When Does an Incentive for Free Riding Promote Rational Bidding?

By James C. Cox and Stephen C. Hayne*

Abstract

Economics has focused on models of individual rational agents. But many important decisions are made by small groups such as families, management teams, boards of directors, central bank boards, juries, appellate courts, and committees of various types. For example, bid amounts in common value auctions such as the Outer Continental Shelf oil lease auction are typically decided by committees. Previous experimental research with natural groups has found that group bidders are significantly less rational than individual bidders in how they use information in common value auctions. Experiments reported here involve cooperative and non-cooperative nominal groups. The unequal profit-sharing rule applied to non-cooperative nominal groups creates an incentive to free ride within the bidding groups. This incentive to free ride tends to offset the winner's curse and promote rational bidding.

1. Introduction

Economics has traditionally focused primarily on the behavior of individual rational agents interacting in markets and other strategic game environments. But many important economic, political, scientific, cultural, and military decisions are made by groups. Decision-making groups have many forms including families, management teams, boards of directors, central bank boards, juries, appellate courts, and committees of various types.

Numerous researchers in management science and psychology have previously studied group decision-making. Our research involves some important departures from previous work in that: (a) we study group decision-making in the context of strategic market games, rather than non-market games against nature; and (b) we use a natural quantitative measure to determine whether and, indeed, how far groups' decisions depart from rationality.

We study group decision-making in the context of bidding in common value auctions. Bidding strategies in many important auctions are usually decided by groups. For example, oil companies typically use committees comprised of managers and geologists to determine bids for purchasing oil leases (Capen, Clapp & Campbell, 1971; Hoffman, Marsden, & Saidi, 1991). General contractors typically use committees to determine bids for large contracts (Dyer and Kagel, 1996).

In another paper (Cox and Hayne, 2002), we study decisions made by individuals and by "natural" groups – groups whose members conduct face to face discussion to arrive at a single group decision by whatever decision rule they choose to adopt. In this paper, we study decisions made by "nominal" groups – groups whose members arrive at a group decision by some pre-specified decision rule without an opportunity for face-to-face discussion. Nominal groups are further divided into "cooperative" groups (where there is no conflict of interest among group members), and "non-cooperative" groups (where the interests of the individual group members are partially conflicting).

Decision-making responsibility may be assigned to groups, rather than individuals, because of a belief that (a) groups are inherently more rational than individual decision-makers and/or (b) important pieces of information are possessed by different individual members of groups. In Cox and Hayne (2002), we report some perhaps surprising results comparing bids made by individuals with bids made by natural groups of 5 individuals that share equally in the profit or loss from a winning bid. The question posed in that paper is whether natural groups are more or less rational than individuals in common value auctions. We report that the answer depends upon the defining characteristics of natural groups. If one assumes that natural groups are decision-making entities consisting of more than one individual with distinct information then comparison of results from treatments involving natural groups, with value signal sample size of 5, with treatments involving individuals, with signal sample size of 1, supports the conclusion that natural groups are less rational than individuals. On the other hand, if one assumes that natural groups consist of individuals that have common information then comparison of results from treatments involving natural groups, with signal sample size of 1, with treatments involving individuals, with signal sample size of 1, supports the conclusion that natural groups are neither less nor more rational than individuals.

In the present paper, we compare bidding behavior of cooperative nominal groups with that of non-cooperative nominal groups; we change the incentives within the group. The treatments in this experiment involve two categories of groups with three individuals in each group. Bidding occurs under two conditions that differ only with regard to the way in which the group's profit or loss from a winning bid is divided among the group members. This enables us to vary the relationship within the group while keeping intact the number of decision-makers in each group and the nature of their joint decision vis-a-vis the other bidding groups in the market. For both types of nominal groups, the imposed decision rule is that a group's bid is the average of the bids submitted by individual members of the group. In the cooperative group treatment, all members of a group share equally in the profit or loss from a winning bid. In the non-cooperative treatment, the individual members share equally in the value of the item if their group has the winning bid but share unequally in the cost of the winning bid: each member of the winning-bid group pays one-third of the amount of his own bid. While all the members in a non-cooperative group have a common interest in submitting a winning bid, each individual member also has an interest in minimizing his own cost associated with the bid. Thus the non-cooperative treatment provides each player with an incentive to free ride. Consider individual *j* who is a member of a bidding group. Individual *j* prefers that her group-mates submit bids that are high enough for her group to have the winning bid while she bids zero. But if individual *j* bids too low she runs the risk that her group will not have the high bid, and hence receive zero payoff.

