Multilateral Bargaining with Proposer Selection Contest*

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Abstract

This paper experimentally investigates the competition to be selected as the proposer of the subsequent ultimatum bargaining game. The experimental environment varies in three dimensions: voting rule, reservation payoffs, and the information of how much resource each subject spent in the competition. In all treatments, many proposers put quite a generous allocation to the vote, and the average amount of resources spent in the competition was significantly lower than the theoretical benchmark. More importantly, we find that the levels of spending and inequality significantly differed across treatments: Given the simple majority voting rule, the surplus was distributed most efficiently and most equally when the reservation payoffs were heterogeneous and subjects were informed of who had spent how much in the competition. Furthermore, the analysis shows that in the public information treatments, the non-proposer who had spent more was more likely to be selected as a coalition partner or to be offered a greater share. This study contributes to the literature by demonstrating which formal rules are more effective in establishing more efficient informal norms.

Keywords: Multilateral bargaining, Contest, Public choice, Laboratory experiments

1 Introduction

When a group of people negotiate over some economic surplus, the one who makes a proposal often obtains a greater share than others. Consequently, the participants of a

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negotiation may be willing to take costly measures to influence decisions of the one(s) with the power or to be recognized as the proposer himself/herself. If the rent for the proposer is expected to be substantial, a competition among the participants may be inevitable. Examples of such competitions are commonplace, from relatively small organizations such as a condominium board and a student council to a large corporation, a government agency, and an international organization such as United Nations. (See Yildirim (2007) and the reference therein for more detailed examples.) Moreover, in the process of recognition, resources are often spent unproductively (e.g., lobbying other agents, hiring a professional negotiator or other experts, etc.).

In search of the conditions for efficient multilateral bargaining, this paper experimentally examines the competition to win the proposal right. In particular, we introduce a lottery contest (Tullock, 1980) which determines the proposer of the subsequent bargaining game to see (i) how the existence of the contest influences the allocation of the surplus and (ii) how the prospect of a (un)equal division affects the intensity of the competition. In this regard, we follow Yildirim (2007) who theoretically analyzes multilateral bargaining over infinite time horizon. However, we depart from his model by employing an ultimatum bargaining game instead. This is to avoid the multiple equilibria problem which often complicates the interpretation of the experimental outcomes and to focus on the consequences of the competition in the simplest setup.[1]

More specifically, we examine a two-stage game where the players first choose an investment level independently to increase the chance of being selected as the proposer, and then collectively decide how to allocate the given economic surplus. The experimental environment varies in three dimensions: voting rule, reservation payoffs, and the information of how much resource each subject spent in the competition. First, we compare the majority rule to the unanimity rule to see the effects of voting rule not only on the bargaining outcome but also on the level of investment in the competition. The theory predicts that the competition for the proposal right will be less intensive under the unanimity rule because the proposer needs to buy everyone's vote to get the proposal implemented, and thus the potential rent is smaller under the unanimity rule. We also examine the effect of asymmetry in the reservation payoff, which is comparable with the effect of asymmetric (im)patience in the infinite-horizon bargaining. Suppose that one's reservation payoff is larger than the

[1] The source of inefficiency most widely discussed in the literature is asymmetric information which may result in a unnecessarily delayed agreement (see Palfrey (2016) for an overview of the literature). We do not discuss the welfare cost of delays as we consider ultimatum bargaining games. Nevertheless, we do examine under which condition a rejection of a proposal is more likely at the end of Section 5.

others'. It means that his/her vote is more expensive than the others', and thus he/she is more likely to be excluded from the coalition to pass the proposal. Expecting this, the one with the highest reservation payoff will be more eager to win the competition, which in turn will affect the others' decisions on how much resource to spend. This type of strategic consideration does not exist when the reservation payoffs are homogeneous, because then there is no reason for the proposer to favor one player over another. The last dimension of our design is whether or not the information of resource spending is publicly revealed. More precisely, in a set of treatments, we inform the subjects of both who is selected as the proposer and how much investment each participant made in the contest before the bargaining game takes place, whereas in the other treatments, we inform the subjects only of the selected proposer. The theory does not provide any particular prediction along this dimension, because rational agents do not care about the past expenditures. However, previous experimental studies suggest that such information may influence the proposal by altering the reference point or the norms of who deserves how much and what is fair (Hoffman and Spitzer, 1985; Konow, 2000).

We find that in all treatments, most proposers indeed took a greater share of the surplus than the others. At the same time, however, the offered proposals were quite generous in comparison with the theoretical benchmark, which is in line with what has been documented in the bargaining literature. On the other hand, taking the observed generous proposals into account, we show that the level of resource spending was significantly higher than the expected-payoff-maximizing level, which is also consistent with the results found in previous experimental studies of contests.[2] Interestingly, proposers tended to more generously treat the responders who had spent more resource in the contest, which might give an additional incentive for subjects to over-invest.

Furthermore, we find that efficiency and equity go hand in hand: In the environment where the surplus was (expected to be) distributed more equally, the efficiency loss due to the wasteful resource spending was smaller. This might be because as the theory predicts, subjects had weaker monetary incentives to win the contest when the social norm limited the rent extraction more tightly. In particular, it turns out that the average level of resource spending and that of inequality in the distribution of the surplus were significantly lower under two conditions. First, not too surprisingly, the surplus was more equally distributed, and the level of investment was significantly lower under the unanimity rule than under

[2] The average level of investment in the contest was significantly lower than the level predicted by the theory which assumes that whenever indifferent between accepting and rejecting the offer, the non-proposer will vote for the proposal.

the majority rule. On average, the proposers under the unanimity rule took only 44% of the surplus, while those under the majority rule took about 55–59%. Correspondingly, the average level of resource spending under the unanimity rule was only one third of that under the majority rule.

Second, and more interestingly, given the majority voting rule, both levels of resource spending and inequality were particularly low when (i) the reservation payoffs were heterogeneous and (ii) the investment levels were publicly revealed. This condition for efficient bargaining is not as obvious as the unanimous voting rule, although it is not too difficult to see how it might help reduce the wasteful resource spending. In the heterogeneous treatments, one subject (coded "Blue" in the experiment) was endowed with a greater reservation payoff, and as argued above, had a greater incentive to win the proposal right than the others ("Red" and "Green"). Knowing this, the others might be willing to let Blue subject win the contest on condition of a generous proposal. Thus, in a sense, the subjects might be able and willing to form a gift-exchange relationship in which Red and Green subjects yielded up the proposal right, and in return Blue subject offered a generous proposal to the voters. This relationship might be sustained because Blue proposers believed that once the relationship or the norm was formed, an unequal (or unfair) proposal would be rejected with a high probability. In summary, the public information, on one hand, might facilitate forming such a gift-exchange relationship by making it easy to detect any significant deviation from the norm, and the heterogeneity in reservation payoff, on the other hand, might facilitate coordination among subjects. To correctly appreciate this condition, it may be worth noting that the effect of public information substantially differed across treatments. In particular, when the reservation payoffs were heterogeneous, the level of resource spending was lower in the public information treatment than in the private information treatment as noted above. In contrast, when subjects were endowed with the same reservation payoff, they spent more resource in the public treatment than in the private one. This means that neither the heterogeneity nor the public information alone was sufficient to reduce the inefficiency, but together they could.

Over the recent years, economists in various fields have come to agree on the necessity of good institutions for economic prosperity. Here, institutions include informal norms of behavior and shared beliefs as well as written laws, formal rules and social conventions (North, 1990). Despite its importance, however, studies on the conditions for efficient institution building are rather rare, which is partly because studying institution building within the rational agent framework is not straightforward, and especially difficult when the institutions refer to informal norms and beliefs. For instance, our game-theoretical benchmark does not distinguish between the public and the private information treatments, although such information often has a nontrivial impact on the outcome because the notions of what is fair and who deserves how much depend on it. We contribute to the discussion by experimentally showing which formal rules can establish more efficient informal norms.

The rest of this paper is organized in the following way. In the following subsection we discuss the closely related literature. Section 2 sets up the model, and Section 3 presents some theoretical benchmarks. Next, in Section 4, we describe the design and procedure of the experiments, and Section 5 highlights the main experimental results. Section 6 discusses the findings of this study more, and Section 7 concludes.

1.1 Literature Review

We build upon the models of legislative bargaining with endogenous proposer selection. Yildirim (2007) extends the model of Baron and Ferejohn (1989) by allowing the agents to exert effort to be the proposer. Key results include: (i) The agents compete more fiercely under majority rule than under unanimity rule since the value of being the proposer is higher when a smaller coalition suffices for the proposal to pass. (ii) Those who are more patient are likely to be excluded from the winning coalition, so they exert more effort to be the proposer. Yildirim (2010) also analyzes the competition to be recognized as the proposer, but with one modification; the recognition is persistent. The analysis reveals that the distribution of surplus becomes more unequal as the recognition becomes more persistent. Ali (2015) considers the situation where the agents compete in the manner of all-pay auction, instead of a lottery contest. Because in an all-pay auction, expected rents are fully dissipated, the continuation value is expected to be zero in equilibrium. Therefore, the entire surplus is taken by the first proposer. Suh and Wen (2009) model multilateral bargaining as a multi-agent bilateral bargaining. A pair of agents negotiate over who will go on bargaining and how much will be given to the one who steps out, and the negotiation process is over when everybody but one agent steps out. In this process the proposer, the one who keeps on negotiating, is endogenously determined. Güth et al. (2004) endogenize the order of moves so that a player self-selects to be the proposer (i.e., the first mover) or the two players move simultaneously to end up playing the Nash demand game. The authors show that under a certain condition, the unique subgame perfect equilibrium exists, where each player makes a demand and the payoffs approximately correspond to the Nash bargaining solution.

Our experiment is motivated by Yildirim (2007), but we adopt an ultimatum bargaining instead of the bargaining with infinite time horizon, which connects our experiment to the vast literature on the ultimatum bargaining experiment. There have been quite a few experiments where the proposal right was not randomly granted but had to be earned somehow. For instance, Hoffman and Spitzer (1985) conducted an experiment in which a randomly selected subject decided whether to go on to an ultimatum bargaining as the proposer or to opt out. If opting out, the subject could leave the experiment with some money, while the matched subject was given nothing at all. Therefore, in some sense, the proposal right was 'bought' at the price of the foregone money. In the experiments of Hoffman et al. (1996) and Gächter and Riedl (2005), subjects acquired the proposal right or a claim by winning a quiz. It is commonly reported that the proposer tended to take a greater share when the proposal right was earned than when it was randomly granted.

