Multilateral Bargaining with Proposer Selection Contest*

Duk Gyoo Kim† Sang-Hyun Kim ‡

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Abstract

This study investigates the competition to be selected as the proposer in a subsequent multilateral bargaining game experimentally. The experimental environment varies in two dimensions: reservation payoffs (homogeneous or heterogeneous) and information on the extent of each subject's investment in the competition (public or private). The proposer's share was significantly lower than what theory predicts, and with taking into account the proposer's partial rent extraction, subjects over-invest to increase their chances of winning the right to propose. More importantly, we find that inefficiency (due to the costly competition) and inequity go hand in hand; the surplus was distributed most efficiently and most equally when subjects were informed of who had spent how much in the competition, and slightly more when the reservation payoffs were heterogeneous. The proportion of proposals being rejected was smaller in the public treatments than in the private treatments. This study contributes to the literature by identifying formal rules that are more effective in establishing efficient informal norms.

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

JEL codes: C72, C92, D72

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†Department of Economics, University of Mannheim, *d.kim@uni-mannheim.de*

‡School of Economics, Yonsei University, *sang.kim@yonsei.ac.kr*

1 Introduction

When a group of people negotiates over some economic surplus, an individual who makes a proposal often obtains a greater share than others. Consequently, the participants in a negotiation may be willing to take costly measures to influence the 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 the 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 and hiring a professional negotiator or other experts).

In search of the conditions for efficient multilateral bargaining, this study experimentally examines the competition to win the proposal right for the subsequent bargaining procedure. 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 an (un)equal division affects the intensity of the competition. In this regard, we follow Yildirim (2007), who theoretically analyzes multilateral bargaining over the infinite-time horizon. However, we depart from his model by employing a many-player ultimatum bargaining game instead. This departure 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 most straightforward setup.[1]

More specifically, we examine a two-stage game where the players first choose an investment level independently to increase their chances of being selected as the proposer and then vote on the allocation of the given economic surplus, which is proposed by the player selected in the first stage. The experimental environment varies in two dimensions: reservation payoffs and information on each subject's investment at the contest stage. First, we examine the effect of heterogeneity in the reservation payoffs, which is comparable with the effect of heterogeneous (im)patience in the infinite-horizon bargaining model. Suppose that one's reservation payoff is larger than that of the others. Since his/her vote is more expensive than the others', he/she is more likely to be excluded from the coalition to pass the proposal. With expecting this, the one with the higher reser-

[1]The source of inefficiency most widely discussed in the literature is asymmetric information, which may result in an 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.

vation payoff will be more eager to win the competition, which in turn will affect the others' decisions on investing at the contest stage. This type of strategic consideration does not exist when the reservation payoffs are homogeneous, as there is no reason for the proposer to favor one player over another.

The second dimension of our design considers whether the information on resource spending is publicly revealed. More precisely, in two treatments, we inform the subjects of the selected proposer and the investment of each participant in the contest before the bargaining game takes place, whereas, in the other two treatments, we inform the subjects only of the selected proposer. The theory does not provide any particular distinctions between public and private information, because rational agents do not care about past expenditures, and the equilibrium investment level can be determined ex-ante. From the theoretical perspective, knowing the investment levels of other members does not affect the equilibrium outcomes given that the information is on the equilibrium path. However, we doubt this null effect of public information for two reasons. First, 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). Second, the null effect of public information only holds when subjects observe that the investment levels are consistent with equilibrium levels. What would happen if the information *deviates* from what one would expect in equilibrium? We claim that conducting lab experiments is useful in cases with many possible directions for the outcome; however, the theory is silent on this point.