While the non-cooperative treatment involves an incentive to free riding, whether or not a low bidder actually free rides depends on the bids of the other group members. If the low bidder prevents his group from winning an auction in which, because of their high bids, the other two group members would have lost money, then he is not gaining at their expense, hence not actually free riding. In contrast, if a group has the high bid in spite of a low bid by one member of the group, then the low bidder is free riding. In any case, the non-cooperative treatment does provide an incentive to group members to free ride on others' bids that are high enough to win the auction.

The behavior of cooperative nominal groups can be compared with that of the natural groups studied in Cox and Hayne (2002). This comparison allows one to separate the effect on group decision-making of processes associated with face-to-face interaction from the effect of the mere aggregation of individuals' decisions. In contrast, comparison of the bidding behavior of cooperative and non-cooperative nominal groups allows one to isolate the effect on group bidding behavior of the incentive to free-ride created by the unequal sharing rule for non-cooperative groups. This permits us to address the question of when, or indeed if an incentive for free riding promotes rational bidding in common value auctions.

2. A Quantitative Measure of Deviation from Rational Bidding Behavior

Consider an auction market where the bidders do not know the value of the item being sold when they submit their bids and the value, v of the item is the same for all bidders. Consider a first-price sealed-bid auction in which the high bidder wins and pays the amount of its bid for the auctioned item. Further envision that each bidder receives an independent signal, s_i that provides an unbiased estimate of the object's true value. The expected value of the auctioned item conditional on the bidder's signal is denoted by $E(v \mid s_i)$. The expected value of the auctioned item conditional on the bidder's own signal being the highest of N signals (i.e., equal to the highest order statistic, y_N) is denoted by $E(v \mid s_i = y_N)$. For bids by $N > 1$ bidding entities, one has

(1) $$E(v \mid s_i) = s_i > E(v \mid s_i = y_N)$$

by well-known properties of order statistics. Thus if bidders naively submit bids equal to or slightly below their common value estimates, s_i they will have an expected loss from winning the auction; that is, they will suffer from the winner's curse.

Consider the case where the common value of the auctioned item is uniformly distributed on the interval, $[v_l, v_h]$ and each individual agent's signal is independently drawn from the uniform distribution on $[v - \theta, v + \theta]$. For this case, one has

(2) $$E(v \mid s_i = y_N) - E(v \mid s_i) = -\frac{N-1}{N+1}\theta,$$

for all $s_i \in [v_\ell + \theta, v_h - \theta]$. Thus, if bidders naively submit bids equal to their signals then the cursed winning bidder will have an expected loss in the amount $\theta(N-1)/(N+1)$. This expected loss is increasing in the number of bidders, *N*.

Now assume that *each member* of each group has a signal that is independently drawn from the uniform distribution on $[v-\theta, v+\theta]$. Under these conditions, groups of size $G > 1$ have a signal sample size of $G > 1$ on which to base their estimates of the common value. Because the signals are drawn from a uniform distribution, the signal sample midrange, m_i provides an unbiased estimate of the value of the auctioned item. The expected value of the auctioned item conditional on the bidder's signal sample midrange is denoted by $E(v \mid m_i)$. The expected value of the auctioned item conditional on the bidder's own signal sample midrange being the highest of *N* signal sample midranges (i.e., equal to the highest order statistic of sample midranges, z_N) depends on the sample's range, r_i and is denoted by $E(v \mid r_i, m_i = z_N)$. With signals drawn from the uniform distribution, one has

(3) $$E(v \mid r_i, m_i = z_N) - E(v \mid m_i) = -\frac{N-1}{N+1}(\theta - \tfrac{1}{2}r_i).$$

Comparison of statements (2) and (3) reveals that groups with size $G > 1$ signal samples will have a smaller expected loss from naively bidding their signal sample midranges, than will individuals from naively bidding their signals, except in the improbable extreme outcome in which all of the signals in the sample with the highest midrange have the same value (and, hence $r_i = 0$). In the other improbable extreme outcome, in which the signal sample with the highest midrange has a range equal to 2θ, there will be zero expected loss from bidding an amount equal to the sample midrange. But, of course, in this case the bidder knows the auctioned item's value with certainty.

Note that equation (3) suggests a quantitative criterion for determining the extent of deviation from minimally-rational bidding in common value auctions. The magnitude of the winner's curse that is exhibited by winning bidder *i*, in a market with *N* bidders, is

(4) $$EVCurse = b_i^w - E(v \mid r_i^w, m_i^w = z_N)$$

where b_i^w is the winning bid, v is the common value of the auctioned item, r_i^w is the winning bidder's signal sample range (which is zero for signal sample size of 1), m_i^w is the winning bidder's signal sample midrange (or signal, for signal sample size 1), and z_N is the *Nth* order statistic of sample midranges (or signals, for signal sample size 1). Note that *EVCurse* is the magnitude of the expected loss (or profit, if it is negative) from winning the auction.