Probably the most important difference between those studies and ours is that they are mainly interested in the effect of earning a right (or a claim) on the distribution in the bargaining process, whereas our interest lies not only in the distribution but also in the competitive behavior to earn the right. We analyze the competitive behavior to identify the conditions under which the competition is particularly intense, and ultimately, to learn how to lower the unnecessary social cost.

Also very closely related to our experiment are Güth and Tietz (1985, 1986). They assigned the rights to participate in bargaining games using the second-price sealed-bid auction. They find the proposers in their experiments tended to offer less to the responder than those in the ultimatum bargaining experiments without the auction stage. Such a tendency was particularly strong when the bid of the auction winner was high, which we also find in our data. Shachat and Swarthout (2013) allowed the subject to coordinate by providing information of the (average) price of the other player.

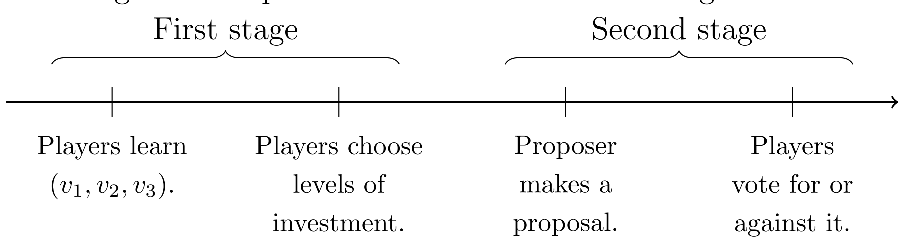
Our experiment differs from theirs in several aspects. (i) We consider multilateral bargaining games as opposed to the bilateral bargaining. (ii) We adopt a lottery contest whereas they used the second price auction. (iii) We assign non-zero reservation payoffs, and vary them to see its effect on the competition. (iv) In our design, even if lost in the competition stage, subjects still participate in the bargaining game as a non-proposer. In their experiment, on the other hand, losing an auction means non-participation. The roles were assigned by the experimenter, and the subjects competed to participate in the bargaining, given the roles. (v) We consider both cases with and without the biding information being publicly available.

2 Model

Consider a two-stage game with three players who first compete to be selected as a proposer, and then decide how to allocate a fixed amount of the economic surplus (normalized to 1). To model the competition for the proposal right, we employ the contest à la Tullock (1980) where player $i \in \{1, 2, 3\}$ makes an irreversible investment, $e_i \geq 0$, and then is selected as the proposer with probability $e_i / \sum_{j=1}^{3} e_j$.

At the beginning of the second stage, the proposer announces a non-wasteful allocation of the surplus, indicating which player may receive how much. $P = \{(p_1, p_2, p_3) | \sum_{i=1}^{3} p_i = 1, \text{ and } p_i \geq 0 \ \forall i\}$ is the set of feasible proposals and $\Delta(P)$ is the set of probability measures on P. Let (a_i, x_i) denote a feasible action of player i in the second stage where $a_i \in \Delta(P)$ is the (possibly mixed) proposal offered by player i as a proposer, and $x_i \in [0, 1]$ is the voting decision threshold (or the minimum acceptable offer) of player i as a non-proposer. Given the announced proposal, players cast their votes sincerely, i.e., player i votes for the proposal if and only if $p_i \geq x_i$. Given q-quota voting rule[3], if the proposal is supported by more than or equal to q players including the proposer himself/herself, the payoffs accrue according to the proposal. If, on the other hand, it gets fewer than q votes, player i receives his/her reservation payoff, v_i. (v_1, v_2, v_3) is public information. Figure 1 summarizes the timing of events.

Figure 1: Sequence of Events in the Two-Stage Game



We adopt the ultimatum bargaining game instead of an infinite-horizon bargaining game that most of previous theoretical studies employ (Baron and Ferejohn, 1989; Eraslan, 2002; Yildirim, 2007, 2010; Ali, 2015) for a couple of reasons. First, while there has been a natural focal point of the theoretical discussions, the stationary subgame perfect Nash equilibrium (SSPE), there exist a continuum of other equilibria in infinite-horizon multilateral bargaining

[3]In the bargaining with three players, $q = 2$ means the majority rule, and $q = 3$ means the unanimity rule.

models.[4] So, when a systematic deviation from the SSPE is observed in the lab, we are unable to tell whether the discrepancy is due to the subjects playing a different equilibrium or other important factors (e.g., social preference, reference dependence and social norm) that have not been properly accounted for. Since the model we consider in this study generates an essentially unique subgame perfect Nash equilibrium, we are free from the concerns related to equilibrium selection, and thus the interpretation of experimental outcomes would be clearer. Second, if the proposer selection contest is repeated in case of the initial proposal being rejected as in Yildirim (2007), the expected outcomes at round t may be affected both by the outcome of the contest at t (because more often than not, people are backward-looking) and by the prospect of the contests at $t + 1$, $t + 2$ and so on (because they are forward-looking as well). Therefore, in such a complicated experiment, we are likely to observe confounded effects of the proposer selection contest. We believe that a simpler case must be analyzed before such a complex one is to be considered. Third, this modification connects our experiment to the literature on the ultimatum bargaining experiment, which provides abundant findings comparable to ours.

Also note that although much simplified, our model keeps the essence of the infinite-horizon bargaining model. One of the key predictions of the multilateral bargaining model is that without asymmetric information, there should be no delay in making a collective decision: The proposer calculates the other members' continuation value, i.e., the expected payoff of moving on to the next round of bargaining, and offers the continuation value to the members of a minimum coalition that would pass the proposal in the first round. Having the reservation payoff v_i as a reduced-form proxy of the continuation value in the infinite-horizon bargaining, our model yields an almost identical set of theoretical predictions. It is a plus that we prevent subjects from miscalculating the continuation value, which typically is a complicated function of the subjective discount factors, the voting rule, and the number of negotiators.

[4] One theoretical feature of the Baron-Ferejohn model is that in their infinite-horizon game, virtually any distribution of feasible payoffs can be supported in an equilibrium. See Proposition 2 of Baron and Ferejohn (1989), which can be understood as an example of a class of results known as "folk theorems."

3 Theoretical Benchmark

A symmetric subgame perfect Nash equilibrium exists, and it is unique.[5] We focus on two particular cases: one with homogeneous reservation payoff, and the other with heterogeneous ones. In the case with heterogeneous reservation payoffs, one (high-type) player has a distinctively greater reservation payoff than the other two (low-type) players have. We consider these two cases separately because when forming a coalition, the proposer may want to choose the one with the lower reservation payoff if the responders are heterogeneous, but there is no reason for the proposer to do so if homogeneous. To exclude trivial corner solutions, we restrict our attention to the cases where $v_i \leq 1/3$ for all i. Otherwise, player i may refuse to get into the negotiation process in the first place.[6]

3.1 Homogeneous Reservation Payoff

First, suppose that every player's reservation payoff has the same value v. The following proposition describes the symmetric SPNE.

Proposition 1. *Consider three players with homogeneous reservation payoff v. Under q-quota voting rule, the equilibrium investment level for the proposer selection contest is $e^* = [2 - 3(q-1)v]/9$. The proposer randomly selects $(q-1)$ coalition members, and offers v to each of them who then accept the proposal. The proposer's equilibrium share is $1-(q-1)v$. The expected payoff of each player is $1/3 - e^*$ in equilibrium.*

Proof: See Appendix A.

The proposition implies that the equilibrium investment level under the majority rule is $(2-3v)/9$, and under the unanimity rule, it is $(2-6v)/9$. Proposition 1 meets our intuition well. If q is larger, each individual invests less. That is, when there are more members

[5] There are asymmetric equilibria with homogeneous reservation payoff v in which players coincidentally believe a particular asymmetric coalition formation pattern. For illustration, consider three players with homogeneous v, negotiating under the simple majority voting rule. If player 1 always chooses player 2 as a coalition member, vice versa, and player 3 chooses one of the other members with equal probability, player 3 would invest more than the other members because otherwise he cannot have a positive share in the bargaining stage. In general, if we allow any sort of asymmetric mixing strategies in forming a minimum winning coalition, there will be a continuum of equilibria. We claim this asymmetric type of equilibrium cannot be a proper ground for the experiment where every round subjects are randomly re-matched and the identity codes are reassigned.

[6] As we will see shortly, the expected equilibrium payoff is the equal-split share, $1/3$, minus the equilibrium investment level. Thus, unless the equilibrium investment level is zero, player i with $v_i > 1/3$ is always better off by not participating in the bargaining process.

that need to be included in the winning coalition, the advantage of being the proposer gets smaller, which decreases the level of resource spending. Note also that the expected payoff is the ex-ante expected share minus the investment level. In equilibrium, each member invests the same amount, and eventually one of the members is selected as a proposer with equal probability. Thus, the expected payoff is that in bargaining with random proposer selection (1/3) minus the resource spending (e^*). Hence, the social inefficiency due to the proposer selection contest is $3e^*$.

3.2 Heterogeneous Reservation Payoffs

Now, we consider the case where $v_1 = v_2 = v - \alpha$ and $v_3 = v + 2\alpha$, where $\alpha \in (0, v)$. By keeping the sum of reservation payoffs the same, we are making this case comparable to that with homogeneous reservation payoffs. For notational simplicity, let v_l denote $v - \alpha$ and v_h denote $v + 2\alpha$. We call the player with v_h is the high type, and the other players are the low type.

Proposition 2. *Consider three players with heterogeneous reservation payoff v_i. Under the simple-majority voting rule, the equilibrium investment levels in the proposer selection contest are $e_h^* = (2-3v_l)/[9(1-v_l)]$ for the high-type player, and $e_l^* = [(2-3v_l)^2]/[18(1-v_l)]$ for the low-type players. When the high-type player is selected as the proposer, he randomly selects a coalition member, and offers v_l. When the low-type player becomes the proposer, he deterministically chooses the other low-type player, and offers v_l. The coalition member accepts the proposal. The proposer's equilibrium share is $1 - v_l$, regardless of his reservation payoff. The expected payoff of each player is $1/3 - e_i^*$ in equilibrium.*

Proof: See Appendix A.