We find that in all treatments, most proposers indeed took a greater share of the surplus than the others. However, simultaneously, the offered proposals were quite generous in comparison to the theoretical benchmark, which is in line with what has been documented in the literature on bargaining. This partial rent extraction does not imply that the subjects were naïve and irrational; in line with the theory, more than three-quarters of the total proposals form a minimum winning coalition, and less than 15% of those were rejected. Also, taking the observed generous proposals into account, we show that the level of resource spending was significantly higher than the level that maximizes the expected payoff, which is consistent with the results in previous experimental studies of contests.[2] Interestingly, proposers who had spent more resources in the contest tended to treat the non-proposers less generously, and when the information on resource spending at the contest stage is publicly disclosed, fewer proposals are rejected by the members. This entitlement effect might provide an additional incentive for subjects to

[2]The average level of investment in the contest was lower than the "equilibrium" level predicted by the theory, which assumes that (1) whenever the non-proposer is indifferent between accepting and rejecting the offer, he/she will vote for the proposal, and (2) the proposer will fully exploit the rent in the second stage.

over-invest in the public information treatment.

Furthermore, we find that efficiency and equity go hand in hand; in an environment where the surplus was (expected to be) distributed more equally, the efficiency loss due to wasteful resource spending was smaller. This positive relationship between efficiency and equity might be because subjects had weaker monetary incentives to win the contest when the social norm limited the rent extraction more tightly. In particular, the average level of resource spending and that of inequity in the distribution of surplus were significantly lower when (i) the investment levels were publicly revealed and (ii) the reservation payoffs were heterogeneous.[3] 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"). With knowing this, the others might be willing to let Blue win the contest on the 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 gave up the proposal right, and in return, Blue offered a generous proposal to the voters. This relationship might be sustained because Blue, who are more likely proposers, believed that once the relationship or norm was formed, there was a high probability that an unequal (or unfair) proposal would be rejected. In summary, public information, on the one hand, facilitates such a gift-exchange relationship by making it easy to detect any significant deviation from the norm, and on the other hand, the heterogeneity in reservation payoff facilitates coordination among subjects.

In 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, studies on the conditions for building an efficient institution are rare, because such studies within the rational agent framework are not straightforward, and especially tricky when the institutions conform to informal norms and beliefs. For instance, our game-theoretical benchmark does not distinguish between public and private information treatments, although such information often has a non-trivial impact on the outcome, because the social notions of fairness and entitlement 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 as follows. 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

[3]Not all treatment effects are statistically significant, but most of them are once we take into account the theoretical benchmark. See Section 5 for more details.

experiments, and Section 5 highlights the main experimental results. Section 6 discusses the findings of this study further, 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 by Baron and Ferejohn (1989) by allowing the agents to exert effort to become the proposer. The key results are as follows: (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) The agents who are more patient are likely to be excluded from the winning coalition; therefore, 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 a situation where the agents compete in an all-pay auction, instead of a lottery contest. In an all-pay auction, as expected rents are entirely dissipated, the continuation value is expected to be zero in equilibrium. Therefore, the entire surplus is taken by the first proposer. Baranski (2016) interprets the size of the surplus being negotiated as a total value of a common project voluntarily invested by committee members. In one treatment (covered in the online appendix), he considers a situation where the recognition probability of each committee member is the relative contribution, which mimics the winning probability of a Tullock contest. Subject behavior, regardless of whether the recognition probability depends on the level of contribution or not, was virtually identical in all respects of redistribution, contribution, and voting strategies. Suh and Wen (2009) model that multilateral bargaining as multi-agent bilateral bargaining. A pair of agents negotiate over who will continue bargaining and how much will be given to the one who steps out, and the negotiation process is over when all but one agent step out. In this process, the proposer, the one who continues negotiating, is endogenously determined. Güth et al. (2004) endogenize the order of moves so that a player self-selects to be the first mover (i.e., the proposer) or the two players move simultaneously to end up playing the Nash demand game. The authors show that under a specific 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 ultimatum bargaining instead of infinite-horizon bargaining, which connects our experiment with the vast literature on the ultimatum bargaining experiment. In several experiments, 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 continue to ultimatum bargaining as the proposer or 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.

While previous studies are mainly interested in the effect of obtaining a right (or claim) on the distribution in the bargaining process, our interest also lies in the competitive behavior to earn that right. We analyze competitive behavior to identify the conditions under which competition is particularly intense, and ultimately, to learn to lower unnecessary social costs.