In order not to have an expected loss from winning, a bidding group or individual must discount its naive estimate of the common value (its signal or its signal sample midrange) by at least the amount $(\theta - \frac{1}{2} r_i)(N-1)/(N+1)$, where it is understood that $r_i = 0$ for signal samples of size 1. Furthermore, the size of this minimum rational discount is independent of m_i so long as $m_i \in [v_\ell + \theta, v_h - \theta]$. These conditions are essentially always satisfied by the signals drawn in our experiments in which $\theta = 1800$ and $[v_\ell, v_h] = [2500, 22500]$. Therefore, deviations from minimally-rational bidding can be measured by linear regressions relating winning bids to the signal sample ranges and midranges of the winning bidders, as we do in section 4. Bids that yield zero expected profit are given by the following equation when $m_i \in [v_\ell + \theta, v_h - \theta]$:

$$(5) \qquad b^{Zero} = -\frac{N-1}{N+1}\theta + m_i + \frac{N-1}{2(N+1)} r_i .$$

Bids that are lower than b^{Zero} have non-negative expected profit regardless of what rival bidders are bidding. In contrast, bids that are higher than b^{Zero} are not economically rational because they have non-positive expected profit, that is, they exhibit the winner's curse. Of course, a bid may be less than b^{Zero} but still higher than the Bayesian-Nash equilibrium bid for the bidder's signal sample. But that would not imply that the bid is irrational unless the bidder knew that all other bidders were bidding according to the Bayesian-Nash equilibrium bid function. If rival bidders are bidding above the Bayesian-Nash equilibrium bid function then a bidder's rational best reply may be to also bid higher than bids specified by the equilibrium bid function. But it would never be rational to bid higher than b^{Zero} because: (a) such bids have non-positive expected profit regardless of what rival bidders are bidding; and (b) such bids have negative expected profit if rival bidders are bidding less than b^{Zero}. In short, a bidder who bids above b^{Zero} will have negative expected profits unless there are "bigger fools" to save him from having the high bid by making bids with negative expected profits themselves. Therefore, it is comparison with b^{Zero} that provides a strong test for rational bidding. Any bid above b^{Zero} is characterized by the winner's curse, which is not rational bidding.

3. Experimental Design and Procedures

The design of our experiments addresses the effects on nominal groups of different profit-sharing rules. Individuals are randomly assigned to three-person groups. Each market includes three nominal group bidders. A nominal group's bid is the average (that is, the mean) of the three bids submitted by individual members of the group. In the cooperative-group treatment, the members of the group with the highest average bid share equally in the profit or loss from submitting the winning bid. In the non-cooperative-group treatment, each member of the highest-bid group receives one-third of the value of the auctioned item and pays one-third of the amount of his individual bid.[1] This unequal profit-sharing rule produces an incentive for free riding within groups: an individual member of a group will realize the highest possible profit (conditional on the common value) when the bids by the other two group members are high enough to win the auction and she bids zero. But if a subject bids too low he runs the risk that his group will not have the high bid and incur an opportunity cost of foregone profit.

Reports of results from previous common value auction experiments with individual bidders (Kagel and Levin, 1986; Kagel, et al., 1989) have focused on the behavior of experienced subjects, where "experience" means having participated in one or more previous common value auction experiments. The reason for this is that most subjects fall victim to the winner's curse in *all* experimental treatments when they are first-time bidders but such inexperienced behavior is not considered to be very interesting. We use subject experience as a treatment to allow comparison of our results with those in the literature.

The experiment was conducted in the Economic Science Laboratory (ESL) at the University of Arizona. Each individual had his own personal computer that was connected via the Internet to software running on a server at Colorado State University. Subjects were recruited from the undergraduate student population. Experimental sessions were run in two-day sequences of two-hour blocks. Subjects were paid all of their earnings at the end of the experiment on the second day. Subjects were randomly assigned to groups and randomly dispersed to computers as they moved into the laboratory.

The subjects were given written instructions describing bidding procedures in the first-price sealed-bid auctions. The instructions are reproduced in the appendix. The instructions contain a detailed description of the information environment of the common value auctions. Thus, subjects were informed in non-technical terms that in each auction round the computer would draw a value for the auctioned item from the discrete uniform distribution on the integers greater than or equal to 2,500 experimental dollars and less than or equal to 22,500 experimental dollars. They were informed that the common value would not be revealed but that it would be the midpoint of a uniform distribution from which their value estimates, or signals, would be independently drawn. They were informed in non-technical terms that, after the computer drew a common value v for a round, it would draw all signals independently from the uniform distribution on [v-1800, v+1800]. Information about how the signals would be drawn was presented to the subjects both in their written instructions and orally by the experimenters. The oral presentation used the analogy with bidding on oil leases and interpreted the signal(s) as estimates of the value of an oil lease by geologist(s). The instructions did not contain any discussion of the order statistic property that is conventionally thought to underlie the winner's curse. The instructions contained non-technical explanations of how the common values and subjects' signals were generated, the rules of the first-price sealed-bid auction, and the applicable profit-sharing rule.