The high-type player invests more to attain a higher probability of being a proposer, $e_h^* = (2 - 3v_l)/[9(1 - v_l)] > [(2 - 3v_l)^2]/[18(1 - v_l)] = e_l^*$. This is because the only way for the high-type player to get a strictly positive payoff is to become a proposer: Since the simple-majority voting rule does not require everybody's favorable vote, the proposer has an incentive to form a minimum winning coalition, that is, to "buy" only one vote which is the cheapest. Therefore, the high-type player would never be selected as a coalition member because $v_h > v_l$.[7] Another observation worth mentioning is that the expected payoff is,

[7] Because of the difference in choosing minimum winning coalition members, the homogeneous reservation payoff case cannot be nested in the heterogeneous case at $\alpha = 0$.

again, the equal-split share minus the equilibrium investment level. The expected payoff the high-type player is smaller than that of the low-type player, and this is solely driven by the different investment decisions.

Next, we compare the resource spending in the case with homogeneous reservation payoffs with that in the heterogeneous case. It may be natural for the player with v_h to invest more than a player with v does, that is, $e_h^* > e^*$, because the high-type player is to be excluded from the winning coalition when not chosen as a proposer. An interesting observation is that e_l^* is also *greater* than e^* as long as α is not too small. To state this formally, we define a threshold:

$$\alpha^* := \frac{6v - 4 + \sqrt{(3v-8)(3v-2)}}{9}$$

which can be shown to be strictly smaller than v.

Proposition 3. *e_l^* is greater than e^* for $\alpha \in (\alpha^*, v)$.*

Proof: See Appendix A.

For example, if $v = 0.15$, then for any $\alpha \in (0.0357, 0.15)$, $e_l^* > e^*$. An increase of α generates two different effects. On one hand, a positive α makes the players asymmetric. Because the high-type player is to be excluded from the winning coalition when lost, he spends more resources to win the proposal right, while a low-type player is to be picked as a coalition member with a high probability, which altogether lowers the low-type players' incentive to make a greater investment. On the other hand, as α increases, the rent for a proposer grows larger (recall that a proposer offers $v - \alpha$ to a coalition member), so does the incentive to make a larger investment. Proposition 3 states that as long as α is not too small, the latter incentive dominates the former.

4 Experimental Design and Procedure

The basic procedure of an experimental session was as follows: Each subject was endowed with 400 tokens in his/her account where 1 token was equivalent to USD 0.015 (1.5 cents). A session consisted of 15 bargaining rounds. In each round, each subject was randomly assigned to a group of three and then was randomly assigned a color (Red, Green, or Blue) as an ID. Then, a group were given 150 tokens which were to be divided among them. Each subject could spend up to 40 tokens to increase the chance to be selected as a proposer, and the tokens spent in the contest were subtracted from his/her account. Subject i's probability to win the proposal right was $e_i/(e_R + e_G + e_B)$, $i \in \{R, G, B\}$, where e_i is the amount of tokens that subject i spent. When no one spent, one member was selected at random with equal probability. The selected subject proposed a non-wasteful allocation of 150 tokens. Observing the proposal, all members voted for or against it to determine the allocation. At the end of each round, they were randomly re-assigned to a new group of three and assigned a new color ID for the next round. At the end of a session, subjects were asked to fill out a survey.

We tailor our experiments to investigate the following questions: What are the effects of the contest on bargaining and vice versa? More specifically, how does the proposer's own spending affect the proposed allocation? Does the information of the other players' investment levels matter in bargaining? If so, does the impact of the information depend on the heterogeneity in reservation payoffs? How does the prospect of a (un)equal division affect the intensity of competition? Under which condition is the wasteful spending minimized?

In total, we have seven treatments, five main treatments and two controls, which are summarized in Table 1. The five main treatments differ in three dimensions: the number of votes required to pass a proposal, the heterogeneity of the reservation payoffs, and whether or not the levels of resource spending are publicly disclosed. Among the five, four treatments adopt the majority voting rule, and one adopts the unanimity rule. Those with the majority rule are PubHoM (*Pub*lic information of resource spending + *Ho*mogeneous reservation payoffs + *M*ajority voting rule), PubHeM (*Pub*lic + *He*terogeneous + *M*ajority), PriHoM (*Pri*vate information + *Ho*mogeneous + *M*ajority), and PriHeM (*Pri*vate + *He*terogeneous + *M*ajority). The one adopting the unanimity rule is PubHoU (*Pub*lic + *Ho*mogeneous + *U*nanimous voting rule). For control, we consider two experimental environments without the contest stage, i.e., the standard ultimatum bargaining games: RaHoM (*Ra*ndom proposer selection+ *Ho*mogeneous + *M*ajority rule), RaHeM (*Ra*ndom + *He*mogeneous + *M*ajority).[8] In the random treatments, subjects were not endowed with the 400 tokens which were given in the other treatments.

In the public treatments, the amount of tokens that each member of the group spent was disclosed with the announcement of the proposer, while in the private treatments, only the proposer was announced. Under the majority treatments, if the proposal received two

[8]Having Random vs. Contest as the fourth dimension of the design, we could have had $16(= 2 \times 2 \times 2 \times 2)$ treatments. However, we decided to focus on the seven treatments for the following reasons. First, when the proposers are selected randomly there is no difference between the public and the private treatments. Second, under the unanimity rule, even the most expensive vote must be bought to get the proposal passed. So the difference between the heterogeneous and homogeneous treatments might be minor.

Table 1: Experimental Design

Majority		Reservation payoffs **Ho**mogeneous	**He**terogeneous
Information	**Pub**lic	PubHoM	PubHeM
	Private	PriHoM	PriHeM
No Contest (**Ra**ndom)		RaHoM	RaHeM
Unanimity			
Information	**Pub**lic	PubHoU	

Each session consisted of 15 rounds. In each round, 150 tokens were given to be divided among a group of three. Except in RaHoM and RaHeM, each subject could spend up to 40 tokens to increase the chance to be selected as a proposer. When the proposal obtained more than or equal to the required number of votes, it was implemented. Otherwise, each member earned his/her own reservation payoff.

or more votes, then it was accepted, and the members earned tokens according to the proposal. Under the unanimity treatment, on the other hand, the proposal was accepted only when all three members voted for it. When the proposal was rejected, each member of the group received his/her reservation payoff. In the homogeneous treatments, each member's reservation payoff was 25 tokens, i.e., $(v_R, v_G, v_B) = (25, 25, 25)$. So, when the proposal was rejected, every group member got 25 tokens minus his/her spending in the proposer selection contest. In the heterogeneous treatments, the "Blue" subject's reservation payoff was 45 tokens, while the other two members' was 15 tokens, i.e., $(v_R, v_G, v_B) = (15, 15, 45)$.[9] Each member's reservation payoff was publicly known. Table 4 summarizes some relevant theoretical predictions.

All the experimental sessions were conducted at the Experimental Social Science Laboratory (ESSL) at the University of California, Irvine on September 28–29, 2017. The participants were drawn from the ESSL subject pool. A total of 168 subjects participated in one of the sessions. Python and its application Pygame were used to computerize the games and to establish a server–client platform. After the subjects were randomly assigned to separate desks equipped with a computer interface, they were asked to carefully read the instructions for the experiment. After reading the instructions, subjects took a quiz to prove their understanding of the experiment. Those who failed the quiz were asked to read the instructions and to take the quiz again until they passed. An instructor answered all

[9]Note that the sum of the reservation payoffs was always 75. Although Blue subjects in the heterogeneous treatments had a larger reservation payoff for the round, ex-ante no subject was favored (or discriminated), since in each round every subject was randomly assigned a new color ID.

Table 2: Treatments and the Corresponding Theoretical Benchmarks

Treatment	(e_R^*, e_G^*, e_B^*)	Pr(Coalition)	Proposer's Payoff
PubHoM	(25.0, 25.0, 25.0)	$(\frac{1}{2}, \frac{1}{2}, \frac{1}{2})$	125
PubHeM	(26.8, 26.8, 31.5)	$(1, 1, 0)$	135
PriHoM	(25.0, 25.0, 25.0)	$(\frac{1}{2}, \frac{1}{2}, \frac{1}{2})$	125
PriHeM	(26.8, 26.8, 31.5)	$(1, 1, 0)$	135
RaHoM	n.a.	$(\frac{1}{2}, \frac{1}{2}, \frac{1}{2})$	125
RaHeM	n.a.	$(1, 1, 0)$	135
PubHoU	(16.7, 16.7, 16.7)	$(1, 1, 1)$	100

e_i^* is player i's equilibrium investment level in tokens. Pr(Coalition) is the conditional probability that each player is included as a coalition member (presented in the order of (Red, Green, Blue)) given that he/she is not selected as a proposer. Proposer's share is the amount of tokens that the proposer obtains in equilibrium.

questions until every participant thoroughly understood the experiment.

Although new groups were formed every round, there was no physical reallocation of the subjects, and they only knew that they were randomly shuffled. They were not allowed to communicate with other participants during the experiment, nor allowed to head up to look around the room. It was also emphasized to participants that their allocation decisions would be anonymous. At the end of the experiment, they were asked to fill out a survey asking their gender and age as well as their degree of familiarity with the experiment. In addition, we asked how well they would perform if they were asked to participate in a similar experiment again. The subjects' risk preferences were also measured.[10] The total amount of tokens that each subject earned was converted into US dollars at the rate of 1.5 cents/token.[11] Payments ($14.73 on average) including the show-up payment of $7 were made in private, and subjects were asked not to share their payment information.

5 Result

5.1 Summary

We begin the analysis by presenting a summary of the data in Table 3. Resource Spending refers to the average level of tokens spent by a subject in the contest game. Proposer's Share is

[10]We could not collect the survey data in one session of PubHoU for a technical reason.

