. *Econometrica* 47: 263-291.

Kahneman, D., Knetsch J.L. and Thaler R.H. (1990) Experimental Tests of the Endowment Effect and the Coase Theorem. *Journal of Political Economy* 98: 1325-1348.

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

List, J. A. (2003). Does Market Experience Eliminate Market Anomalies? *Quarterly*

Journal of Economics 118: 41-71.

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

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

Nitzan, S. (1994) Modelling Rent-seeking Contests. *European Journal of Political Economy* 10: 41-60.

Potters, J., de Vries, C. and van Winden, F. (1998) An Experimental Examination of Rational Rent-seeking. *European Journal of Political Economy* 14: 783-800.

Schmidt, D., Shupp, R. and Walker, J. (2006) Resource Allocation Contests: Experimental Evidence. *CAEPR Working Paper*, No. 2006-004.

Shogren, J.F., Baik, K.H. (1991) Reexamining Efficient Rent-seeking in Laboratory Markets. *Public Choice* 69: 69-79.

Tullock, G. (1967) The Welfare Costs of Tariffs, Monopoly and Theft. *Western Economic Journal* 5: 224-232.

Tullock, G. (1980) Efficient Rent-seeking. In J.M. Buchanan, R.D. Tollison and G. Tullock (Eds.), Toward a theory of rent-seeking society, 97-112. College Station: Texas A&M University Press.