On day 1, the inexperienced subjects first participated in 10 periods of practice auctions. After each practice auction, the subjects' computer monitors displayed the common value, all subjects' bids, and the amount won or lost by the high bidder. The subjects were each given a capital endowment of 1,000 experimental dollars in order to allow them to make at least one sizable overbid without becoming bankrupt. At the end of the practice rounds, the subjects' profits and losses were set to zero and they began at least 30 monetary-payoff rounds with new 1,000 experimental dollar capital endowments. The actual number of monetary-payoff rounds to be completed was not announced. Signals were presented to the subjects on sheets of paper; each subject was given a single sheet of paper with signals for 10 practice rounds and 40 monetary-payoff rounds. The experiment was ended on a monetary payoff round randomly chosen between 30 and 40. Signals, common values, and bids were denominated in experimental dollars, with a clearly specified exchange rate into U.S. dollars. During the monetary-payoff rounds the information reported at the end of each auction included only the common value and the high bid, not the bids by other bidders. We decided not to report all bids in order to make collusion more difficult and to adopt procedures that correspond to minimal reporting requirements in non-laboratory auctions. Each individual in a winning bidder nominal group could see his individual profit or loss and cumulative balance. The procedures were the same on day 2 as on day 1. Earnings from both day 1 and 2 sessions, together with the $15 individual participation fees, were paid after the end of the day 2 sessions.

A few individuals made data entry errors during the experiment sessions with *inexperienced* subjects even though the software asked them to confirm their bids. Such errors were obvious because they usually consisted of mistakenly typing one fewer or one more digit in the bid than was intended. Subjects who made these errors usually immediately brought them to the experimenters' attention. Such errors were usually obvious because they produced bids that were too low or too high by a multiple of 10. We forgave losses resulting from data entry errors. Auction period data with data entry errors are excluded from our data analysis for the inexperienced bidders. There were no known data entry errors in the experiment sessions with *once-experienced* subjects.

Many *inexperienced* group-bidding entities made winning bids that turned out to be so high that they attained negative cumulative payoffs. A few once-experienced groups also incurred negative balances in the cooperative treatment but none did so in the non-cooperative treatment (see Table 1). When a group's cumulative payoffs were negative at the end of a session, the loss was forgiven (the group was permitted to "go bankrupt"). Allowing bidders to continue bidding after they have attained a negative cumulative balance can be a problem because the experimenter might lose control of their incentives. Therefore, we analyze data in Section 4.2 only from periods in a bidding market session prior to a period in which any bidding group had a negative cumulative balance at the beginning of the period.

4. Data Analysis

4.1. Group Payoffs and Bankruptcies

The nominal groups' and individual subjects' high, low, and average money payoffs from bidding in all rounds of all sessions in the common value auctions (excluding the participation fees) are reported in Table 1.[2] The individual subject payoff amounts are, by definition, equal to one-third of the group amounts except for the low payoff and high payoff amounts for the non-cooperative treatment. There were large differences between the lowest and highest payoffs in all treatments. The average payoff in non-cooperative sessions was about twice what it was in cooperative sessions for both inexperienced and once-experienced subjects. This reflects the much higher incidence of the winner's curse, resulting in many more bankruptcies in the cooperative treatment than in the non-cooperative treatment. More than half of the inexperienced groups in the cooperative treatment went bankrupt while only two inexperienced groups went bankrupt in the non-cooperative treatment. The rate of bankruptcy decreases with subjects' experience in both treatments but remains very different. Nine out of 36 once-experienced groups became bankrupt in the cooperative treatment while none did so in the non-cooperative treatment. Thus the incentive to free ride, by submitting low bids, in the non-cooperative treatment increases average profits from bidding and decreases bankruptcies resulting from the winner's curse. However, it is interesting to note that the incidence of zero bids is *not* higher in the non-cooperative treatment than in the cooperative treatment.[3]