[11]We instructed subjects that the currency exchange should not be a concern as it would be handled by the server computer.

the percentage taken by the proposer from the entire surplus, 150 tokens. Rejected proposals are excluded when calculating the proposer's average share. MWC refers to the proportion of the proposals that explicitly excluded one member to form a minimum winning coalition (MWC). More precisely, we count a proposal as a MWC proposal if it gave someone less than his/her reservation payoff. Rejection is the proportion of rejected proposals.

Table 3: Data Summary

Treatment	Number of Participants	Resource Spending	Proposer's Share (accepted, %)	MWC (%)	Rejection (%)
PubHoM	36	20.43	55.27	58.33	15.00
PubHeM	18	13.59	50.62	48.89	13.33
PriHoM	27	16.54	58.40	51.85	10.37
PriHeM	21	20.20	68.57	76.19	10.48
RaHoM	21	–	59.22	69.52	6.67
RaHeM	21	–	59.00	72.38	7.62
PubHoU	27	6.31	44.23	–	30.00

Resource spending refers to the average investment levels per subject across the whole session. Proposer's Share is the percentage of tokens taken by the proposer from the entire surplus, 150 tokens. MWC refers to the proportion of the proposals that explicitly excluded one member to form a minimum winning coalition (MWC). Rejection is the proportion of rejected proposals.

A few observations, which are detailed in the following subsections, are worth noting:

1. *Treatment Effects*: Both the behavior in the contest and that in the bargaining substantially differed across treatments.

2. *Under-investment*: In all treatments, the average amount of tokens spent in the contest was significantly lower than the theoretical benchmark (25–31.5 tokens under the majority rule and 16.7 under the unanimity rule).

3. *Varying Effect of Information*: When the reservation payoffs were heterogeneous, the level of resource spending was lower in the public information treatment than in the private information treatment. In contrast, when subjects had the same reservation payoff, they spent more resource in the public treatment than in the private one.

4. *Generous Proposal*: Most proposers took a greater share of the surplus than the others. However, the proposer's share was significantly smaller than the theoretical benchmark (83.3–90% under the majority rule and 66.7% under the unanimity rule).

5. *Equity–Efficiency*: In treatments where the proposer's share was smaller (i.e., more equal distribution), the average resource spending was lower (i.e., less wasteful spending).

6. *MWC*: In the majority treatments, more than half of the proposers formed (or tried to form) a minimum winning coalition.

In the following analysis, we also document:

7. *Over-investment*: Given the generous proposals, the amount of tokens spent in the contest turns out to be significantly higher than the optimal level.

8. *Compensation*: In the public treatments, a non-proposer who had spent more at the contest stage was offered a greater amount of tokens, and when a MWC was formed, more likely to be chosen as a MWC member.

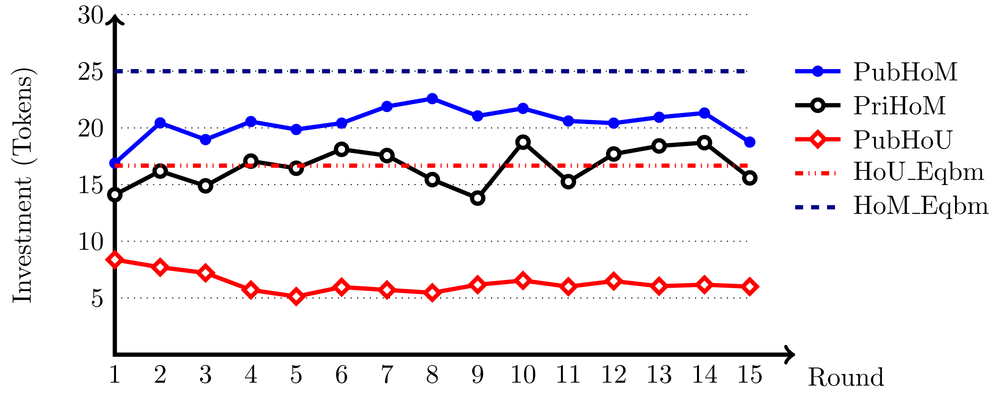
9. *Individual Characteristics*: Gender, age, familiarity with the game, confidence in one's performance, and risk preferences were not significant factors.

5.2 Competition for the Proposal Right

We first scrutinize the competitive behavior of subjects in different treatments. Figure 2 shows the average investment level in the public treatments over time. The investment behavior turns out to be quite stable over the rounds at least at the aggregate level. The dashed lines mark the theoretical predictions under the majority rule (25 tokens) and under the unanimity rule (16.7 tokens). It is clear that the actual levels of spending were significantly lower than the theoretical benchmarks: The average investment level of PubHoM is 20.43 tokens while those of PriHoM and PubHoU are, respectively, 16.54 and 6.31 tokens.

The investment level under the unanimity rule is significantly lower than that under the majority rule (p-value < 0.0001). Interestingly, the deviation from the theoretical benchmark also differs across the treatments: The difference is largest in PubHoU and smallest in PubHoM. Also, recall that the theory does not distinguish the private information treatment from the public information one: Because a rational agent is completely forward-looking in an environment without any remaining uncertainty, the information of the past expenditure should not affect the decisions in the bargaining. However, we find that subjects did care about the past expenditure. Given the homogeneous reservation payoff, subjects competed more fiercely in the public treatment than in the private treatment, and the difference is

Figure 2: Average Investment Level by Round: Homogeneous Treatments



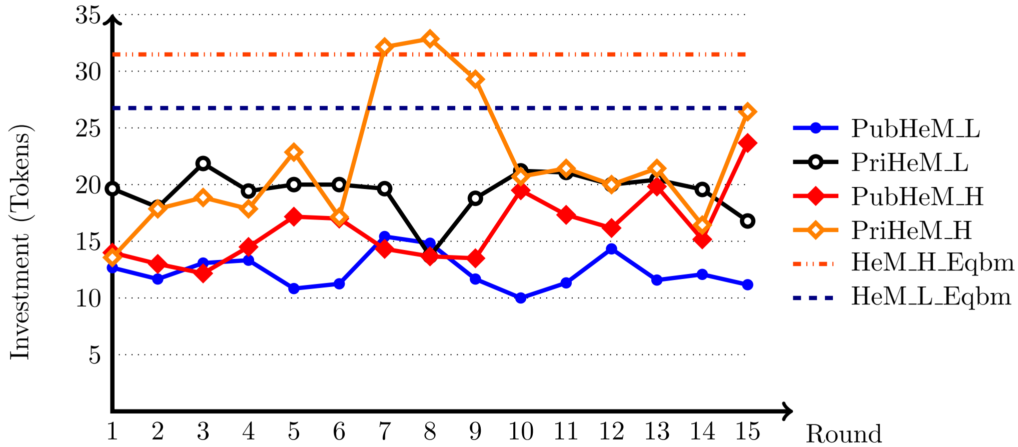
statistically significant at 99% confidence level. This may be because the information of the others' competitive behavior ignited the desire for winning or because it awakened the fear of losing.

Figure 3 shows the average investment levels in the heterogeneous treatments over time. The investment behavior in the heterogeneous treatments appears to be less stable than that in the homogeneous treatments, which is partly because we separate the sample into two subsamples, the sample of high-type (Blue) subjects and that of low-type (Red and Green) subjects. For instance, PubHeM_H is the trajectory of the average resource spending of the high-type subjects in PubHeM, and PubHeM_L is that of the low-type subjects. Again, the dashed lines mark the theoretical predictions for the high-type subject (31.5 tokens) and for the low-type subject (26.75 tokens). As before, the actual levels of spending were significantly lower than the theoretical benchmarks: The average investment level of the low type in PubHeM is 12.35 tokens, and that in PriHeM is 19.34 tokens. The average investment level of the high type in PubHeM is 16.07, and that in PriHeM is 21.92. They all are statistically different from the theoretical benchmark at 99% confidence level.[12]

To sum up, in every treatment most subjects spent less than the equilibrium level, which may appear to contradict previous studies reporting over-investment in contest experiments (Chowdhury et al., 2014; Dechenaux et al., 2015). We, however, claim that this seeming under-investment was likely driven by the prospect of a "fair" division of the surplus, and that taking the generous empirical proposals into account, subjects actually spent too much in the contest (i.e., over-investment). To see this, recall that a non-proposer in the SPNE accepts

[12]There is a surge of the high type subject's investment level on rounds 7–9 of PriHeM treatments. Even after controlling for it, the difference is still statistically significant.

Figure 3: Average Investment Level by Round: Heterogeneous Treatments



any offer greater than (or equal to) one's reservation payoff, so the proposer offers an amount slightly greater than the reservation payoff to maximize his/her own share. Expecting this large rent, the players compete fiercely to win the proposal right. In the experiment, however, the benefit of being selected as a proposer was not so large, because responders often rejected "unfair" proposals, and thus proposers had to offer a generous division.

Figure 4: Average Proposer's Share by Treatment (All, Last 5)

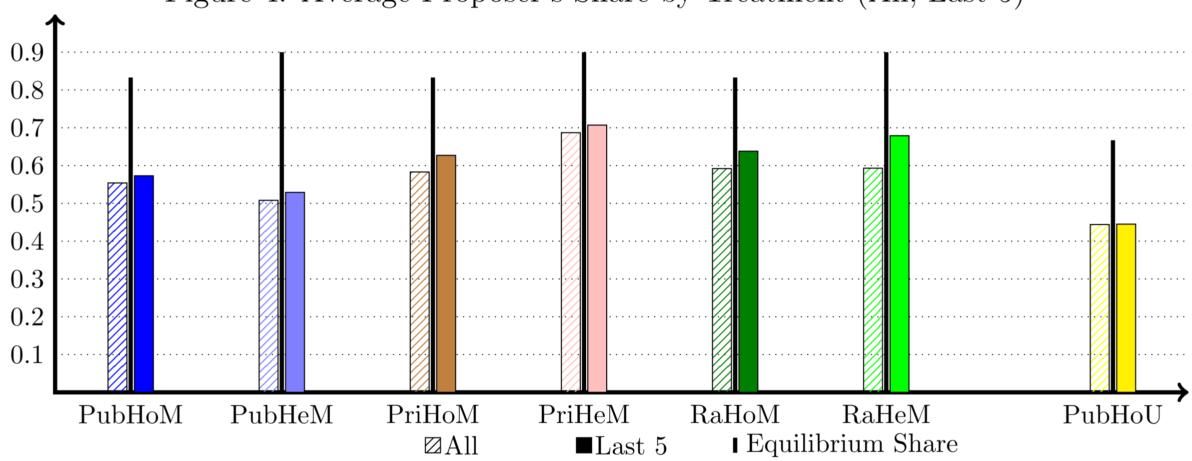


Figure 4 shows the proposer's average share in the accepted proposals. Consistent with the observations in previous studies of bargaining, in all treatments, proposers did not fully extract their rent.[13] To take this partial rent extraction into consideration, we construct

[13]See Palfrey (2016) for the experimental studies reporting partial rent extraction in multilateral bargain-

another benchmark, which we call 'empirically optimal investment', in the following way:

(i) Calculate the expected earnings of a proposer and a non-proposer using the data where

$$\text{Expected earning} = Pr(\text{Accepted}) \times E(\text{Proposed payoff} \mid \text{Accepted}) \\ + Pr(\text{Rejected}) \times (\text{Reservation payoff}).$$

(ii) Taking the difference in the expected earnings as the value of the prize, find the equilibrium investment level of the contest game.