Further insight into bidding behavior in the cooperative and non-cooperative treatments is provided by analysis of data from periods in which no groups were bankrupt and hence, as explained in section 3, there is not a concern that the experimenters may have lost control of some subjects' incentives. Data analysis reported in Tables 2 and 3 excludes data from all market periods after any bidding group attained a negative cumulative balance. This has a large effect on data used for inexperienced subjects, especially for the cooperative treatment. In the 12 cooperative group sessions with inexperienced subjects there were 83 bidding periods in which all groups' cumulative balances were positive and 277 periods in which at least one group's balance was negative. In contrast, in the eight non-cooperative group sessions with inexperienced subjects there were 216 bidding periods in which all groups' cumulative balances were positive and 24 periods in which at least one group's balance was negative. In the 12 cooperative group sessions with once-experienced subjects there were 156 bidding periods in which all groups' cumulative balances were positive and 204 periods in which at least one group's balance was negative. In contrast, in the eight non-cooperative group sessions with once-experienced subjects there were 240 bidding periods in which all groups' cumulative balances were positive and no period in which any group's balance was negative.

4.2. Bidding Behavior by Nominal Groups

Table 2 reports summary comparisons of bidding behavior in all periods in which no bidding groups were bankrupt. The first column of Table 2 reports the experience of the groups (inexperienced = 0, once-experienced = 1). The second column shows the experimental treatment: cooperative or non-cooperative nominal bidding groups. The third column reports the average difference between individual subjects' signals and their bids. This is a measure of the extent to which individual subjects avoid the winner's curse by discounting their signals. The fourth column reports the standard deviation of the difference between individual subjects' signals and their bids. This is a measure of heterogeneity of individual subjects' discounting behavior. First consider the results for inexperienced subjects. The mean is higher and the standard deviation is lower in the non-cooperative treatment than in the cooperative treatment. Thus inexperienced subjects in the non-cooperative treatment are more effective in avoiding the winner's curse, and they are less heterogeneous in their discounting behavior than subjects in the cooperative treatment. Now compare the top two rows on Table 2 with the bottom two rows. Note that more experience leads bidders in both treatments to discount their signals by larger amounts. Finally, compare the bottom row of Table 2 with all other rows. Note that once-experienced subjects in the non-cooperative treatment discount their signals by the largest amount and they are the least heterogeneous in this discounting behavior. Thus the "rationalizing" effect on bidding behavior of the free-riding incentive has a homogenizing effect on individual subjects' bidding behavior.

Table 2 includes all bids made by subjects in market periods with no bankrupt groups. We now turn our attention to analysis of market prices (winning bids). Table 3 reports results from random effects regressions with estimating equations of the form,

(6) $$b_{jt} = \alpha + \beta m_{jt} + \gamma r_{jt} + \mu_j + \varepsilon_{jt},$$

where b_{jt} is the bid by group *j* in period *t*, m_{jt} is group *j*'s signal sample midrange in period *t*, and r_{jt} is group *j*'s signal sample range in period *t*. The estimated coefficients are compared to the coefficients in the zero-expected-profit equation (5) to test for deviations from economic rationality. The estimation uses winning bids (market prices) and the associated right-hand variables.

The first and second columns of Table 3 report the experience level of the groups and the experimental treatment. The third column reports the "minimum rational discount," which is the intercept in the zero-expected-profit bid equation. The fourth, fifth and sixth columns report the estimated parameters and their standard errors (in parentheses). The seventh column reports the R^2's.

The last two rows in Table 3 report the random effects regression results for once-experienced subjects. Comparison of the estimated intercepts with the minimum rational discount and the estimated coefficients on slopes with a slope of 1 provides a measure of the departure from rational bidding by the high bidders in an experiment. The intercept for the cooperative-group treatment is –623, which is significantly greater than the minimum rational discount of –900 by a one-tailed *t*-test at the 5% confidence level, and the slope is 0.990, which is not significantly different from 1.000 by a two-tailed *t*-test at the 5% confidence level. Therefore, the winning bidders in the cooperative group treatment deviated significantly from minimally-rational bidding, in the direction of bidding to high; that is, cooperative bidding groups fell prey to the winner's curse. In contrast, the intercept for the non-cooperative group treatment is –949, which is obviously not greater than the minimum rational discount of –900, and the slope is 0.986, which is not significantly different from 1.000. Therefore, the winning bidders in the non-cooperative group treatment did not differ significantly from minimally-rational bidding; rather than falling prey to the winner's curse, the non-cooperative group bidders had positive expected profits. The incentive to free ride within non-cooperative groups tends to offset the winner's curse and promote rational bidding.

4.3. Comparison of Nominal and Natural Groups' Bidding Behavior

Table 4 reproduces data from two of the natural group treatments reported in Cox and Hayne (2002). Like the cooperative nominal group, the natural group treatment uses an equal profit-sharing rule. Unlike both cooperative and non-cooperative nominal groups, the natural group treatment involves face-to-face, within-group discussion and endogenously-determined rather than imposed decision rules.