Table 4 reports the average earnings of proposers and non-proposers, and the 'empirically optimal' investment levels.[14] If we compare the data with the theoretical benchmark ((D)−(T)), we will have to conclude that subjects spent too little. If, however, we compare it with the empirically optimal level ((D)−(O)), the conclusion will be completely reversed: Subjects spent too much in all treatments. Since we believe that the empirically optimal investment is a more relevant benchmark for the contest experiment, we claim that over-investments are unequivocally observed, which is consistent with the results of previous studies on contests.

Table 4: Empirically Optimal Investment and Over-investment

Treatment	**Expected Earning**		**(O) Optimal**	**(T)**	**(D)**	**(D)−(T)**	**(D)−(O)**
	Proposer	**Non-Proposer**	**Investment**	**Theory**	**Data**		
PubHoM	74.22	32.26	9.32	25.00	20.43	-4.57	11.11
PubHeM_L	62.45	34.89	5.21	26.75	12.35	-14.40	7.14
PubHeM_H	78.41	37.7	10.18	31.48	16.07	-15.41	5.89
PriHoM	81.11	30.56	11.23	25.00	16.53	-8.47	5.30
PriHeM_L	86.74	25.30	12.60	26.75	19.34	-7.41	6.74
PriHeM_H	96.98	21.07	18.54	31.48	21.92	-9.56	3.38
PubHoU	53.94	36.65	3.84	16.67	6.30	-10.37	2.46

Expected Earnings are the empirical average earning of proposers and non-proposers. Optimal Investment refers to the empirically optimal investment level based on the empirical average earnings.

By comparing the values across the treatments, we add a few more observations. First, the theory predicts that resource spending in the homogeneous treatments is smaller than

ing.

[14]The empirical expected earning may be different from what subjects actually expected. However, the observed behavior seems to suggest that subjects did take the expected earning into account when making an investment. This might be either because they learned what to expect over time or because they had more or less correct prior beliefs from the beginning.

that in the heterogeneous treatments, i.e., $e_h^* > e_l^* > e^*$. In the private treatments, the order appears as predicted, but in the public treatments, the subjects spent too many tokens when they were homogeneous, that is, $e^{Pub} > e_h^{Pub} > e_l^{Pub}$. Second, the empirically optimal level of investment is lower in the public treatments than in the private treatments. This is because the surplus was more equally distributed in the public treatments. Third, although the degree of over-investment (i.e., (D)$-$(O)) seems to vary substantially across the treatments, the rank order of the treatments in (O) and that in (D) coincide with an exception of PubHoM. Because the empirically optimal level of investment reflects the empirical allocation of the surplus, this observation means that in treatments where the surplus was more equally distributed, the efficiency loss due to the wasteful resource spending was lower. Also, it may suggest that subjects indeed took the bargaining outcomes into consideration when making the investment decision.

We test whether the actual investment level is statistically different from the empirically optimal level. In all subsamples, they are statistically different at 99% confidence level. Then, why did the subjects over-invest in the contest? Previous studies have attributed over-bidding in rent-seeking games to judgmental biases or a non-monetary utility for winning (see Dechenaux et al. (2015) for a more detailed discussion). Our experiment differs from the standard contest experiment in that the value of the prize (or the size of the rent) is not exogenously given but endogenously determined. Therefore, there might be a different incentive for over-bidding. More precisely, the resource spending in the contest might influence the bargaining outcome by changing the informal institutions (i.e., norms and beliefs) of what is fair and who deserves how much. Subjects might put more tokens in the contest than the optimal level, expecting it to be compensated even when not selected as the proposer. To study this issue, we regress the amount of tokens offered to a non-proposer on the amounts spent by himself/herself and by the selected proposer. Additionally, for the heterogeneous treatments, we include a dummy variable indicating whether the responder was a Blue (i.e., high-type) player. Table 5 reports the results.

The first column shows the results of the estimation with the entire sample, and the rest shows the results treatment by treatment. Furthermore, for the heterogeneous treatments, we separate the sample with Blue proposers from that with Non-Blue (that is, Red and Green) ones. Note first that the proposers in the public treatments tended to offer more tokens to one who spent more at the contest stage, whereas in the private treatments, not surprisingly, the spending of the non-proposer had little impact on the distribution of the surplus. In other words, informed proposers tended to compensate the resource spending

Table 5: Amount Offered to a Non-proposer

	All	PubHoM	PriHoM	PubHeM		PriHeM		PubHoU
				Blue	Non-Blue	Blue	Non-Blue	
Own	0.1111**	0.4718***	-0.0626	0.6874***	0.134	0.046	0.2192*	0.0869
	(0.045)	(0.1036)	(0.0888)	(0.2367)	(0.2009)	(0.1207)	(0.1262)	(0.1835)
Proposer's	-0.3943***	-0.386***	-0.1169	-0.5135**	0.0418	-0.0733	0.0153	-0.398***
	(0.0446)	(0.1051)	(0.1092)	(0.2001)	(0.2353)	(0.1522)	(0.1619)	(0.1302)
Blue	-7.4581***				-5.618		-16.375***	
	(1.8617)				(3.407)		(3.7154)	
R^2	0.0707	0.0901	0.0067	0.1717	0.0271	0.0036	0.1759	0.0393
N	1260	360	270	68	112	106	104	240

The dependent variable is the amount of tokens offered to a non-proposer. Own is the amount of tokens spent in the proposer selection contest by the non-proposer, and Proposer's is that by the selected proposer. Blue is a binary variable indicating whether the non-proposer was a Blue (i.e., high-type) player. SEs are in parenthesis. *, **, and *** indicate statistical significances at the 10% level, 5% level, and 1% level, respectively.

of a non-proposer by making a more generous offer. On the other hand, the proposers who tried harder to win the competition assigned a greater share for themselves. Interestingly, such a tendency was clearer in treatments where the compensation for non-proposers was generous: The proposers in PubHoM and Blue proposers in PubHeM actively incorporated the information of their own investment as well as the others' when making a proposal, while the proposers in the private treatments and Red and Green proposers in PubHeM did not take more tokens even when they spent more at the contest stage. This suggests that the proposers might compensate the others' spending to justify themselves compensating their own loss.

Since the high-type player is offered zero surplus in SPNE, the coefficient of Blue is predicted to be negative, which is indeed the case in all subsamples.[15] However, the size of estimates differs substantially: In the private treatment, Blue player was offered on average 16.37 fewer tokens than the others (recall that the reservation payoff of Red and Green players was 15 tokens), whereas those in the public treatment was offered 5.6 fewer tokens. This means that the distribution of the surplus was more egalitarian in PubHeM than in PriHeM.

[15]Similarly, Miller et al. (2018) report that the player with the highest reservation payoff was more likely to be excluded from MWC in an infinite-horizon bargaining experiment.

5.3 Proposal types

In the previous subsections, we find that the average amount of tokens taken by a proposer was significantly smaller than the theoretical benchmark in all treatments (see Figure 4). Here, we further investigate how the remaining surplus was distributed *among the non-proposers*, focusing on the majority treatments. One of the strong theoretical predictions is that the proposer will form a winning coalition that guarantees the just enough number of 'yes' votes for the proposal to be accepted, i.e., under the majority rule, the proposer offers an amount smaller than the reservation payoff or nothing at all to one of the voters. We find experimental evidence consistent with the theoretical prediction. Figure 5 shows the proportion of the MWC-type proposals in the majority treatments.[16] The MWC-type proposals are observed most frequently across all treatments. In the public treatments, about a half of the proposals were the MWC proposals, while in the others, the MWC proposals were even more popular: In the last five rounds, more than 80% were MWC proposals. In other words, the surplus was likely to be distributed in a more egalitarian manner when the investment information was public. Moreover, the fact that MWC proposals were popularly adopted in all majority treatments tells indirectly why the distribution was relatively more egalitarian in the unanimity treatment where any MWC proposal was to be rejected.

Figure 5: Proportion of MWC-Type Proposals (All, Last 5)

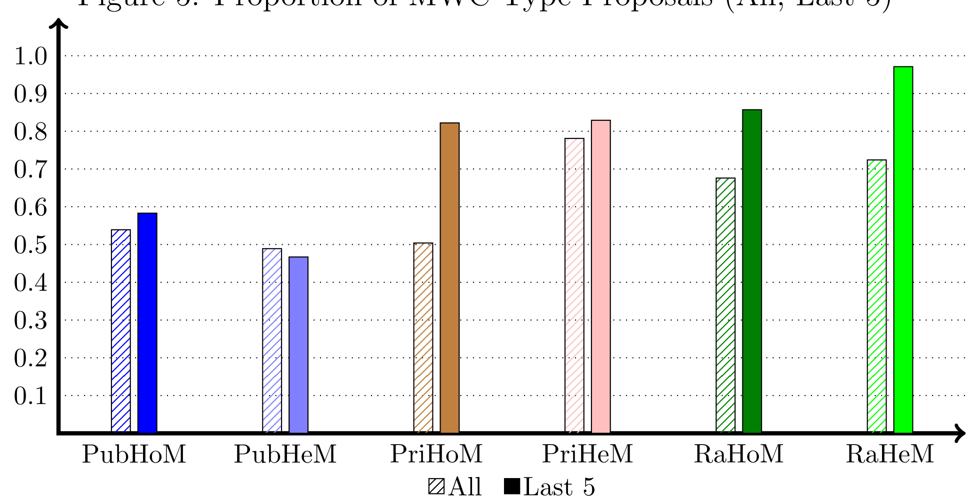
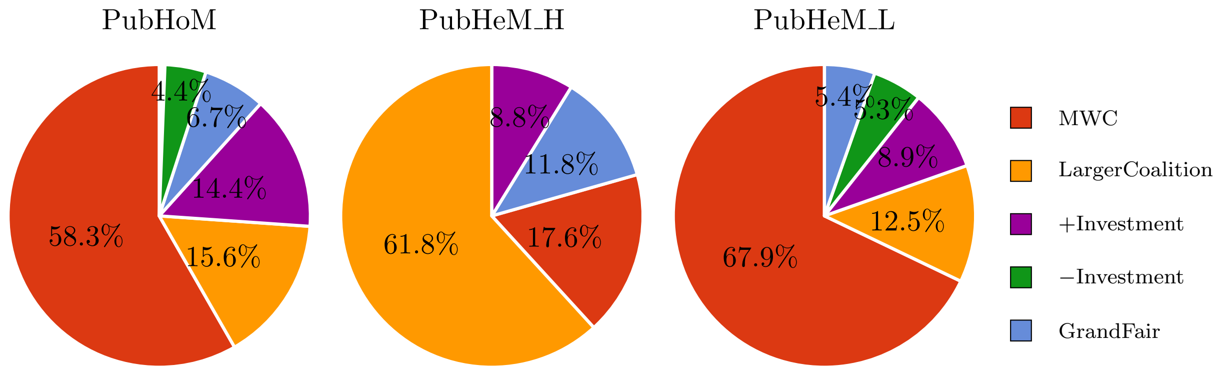


Figure 6 shows what other types of proposals were made.[17] In PubHeM, the proposal

[16] We coded any proposal that involves an offer smaller than a member's reservation payoff as the MWC type.

[17] The pie chart for PubHeM adds up to 99.4%, not 100%, because in one bargaining round, the (Blue)

Figure 6: Proposal Types in Public Treatments



A MWC proposal allocates fewer tokens than the reservation payoff to one member. A GrandFair proposal divides the surplus (almost) equally. A LargerCoalition proposal allocates the same amount—but smaller than the proposer's— to the non-proposers. A +Investment proposal allocates more tokens to the non-proposer with the greater investment, and a −Investment proposal is defined in a similar manner.

pattern of the subjects with the larger reservation payoff (i.e., Blue) was far different from that of the others. So, we look at them separately. PubHeM_H denotes the case where a Blue subject became the proposer, and PubHeM_L denotes the other cases. We categorize the proposals in the following way:

- A *MWC* proposal allocates fewer tokens than the reservation payoff to one member. For example, $(p_R, p_G, p_B) = (100, 50, 0)$ excludes the Blue subject from the coalition to pass the proposal.

- A *GrandFair* proposal divides the surplus equally or nearly so. Precisely, if the difference between the maximum and the minimum amounts is smaller than or equal to 6 tokens, for example $(52, 49, 49)$, we code such a proposal as GrandFair.

- A *LargerCoalition* proposal allocates the same amount—but smaller than the proposer's—to both of the non-proposers. For example, $(70, 40, 40)$ is coded as a LargerCoalition proposal.

- A *+Investment* proposal allocates more tokens to the non-proposer with larger investment. For instance, if Red subject is the proposer and Green spent more than Blue did, $(p_R, p_G, p_B) = (70, 50, 30)$ is coded as +Investment.

proposer proposed (20, 20, 110), allocating fewer tokens than the reservation payoff to both. This proposal does not fit into our classification.

- A $-$*Investment* proposal is defined similarly. For example, if Green spent more than Blue did, $(p_R, p_G, p_B) = (70, 30, 50)$ is coded as $-$Investment.[18]

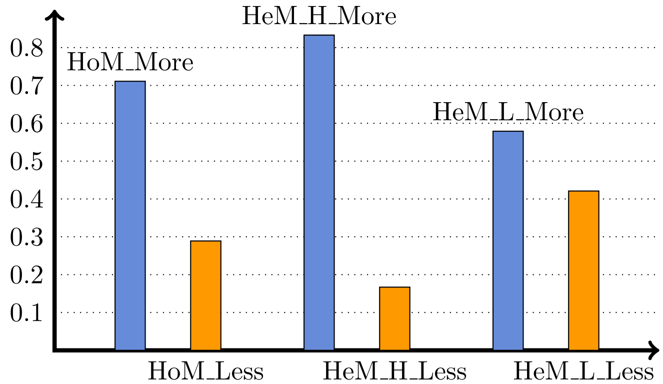
It turns out that LargerCoalition and +Investment proposals were also popularly offered, and GrandFair and $-$Investment proposals were the least popular ones. Moreover, there is a noticeable difference between the behavior of Blue proposers in PubHeM and that of the others: Blue proposers in the heterogeneous treatment made MWC-type proposals much less often. Instead, LargerCoalition and GrandFair proposals were made more frequently. Given that most of Blue proposers in the private treatments made the MWC-type proposals, it indicates that the information of the other members' investment levels had a significant impact on the allocation decisions. We discuss this observation in a more detailed manner in the next section.

Lastly, let us consider the following question to better understand the proposal pattern. If a proposer comes to know that one member spent more resource at the contest stage than the other member, whom should the proposer choose as a coalition member? The theory predicts that the proposer will form a minimum coalition, but does not provide any prediction for the question of who should be the coalition member. On one hand, the proposer may want to infer from the investment levels how eager each member was to be a proposer and how demanding he/she will be. Since the one who spent more is likely to have a high reference point, the proposer may want to choose the member who spent less. On the other hand, the proposer may want to strategically exploit the fact that the member with the larger investment knows that he/she may lose even more unless included in the coalition. Or, the proposer may want to pick the one who spent more as a coalition member without any strategic consideration but simply out of compassion to compensate the loss of the member.

In the previous subsection, we show that proposers tended to offer more tokens to the member whose investment level was higher (Table 5). This tendency is found again in the choice of the MWC member. Figure 7 shows the proportions of proposals which select the one who spent more as a coalition member and of those which select the other. HoM_More refers to the proportion of MWC members in PubHoM who invested more than the other member. Similarly, HeM_H_More refers to the proportion of MWC members in PubHeM who invested more than the other member, when the proposer was of high type (i.e., Blue).

[18] The proposals categorized as LargerCoalition, +Investment and $-$Invesetment proposals are those which are neither MWC nor GrandFair proposals. In other words, we first check whether a proposal can be put in MWC or GrandFair category. If it is neither MWC nor GrandFair, we then categorize it to LargerCoalition, +Investment or $-$Invesetment. One proposal in PubHoM, which offered 20 tokens to both members, is excluded.

Figure 7: Choice of MWC Member in Public Treatments



HoM_More refers to the proportion of MWC members in PubHoM who invested more than the other member. HeM_H_More refers to the proportion of MWC members in PubHeM who invested more than the other member, when the proposer was of high type.

In the public treatments, spending the tokens at the contest stage was beneficial in two ways: It increased the chance to win the proposal right as well as the chance to be included in the winning coalition.

5.4 Efficiency in Bargaining

To see under which condition the surplus can be shared at a lower cost, we construct two (in)efficiency measures, the aggregate spending at the contest stage and the probability of rejection at the bargaining stage.

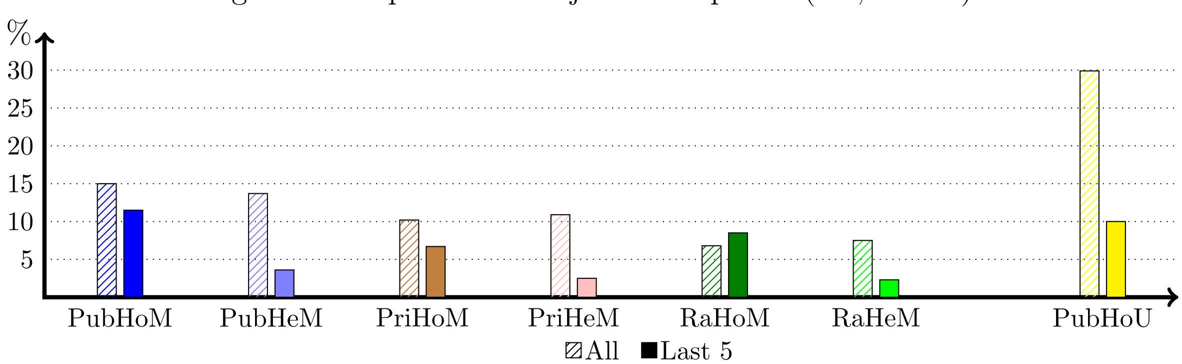
Let us first consider the aggregate investment. Recall that while the resources spent at the contest stage are wasted, at the bargaining stage, the entire surplus is shared among the players upon agreement. Therefore, $\sum_i e_i$ is the amount of the social cost that could have been avoided if the players collectively decided not to compete. Table 6 compares the empirical social cost to the theoretical benchmark.

The social costs due to the competition were lower than the benchmark in all treatments. It may also be noteworthy that the data/theory ratio is particularly low in two treatments, PubHoU and PubHeM. It is predicted by the theory that the aggregate expenditure will be smaller in PubHoU than in the majority treatments, but the actual expenditure was almost one third (0.3772) of the benchmark. On the other hand, PubHeM is the treatment that involves the largest amount of the theoretical social cost, 84.98 tokens, but the actual expenditure was the lowest among the majority treatments, 40.77 tokens.