Comparison of data from the two experiments can only be suggestive because the natural group experiments used five-member groups and the nominal group experiments used three-member groups. The first column of Table 4 reports the treatment parameters, Group size (5), Signal sample size (1 or 5) and Market size (3). Comparison of the intercept estimates in the two rows shows part of the support for the conclusion that more information (3 signals or common value estimates rather than 1) leads to less rational bidding by natural groups because the intercept estimate for the treatment with 5 signals (5,5,3) is significantly larger than the zero-profit intercept of -900 and the intercept estimate for the treatment with 1 signal (5,1,3) is not. Comparison of intercept estimates for natural (Table 4) and nominal (Table 3) groups leads to the following conclusions. Non-cooperative nominal group bidders are the only type that escapes the winner's curse and has bidding behavior with positive expected profits:

$-949 < -900$. Cooperative nominal groups with 3 signals are less subject to the winner's curse than natural groups with 5 signals ($-623 < -527$) but more subject to the curse than natural groups with a single signal ($-623 > -708$).

5. Concluding Remarks

Data from our research on group bidding behavior supports some striking conclusions. The experiment reported in Cox and Hayne (2002) comparing bidding behavior of natural, face-to-face groups with bidding behavior by individuals reveals a "curse of information" that compounds the winner's curse. The bidding behavior of both individuals and natural groups deteriorates when they are given more information (a larger signal sample size) but bidding by groups deteriorates much more dramatically. Most strikingly, natural group bidders with more information (5 signals) are significantly less rational bidders than individuals with less information (1 signal).

Data from the nominal-group experiment reveal a rare instance in which an incentive to free ride leads to more, rather than less rational economic outcomes. The non-cooperative nominal group treatment, with the unequal profit-sharing rule providing a free-riding incentive, produced bidding behavior that was more rational than that observed with the cooperative nominal group treatment with no incentive to free riding.

Endnotes

* Department of Economics, University of Arizona (Cox) and Department of Computer Information Systems, Colorado State University (Hayne). The authors are grateful for financial support from the Decision Risk and Management Science Program of the National Science Foundation (grant numbers SES-9709423 and SES-9818561) and to Rachel Croson and an anonymous referee for helpful comments on an earlier draft.

1. A deviation from this profit-sharing rule was required to handle some losses. If an individual member of a non-cooperative group attained a negative cumulative balance then other members of the group had to cover the loss. This was necessary to preclude a money pump that could result from limited liability of an individual subject. This cumulative loss-sharing rule was explained in the subject instructions.

2. The experimental/U.S. dollar exchange rate was held constant across treatments.

3. As shown by the subject instructions in the appendix, individual subjects were permitted to abstain rather than enter a bid. A few abstentions did occur, most by a single individual in a bankrupt group in the cooperative treatment.

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Appendix. Subject Instructions

A.1. Instructions for the Cooperative Nominal Group Treatment

Internet Auctions

INSTRUCTIONS

If you follow these instructions carefully, and make good decisions, you may earn a CONSIDERABLE AMOUNT OF MONEY. The amount of money you earn will be PAID TO YOU IN CASH at the end of the second day's experiment.

1. In this experiment we will create an auction market in which you will act as member of a group bidding for a fictitious item in a sequence of many bidding periods. There will be several groups bidding on the item. A single unit of the item will be auctioned off in each trading period. There will be several practice periods without money payoff followed by many "real" periods with money payoff.

2. Your task is to work with the other members of your group and submit a group bid for the item. This will place your group in competition with other bidding groups. The precise value of the item at the time your group makes its bid will be unknown to you. Instead, each of you will receive a "signal" that provides an unbiased estimate of the item's value.

Each individual in your group can submit a number that they think the group should bid bid (or an individual can abstain from bidding). The auction server computer will then **average** the numbers submitted by you and the other members of your group and submit that **average** as your group's bid in the auction. Abstentions are not included in this average.

3. When you bid in the auction, you will bid using *experimental* dollars. These experimental dollars can be redeemed at the end of the second day's experiment at the exchange rate shown on the computer. For example, if your group earned 4008 experimental dollars and the exchange rate was 80 experimental dollars per 1 U.S. dollar, then your group would earn $50.10 in **real U.S. dollars**.

4. The group with the highest bid in an auction period will be paid the value of the auctioned item and have to pay the amount of its bid. Thus, the group with the highest bid will receive a profit or loss equal to the difference between the value of the item and the amount that they bid:

GROUP PROFIT OR LOSS = VALUE OF ITEM - HIGHEST BID

If your group does not make the high bid on the item, your group will earn zero profit. In this case you neither gain nor lose from bidding on the item.