Table 6: Aggregate Expenditure in the Proposer Selection Contest (in Tokens)

Treatment	Theory	Data	Data/Theory
PubHoM	75	61.29	0.8172
PriHoM	75	49.59	0.6612
PubHeM	84.98	40.77	0.4798
PriHeM	84.98	60.60	0.7131
PubHoU	50.1	18.9	0.3772

Figure 8: Proportion of Rejected Proposals (All, Last 5)



The rejection rate is another measure of (in)efficiency in that once a proposal was rejected, the total surplus shank down to a half (recall that the sum of reservation payoffs was 75 tokens). Also, notice that the reservation payoffs in our model corresponds to the continuation values in an infinite-horizon bargaining model. Similarly, a rejection in this study is comparable with a delay in an infinite-horizon bargaining, which many previous studies have used as the measure of inefficiency. Figure 8 shows the rejection probability by treatment. As expected, the vast majority of proposals were accepted, and the rejection rate was especially low at the last five rounds. Overall, the rejection rate was much lower in the majority treatments than in the unanimity treatment. This observation may not be too surprising given the fact that in PubHoU just one negative vote could reject the proposal. Among the majority ones, PubHoM recorded the highest rejection rate: Even in the last five rounds, more than 10% of the proposals were rejected.

5.5 Individual Characteristics

In this subsection, we test whether the individual characteristics had any impact on the outcomes of the experiment. Table 7 reports some regression results. The dependent variable in the first regression is the amount of tokens spent at the contest stage. For the next two columns, the amount of tokens earned at successful bargaining is the dependent variable. To produce the second column, we use the sample of proposers, and for the third, we use that of non-proposers. Some explanatory variables are from the post-experiment survey. In the survey, we gave the subjects an option to disclose their age and gender. Familiarity is a subjective assessment of how familiar he/she was with experiments, and Confidence is a subjective assessment of how well he/she would perform if participating in a similar experiment again. The subjects' risk preferences were measured by the dynamically optimized sequential experimentation (DOSE) method (Wang et al., 2010), where we asked subjects to answer at most two questions, which enables us to categorize a subject into one of seven types in terms of risk preference. We could not collect the survey data in one session of PubHoU for a technical reason. As control variables, we include treatment dummies, the investment level, and an indicator of "Blue player" in the heterogeneous treatments.[19] In all regressions, PubHeM is set to be the baseline treatment. Since the individual choices are positively correlated across rounds, cluster-robust standard errors at the individual level are used.

[19]Having the investment level as an explanatory variable, we cannot use the sample of the random treatments.

Most individual characteristics did not make any significant impact on the investment decision or those in the bargaining. An exception is the positive relationship between age and the amount of tokens given to a non-proposer. This is because older subjects rejected “unfair” offers more often and we use the sample of successful negotiations for the second and third regressions. Comprehensibility of the game affected neither the investment level nor the bargaining behavior: We compared those who failed to pass the quiz at least once with those who passed the quiz on their first try, and no interesting differences were observed.

Table 7: Individual Characteristics

Dep.Var.	Investment	Tokens taken by a proposer	Tokens given to a non-proposer
Age	2.316	-3.134	2.347**
	(1.586)	(2.681)	(0.9881)
Gender	-1.192	1.118	1.456
	(2.07)	(3.435)	(1.59)
Familiarity	-1.045	-1.603	0.2956
	(1.261)	(1.972)	(0.8292)
Confidence	-2.357	-0.7492	-0.0272
	(1.628)	(2.935)	(0.9685)
Risk	-0.8267	-3.89*	-0.465
	(1.265)	(2.342)	(0.8125)
PubHoM	8.643***	2.841	-6.239***
	(1.983)	(4.648)	(2.112)
PriHoM	3.825	7.439	-8.046***
	(2.464)	(4.57)	(2.065)
PriHeM	6.8**	21.52***	-14.17***
	(2.725)	(5.269)	(1.762)
Blue	3.714***	0.0256	-6.904**
	(1.785)	(2.355)	(2.387)
Investment		0.3107***	0.1503**
		(0.1042)	(0.0671)
Clustered SE	Yes	Yes	Yes
Individual RE	Yes	Yes	Yes
R^2	0.1086	0.2522	0.072
N	1485	434	864

SEs are in parenthesis. *, **, and *** indicate statistical significances at the 10% level, 5% level, and 1% level, respectively.

6 Discussions

6.1 Conditions for efficient bargaining

The two treatments in which the social cost due to the competition was lowest were PubHoU and PubHeM. These are also the two treatments in which the surplus was most equally distributed. The theory does predict that the competition will be least intense under the unanimity rule. However, the actual distribution was much more egalitarian, and much less resource was wasted in the competition than the prediction. On average, the proposers under the unanimity rule took only 44.23% of the surplus, while the theory predicts 66.7%. Correspondingly, the average level of resource spending under the unanimity rule was only 37.7% of the predicted level. In other words, a large part of observed patterns are not explained by SPNE, so we may have to resort to a different explanation. A possible explanation is that when formal rules limit the power of a proposer by providing a veto power to non-proposers, it becomes a social norm to divide the surplus in an egalitarian manner, as found in two-player ultimatum game experiments. If one correctly expects such a social norm, he/she will not try hard to become a proposer. On the other hand, it is important not to overlook that the rejection rate, another measure of inefficiency, was much higher in PubHoU than in any other treatment.

Given the majority voting rule, the surplus was most efficiently and equally distributed in PubHeM. This finding is particularly interesting since the theory predicts that the social cost will be largest in PubHeM. We again resort to an alternative explanation. For a starter, recall that proposers responded to the information of the others' resource spending in a way to compensate the others' expenses, and as a consequence, the distribution was more egalitarian in the public treatments. Thus, the information of others' expenses could be a factor that relaxes the competition for the proposal right, and in turn reduces the social cost. However, both the amount of over-investment (i.e., actual investment − empirically optimal investment) and the rejection rate in PubHoM show that relaxing the competition was not always so straightforward. Then, how could PubHeM, but not PubHoM, be an environment facilitating efficient negotiations? We conjecture that the heterogeneity in reservation payoff helped coordination among the subjects.

Let us consider the following scenario. As documented in Brown (2011), the presence of a superstar (like Tiger Woods in golf) may discourage the other players from trying hard to win. Similarly, Blue subjects in the heterogeneous treatments were expected to make a greater amount of investment, thus to win the contest with a higher probability. Therefore, the other subjects might find that it was in their interest to let Blue subject win the contest on condition of a generous proposal, which would improve everybody's welfare if successful. In such a sense, the subjects might be willing and able to form a gift-exchange relationship in which Red and Green subjects yielded up the proposal right, and in return Blue subject put a generous proposal to the vote. This might be a reason why LargerCoalition and GrandFair proposals were frequently offered by Blue proposers. In the experiment, the public information might also facilitate forming such a gift-exchange relationship by making it easy to detect any significant deviation from the norm. Note lastly that even when such a relationship was successfully formed, it was not optimal for Red or Green subject to make no investment, because (i) the rent for a non-Blue proposer was substantial and (ii) Blue proposer was likely to compensate the expense.

6.2 Comparison to infinite-horizon bargaining

Since we often compare our design and results with those of infinite-horizon bargaining, one may wonder how exactly they can be compared. We designed the experiment to ensure a sufficient number of rejections because we were interested in using the rejection rate as a meaningful measure of inefficiency. Also, we wanted the heterogeneity of players in the relevant treatments to be non-trivial. For these purposes, we set the reservation payoffs much higher than the continuation values in the infinite-horizon bargaining game of Yildirim (2007). In the infinite-horizon game, the continuation value does not exceed 0.1, or 15 tokens in the context of the experiment even when the players are extremely patient, for example, when the discount factor, δ, is 0.99. This is because at the beginning of each round, subjects spend resources again to increase the chance to be a proposer in the new round. If we assume $\delta = 0.8$ as in many previous studies[20], the continuation value in the corresponding infinite-horizon bargaining game will be even smaller than 15 tokens. Because we assumed high reservation payoffs, the cost of rejecting a unfair proposal was rather low, and therefore, the high acceptance rate in our data is a strong result.

[20] For example, Agranov and Tergiman (2014), Fréchette et al. (2003), and Fréchette et al. (2012) used $\delta = 0.8$, Battaglini et al. (2012) used $\delta = 0.75$, and Kagel et al. (2010), Fréchette et al. (2005), and Miller et al. (2018) used $\delta = 0.5$ for some treatments.

7 Concluding Remarks

In this paper, we investigate when the surplus is less unequally and less inefficiently distributed in multilateral bargaining with a proposer selection contest. Though the unanimity rule resulted in the most equal distribution and the lowest wasteful resource spending, proposals were rejected most frequently, which generated a significant amount of welfare loss. Given the majority rule, when the reservation payoffs were heterogeneous and the amounts spent for the competition were publicly disclosed, the amount of resource wasted for competition was smallest, and the surplus was distributed in the least unequal manner, while more than 87% of proposals were accepted. In contrast, when the reservation payoffs were homogeneous, the public information of resource spending did not help reduce the social costs.

We also find that in all treatments, the average amount of resource spent in the contest was significantly lower than the theoretical benchmark. However, taking the generous proposals into consideration, we show that subjects actually spent too much at the contest. In the public treatments, a non-proposer who had spent more at the contest stage was offered a greater share of the surplus, and when a MWC was formed, more likely to be chosen as a MWC member, which might be a reason why subjects over-invested. In the majority treatments, more than half of the proposers formed (or tried to form) a minimum winning coalition from which a subject with a greater reservation payoff was more likely to be excluded. The correlations between individual characteristics and the observed behaviors in the lab turn out to be insignificant.

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Appendix: Omitted Proofs

Proof of Proposition 1: Given that all the $n-1$ players choose e^*, the equilibrium investment level under the q-quota voting rule would be

$$e^* = \arg\max_{e\in\mathbb{R}_+} -e + \frac{e}{(n-1)e^*+e}(1-(q-1)v) + \frac{q-1}{n-1}\frac{(n-1)e^*}{(n-1)e^*+e}v,$$

where the last term of the objective function is the expected payoff when the player is selected as one of $q-1$ coalition members. The derivative with respect to e is

$$-1 + \frac{1-(q-1)v}{(n-1)e^*+e} - \frac{e(1-(q-1)v)}{((n-1)e^*+e)^2} - \frac{q-1}{n-1}\frac{(n-1)e^*v}{((n-1)e^*+e)^2}.$$

In symmetric equilibrium it must be equal to zero at $e = e^*$.

$$\frac{1-(q-1)v}{ne^*} - \frac{1-(q-1)v}{n^2e^*} - \frac{(q-1)v}{n^2e^*} = 1.$$

Solving this, we obtain

$$e^* = \frac{n-1-n(q-1)v}{n^2}.$$

To calculate the expected payoff in equilibrium, plug e^* into the objective function so that we have

$$-e^* + \frac{1-(q-1)v}{n} + \frac{(q-1)v}{n} = \frac{1}{n} - e^*.$$

□

Proof of Proposition 2: The player with v_h chooses the investment level e_h with knowing that he will never be chosen as a coalition member.

$$e_h^* = \arg\max -e + \frac{e}{2e_l^*+e}(1-v_l)$$

The first order condition is

$$1 = (1-v_l)\left(\frac{1}{2e_l^*+e_h^*} - \frac{e_h^*}{(2e_l^*+e_h^*)^2}\right) = \frac{(1-v_l)2e_l^*}{(2e_l^*+e_h^*)^2}. \tag{1}$$

Rearranging (1), we get

$$(2e_l^* + e_h^*)^2 = (1 - v_l)2e_l^*. \tag{2}$$

The player with v_l chooses the investment level e_l with knowing that they will be for sure selected as a coalition member when they are not selected as a proposer. Similarly, when the player is chosen as a proposer, he must choose the other player with v_l.

$$e_l^* = \arg\max -e + \frac{e}{e_l^* + e_h^* + e}(1 - v_l) + \frac{e_h^*}{e_l^* + e_h^* + e}\frac{1}{2}v_l + \frac{e}{e_l^* + e_h^* + e}v_l$$

The first order condition is

$$1 = (1 - v_l)\left(\frac{1}{2e_l^* + e_h^*} - \frac{e_l^*}{(2e_l^* + e_h^*)^2}\right) - \frac{v_l}{2}\frac{e_h^*}{(2e_l^* + e_h^*)^2} - v_l\frac{e_l^*}{(2e_l^* + e_h^*)^2}. \tag{3}$$

Rearranging (3), we get

$$(2e_l^* + e_h^*)^2 = (1 - v_l)(e_l^* + e_h^*) - \frac{v_l e_h^*}{2} - v_l e_l^*. \tag{4}$$

Plugging (4) into (2),

$$\begin{aligned}
&(1 - v_l)2e_l^* = (1 - v_l)(e_l^* + e_h^*) - \frac{v_l e_h^*}{2} - v_l e_l^* \\
\Leftrightarrow &(1 - v_l)(e_h^* - e_l^*) = \frac{v_l e_h^*}{2} + v_l e_l^* \\
\Leftrightarrow &e_l^* = e_h^*\left(1 - \frac{3}{2}v_l\right).
\end{aligned} \tag{5}$$

Plugging (5) into (1),

$$(e_h^*(2 - 3v_l) + e_h^*)^2 = (1 - v_l)e_h^*(2 - 3v_l). \tag{6}$$

Solving (6) for e_h^*, we have

$$e_h^* = \frac{2 - 3v_l}{9(1 - v_l)} \tag{7}$$

and with (5),

$$e_l^* = \frac{(2 - 3v_l)^2}{18(1 - v_l)} \tag{8}$$

In equilibrium, the expected payoff for the player with v_h is $\frac{e_h^*}{2e_l^*+e_h^*}(1 - v_l) - e_h^* = \frac{1}{3} - e_h^*$ and that for the player with v_l is $\frac{e_l^*}{2e_l^*+e_h^*}(1 - v_l) + \frac{e_l^*}{2e_l^*+e_h^*}v_l + \frac{e_h^*}{2e_l^*+e_h^*}\frac{v_l}{2} - e_l^* = \frac{1}{3} - e_l^*$. □

Proof of Proposition 3: $e_l^* > e^*$ if

$$\frac{(2-3(v-\alpha))^2}{18(1-v+\alpha)} > \frac{2-3v}{9}.$$

Multiplying by $18(1-v+\alpha)$, we have

$$(2-3(v-\alpha))^2 > (2-3v)(2-2v+2\alpha).$$

Rearranging with respect to α,

$$9\alpha^2 + (8-12v)\alpha + 3v^2 - 2v > 0.$$

When $\alpha = 0$, the inequality doesn't hold since $3v^2 - 2v < 0$. The inequality holds if $\alpha < \frac{6v-4-\sqrt{(3v-8)(3v-2)}}{9} < 0$ or $\alpha > \frac{6v-4+\sqrt{(3v-8)(3v-2)}}{9} > 0$, but we restrict our attention to the positive domain.

Next we want to show $\frac{6v-4+\sqrt{(3v-8)(3v-2)}}{9}$ is strictly smaller than v, so the range of such α is well defined.

$$\begin{aligned}
&\frac{6v-4+\sqrt{(3v-8)(3v-2)}}{9} < v \\
\Leftrightarrow & 6v-4+\sqrt{(3v-8)(3v-2)} < 9v \\
\Leftrightarrow & \sqrt{(3v-8)(3v-2)} < 3v+4 \\
\Leftrightarrow & (3v-8)(3v-2) = 9v^2 - 30v + 16 < 9v^2 + 24v + 16 = (3v+4)^2.
\end{aligned}$$

$\square$

Appendix B: Sample Instructions

Sample Instructions for PubHoM

This is an experiment in group decision making. Please pay close attention to the instructions. You may earn a considerable amount of money which will be paid in cash at the end of the experiment. The currency in this experiment is called ‘tokens’. The total amount of tokens you earn will be converted into US dollars at the rate of \$0.015/token. (The server computer will calculate the final payment including the show-up payment of $7. Please don't worry about this calculation.) In the beginning, you are endowed with 400 tokens.

There will be a quiz after the instructions, to make sure you understand how the experiment works.

Overview:

The experiment consists of 15 group decision-making 'rounds'. In each round, you and two other subjects will receive 150 tokens as a group, and decide how to divide the 150 tokens. The details follow.

How the groups are formed:

In each round, all subjects will be randomly assigned to groups of three. For example, if there are 21 subjects in this lab, there will be seven groups of three subjects. There will be no physical reallocation. Only the server computer knows who are grouped with whom. That is, in any round you will not know who your group members are. Your group members will not know you either.

Each member of the group will be assigned a color (Red, Green, or Blue) as an ID, which will be displayed on the top of the screen.

Once the round is over, everyone will be randomly re-assigned to a new group of three, and will be randomly assigned a new color ID for the next round. The group and color ID assignments are purely random: No previous happenings will affect the random assignments whatsoever.

How the tokens are divided:

Each round consists of (1) a proposer selection stage, (2) a proposal stage, and (3) a voting stage.

(1) Proposer Selection: A server computer will determine the proposer. Every member in the group can spend up to 40 tokens to increase the chance to be the proposer in the current round: The more tokens you spend, the larger chance you could have. Specifically, your probability of being a proposer is the following ratio:

$$\frac{\text{the number of tokens you spent}}{\text{the total number of tokens your group spent}}.$$

For example, if Blue spent 2 tokens and Red and Green spent 1 token each, Blue will be the proposer with 50% of chance, and the other two will be the proposer with 25% of chance each. If Green spent 1 token but the other two didn't spend tokens, Green will be the proposer for sure. If no one spends any token, each one's chance will be the same as 1/3. You will know who the proposer for the round is, as well as know how many tokens each member spent.

(2) Proposal: If you are selected as a proposer, you will make a proposal to divide 150 tokens. You can allocate 0 tokens to some members, but all allocations must add up to 150 tokens. If you are not selected, you will wait until the selected member submits his/her proposal.

(3) Voting: The proposal will be voted on by all members in the group. If the proposal gets 2 or more votes, it is accepted: Members will earn tokens according to the proposal, and move on to the next round. If the proposal is rejected, that is, gets 1 vote or less, each member in your group will earn 25 tokens and move on to the next round.

In every new round, your new group will repeat the processes above: (1) proposer selection, (2) proposal, and (3) voting. Please note that tokens spent in the previous rounds are NOT counted. If you want to increase the chance of being a proposer for the current round, you should spend tokens again.

Summary of the process:

1. The experiment will consist of 15 rounds.
2. Prior to each round, all subjects will be randomly assigned to groups of three members. Each member of the group will be assigned a color (Red, Blue, or Green) as an ID.
3. In the proposer selection stage, spending tokens increases the probability of being a proposer. You may decide to spend 0 to 40 tokens. If no one spends any token, one will be randomly selected, with equal probability. You will know who spent how much.
4. In the proposal stage, a selected member will submit a proposal to divide 150 tokens.
5. In the voting stage, if 2 or 3 members in the group accept the proposal, members will earn tokens according to the proposal, and move to the next round. If the proposal is rejected, then each group member will earn 25 tokens and move to the next round.

Quiz for PubHoM

Q1. In each round, you will be assigned to a group of (A) members. Each group will decide how to divide (B) tokens. What are (A) and (B)?

Q2. Suppose that in round 1, your color is Blue, and Green is selected as a proposer. Which of the followings is NOT true?

1. If Green's proposal is rejected, each of the group members earns 25 tokens.
2. Even if I reject Green's proposal, it could be accepted if Green and Red accept it.
3. In the next round, my color must be Blue again.
4. In round 2, I will have new group members and a new color ID.

Q3. In each round are 150 tokens. Which of the following proposals is NOT feasible?

1. Red: 100 // Blue: 100 // Green: 100
2. Red: 100 // Blue: 50 // Green: 0
3. Red: 50 // Blue: 50 // Green: 50
4. Red: 25 // Blue: 25 // Green: 100

Q4. Suppose you are Blue, you spent 4 tokens, Red spent 1 token, and Green didn't spend any token. What's your probability of being a proposer?

Q5. Suppose you are Blue, you spent 5 tokens, Red spent 2 tokens, and Green spent 13 tokens. What's your probability of being a proposer?