The group profit or loss is different from your individual profit or loss. Your individual profit or loss will be calculated by dividing the group profit or loss by the number of group members.

INDIVIDUAL PROFIT = GROUP PROFIT/GROUP SIZE

For example, if your group bid 12,885 experimental dollars (remember, this is the average of all the individual bids) for the object, it was higher than the other group's bids and the value of the object was revealed to be 13,425 experimental dollars, your group profit would be 540 experimental dollars. If your group size was 3, then your individual profit would be 180 experimental dollars. You can see that if you work well in your group, you may earn a significant amount of money.

5. You will be given a starting capital credit balance of 1000 experimental dollars. Any profit you earn will be added to this amount and any losses will be subtracted from this amount. The net balance of these transactions will be calculated and paid to you in **CASH** at the end of the second day's experiment. The starting capital credit balance, and whatever subsequent profits you earn, permit you to suffer losses in one auction that could be recouped in part or total in later auctions. Your group is permitted to bid in excess of your own capital credit balance in any given period.

6. During each trading period, your group will be bidding in a market with several other groups and after all the bids have been submitted, the winning bid will be announced.

7. The value of the item will be chosen randomly each auction period and will always lie between 2,500 and 22,500 experimental dollars, inclusively. For each auction, any value within this interval has an equally likely chance of being drawn. The value of the item can never be less than 2,500 or more than 22,500 experimental dollars. The values are determined randomly and are independent from auction to auction. As such, a high value in one auction tells you nothing about the likely value in the next auction, i.e. whether it will be high or low.

8. Private Information Signals: Although you do not know the precise value of the item in any particular auction, you will receive information which will narrow down the range of possible values. This will consist of a private information signal which is selected randomly from an interval whose lower bound is the item value less a constant amount, and whose upper bound is the item value plus the same constant. Any value within this interval has an equally likely chance of being drawn and being assigned to you as your private information signal. The value of this constant will be announced prior to the experiment.

For example, suppose that the value of the auctioned item is 12,677 experimental dollars and that the constant is 1,800 experimental dollars. Each of you will receive a private information signal which will consist of a randomly drawn number that will be between 10,877 (12,677 – 1,800) and 14,477 (12,677 + 1,800) experimental dollars. Any number in this range has an equally likely chance of being drawn.

The data below shows an entire set of signals the computer might generate for a group of ten people. (Note these have been ordered from lowest to highest).

The item value is 12,677 and the constant is 1,800 experimental dollars, and the signals are:

14314
13730
13709
13331
12917
12435
12344
11971
11785
11385

You can see that some signal values were above the value of the auctioned item, and some were below the value of the item. Over a sufficiently long series of auctions, the differences between your private signals and the item values will average out to zero (or very close to it). But for any single auction your private information signal can be above or below the value of the item. That's the nature of the random drawing process that is generating the signals. You will also note that the upper bound must always be greater than or equal to your signal value. Further, the lower bound must always be less than or equal to your signal value.

Finally, you may receive a signal value below 2,500 (or above 22,500). There is nothing strange about this, it merely indicates that the item value is close to 2,500 (or 22,500) and this closeness depends on the size of the constant.

9. Your signals are strictly private information.

10. Bids are rounded to the nearest experimental dollar and must be greater than 0. In case of ties for the high bid, a coin toss will determine the winner.

11. You are not to communicate with anyone while the experiment is in progress.

SUMMARY OF MAIN POINTS

1 A group's bid is the average of the bids submitted by individual members of the group. The group with the highest bid wins the auction and receives a profit or loss.

2. Your individual profit or loss will equal your group's profit or loss divided by group size.

3. Your cumulative profit will be paid to you, in **CASH**, at the end of the second day's experiment.

4. Your private information signal is drawn from the interval (item value – 1,800, item value +

1,800). The value of the item can be as much as 1,800 below your signal or 1,800 above your signal.

5. The value of the item will always be between 2,500 and 22,500.

ARE THERE ANY QUESTIONS?

Part 2. Instructions for the Non-cooperative Nominal Group Treatment

The instructions for the non-cooperative treatment were the same as for the cooperative treatment, except as explained here. Paragraph 4 in the INSTRUCTIONS (first part) of section A.1 was replaced by the following paragraphs 4 and 5. (Paragraphs 6 – 12 in section A.2 are the same as paragraphs 5 – 11 in section A.1.) The SUMMARY OF MAIN POINTS in section A.1 was replaced by the one below.

4. If your group does not make the highest bid on the item, each member of your group will receive zero profit or loss. The group with the highest bid in an auction period will be paid the value of the auctioned item and have to pay the amount of its bid.

The individual members of the group with the highest bid do **not** usually share the profit or loss equally. If your group has the highest bid, your individual profit or loss will be calculated by subtracting your bid from the value of the item and dividing that profit or loss by three, the number of people in your group:

$$\textbf{INDIVIDUAL PROFIT OR LOSS} = \frac{\textbf{ITEM VALUE – YOUR BID}}{\textbf{3}}$$

For example, suppose that your group has the highest bid and the value of the object turns out to be 13,425 experimental dollars. If your individual bid was 10,560 then your individual profit would be 955 experimental dollars ((13425-10560)/3). However, if your individual bid was 15,220 then your individual profit would be -598; a **loss** of your experimental dollars ((13425-15220)/3). There is an exception to the above way of calculating individual profits that occurs if any member of your group becomes bankrupt, that is if someone attains negative total payoff.

5. If you abstain from bidding in any period, and your group has the highest bid, then your profit or loss will equal one third of the difference between the item value and the average of the bids submitted by other members of your group.

SUMMARY OF MAIN POINTS

1. A group's bid is the average of the bids submitted by individual members of the group. The group with the highest bid wins the auction and receives a profit or loss.

2. If your group has the highest bid, your individual profit or loss will be equal to 1/3 of the difference between the item value and your bid, so long as no one in your group is bankrupt.

3. If the total payoff of someone in your group becomes negative then the other members of the group must cover that person's losses until such time as he/she attains positive total payoff.

4. Your total payoff will be paid to you, in **CASH**, at the end of the second day's experiment.

5. Your private information signal is drawn from the interval (item value – 1,800, item value + 1,800). The value of the item can be as much as 1,800 below your signal or 1,800 above your signal.

6. The value of the item will always be between 2,500 and 22,500.

ARE THERE ANY QUESTIONS?

Table 1. Summary Bidding Behavior

Experience	Group Type	Total Groups	Bankrupt Groups	Zero Bids	Average Payoff[a]	Low Payoff[a]	High Payoff[a]
0	Coop.	36	19	12	$ 6.31 ($ 18.93)	$ 0 ($ 0)	$ 23.09 ($ 69.26)
0	Non-coop.	24	2	7	$ 12.92 ($ 38.77)	$ 0 ($ 1.60)	$ 42.99 ($ 87.61)
1	Coop.	36	9	12	$ 11.25 ($ 33.74)	$ 0 ($ 0)	$ 25.40 ($ 76.21)
1	Non-coop.	24	0	1	$ 23.01 ($ 69.03)	$ 0 ($ 22.75)	$ 77.39 ($ 103.05)

a. Figures in parentheses are earnings for the whole group.

Table 2. Bidders' Signal Discounts

Experience	Group Type	Average Discount	Std. Dev. Discount
0	Coop.	658	2240
0	Non-coop.	999	1890
1	Coop.	877	2544
1	Non-coop.	1270	1317

Table 3. Random Effects Regressions with Data for Nominal Groups
(standard errors) [*p*-values]

Experience	Group Type	Min. Rnl. Disc.[a]	$\hat{\alpha}$	$\hat{\beta}$	$\hat{\gamma}$	R^2	Nobs.[b]
0	Coop.	-900	156.48* (320.64)	0.9704# (0.014)	0.1502 (0.102)	0.92	264
0	Non-Coop.	-900	-265.17* (206.53)	0.9628# (0.009)	0.1416 (0.071)	0.94	630
1	Coop.	-900	-623.31* (78.0)	0.9901 (0.004)	0.171 (0.031)	0.99	585
1	Non-Coop.	-900	-949.31 (150.23)	0.9864 (0.007)	0.046 (0.048)	0.95	720

a. Min. Rnl. Disc. = minimum rational discount.
b. Nobs. = number of observations.
* Significantly greater than the minimum rational discount by a one-tailed 5% *t*-test.
\# Significantly different than the theoretical value by a two-tailed 5% *t*-test.

Table 4. Random Effects Regressions with Data for Natural Groups
(standard errors) [*p*-values]

G,S,N[a]	Min. Rnl. Disc.[b]	$\hat{\alpha}$	$\hat{\beta}$	$\hat{\gamma}$	R^2
5,5,3	-900	-527[*] (145)	0.994 (0.006)	0.154 (0.051)	0.998
5,1,3	-900	-708 (228)	0.984 (0.013)	---[c]	0.988

a. G, S, N = Group size, Signal sample size, Number of bidders.
b. Min. Rnl. Disc. = minimum rational discount
c. There is no estimated parameter for signal sample range here because the range is always zero by design in this treatment.
[*] Significantly greater than the minimum rational discount by a one-tailed 5% *t*-test.