Also very closely related to our experiment are studies by Güth and Tietz (1985, 1986). They assigned the rights to participate in bargaining games using the second-price sealed-bid auction. They found that 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 on the (average) price of the other player.

Our experiment differs from theirs in several aspects. (i) We consider multilateral bargaining games as opposed to 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 they lost in the competition stage, subjects still participate in the bargaining game as non-proposers. However, in their experiment, losing an auction means non-participation. The experimenter assigned the roles, and the subjects competed to participate in the bargaining, given the roles. (v) We consider both cases, with and without the bidding information being publicly available.

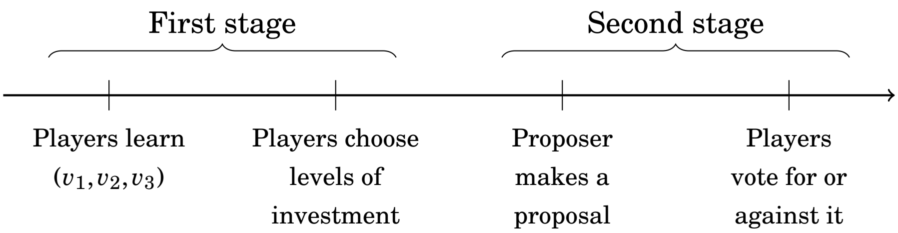
Although we deviate from infinite-horizon multilateral bargaining experiments, it is worth noting the relationships. We observe proposers' partial rent extraction in all treatments, which is a standard finding in the experimental literature on multilateral bargaining (e.g., Fréchette et al., 2003). Recent studies, including Agranov and Tergiman (2014) and Baranski and Kagel (2015) have shown that if committee members are allowed to communicate before bargaining, the chatting facilitates competition among non-proposers (by stating a lower willingness to accept than other members), and it eventually helps the proposers to exploit more rent from them. Although the pre-play chatting has some aspect of cheap-talk competition, it is different from the contest stage where we explicitly implement competition, for two reasons. First, the competition is conducted for determining the proposer, while chatting is useful after a proposer is known. Second, the irreversible investment level in the contest stage does not merely work as a signal of their willingness to accept as a non-proposer but also indicates how eagerly the player wants to be a proposer.

2 Model

Consider a two-stage game with three players who first compete to be selected as a proposer, and then decide the allocation of 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 is then 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. $P = \{(p_1, p_2, p_3) \in [0,1]^3 | \sum_{i=1}^{3} p_i = 1\}$ 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 $p_i \geq x_i$. We restrict our attention to the bargaining game with the simple majority voting rule. Thus, if the proposal is supported by two players (including the proposer) or more, the payoffs accrue accordingly. However, if it gets fewer than two 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 previous theoretical studies employ (Baron and Ferejohn, 1989; Eraslan, 2002; Yildirim, 2007, 2010; Ali, 2015) for three reasons. First, while there has been a natural focal point of the theoretical discussions, which is the stationary subgame perfect Nash equilibrium (SSPE), a continuum of other equilibria in infinite-horizon multilateral bargaining models exist.[4] Therefore, 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 relevant factors (e.g., social preference, reference dependence, and social norm) that have not been adequately accounted. Since the model we consider in this study generates an essentially unique subgame perfect Nash equilibrium, we are free from concerns of equilibrium selection, and thus, the interpretation of experimental outcomes would be more transparent. Second, if the proposer selection contest is repeated when the initial proposal is 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 the confounded effects of the proposer selection contest. We believe that a simpler case must be analyzed before such a complex one is considered. Third, this modification connects our experiment with the literature on the ultimatum bargaining experiment, which provides abundant findings comparable to ours.

Note that although much simplified, our model retains the essence of the infinite-horizon bargaining model. A key prediction 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. Advantageously, 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 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 of heterogeneous reservation payoffs, one (high-type) player has a distinctively greater reservation payoff than the other two (low-type) players. 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 the responders are homogeneous.

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. The equilibrium investment level for the proposer selection contest is $e^* = [2-3v]/9$. The proposer randomly selects a single coalition member and offers v to the chosen member, who then accepts the proposal. The proposer's equilibrium share is $1-v$. The ex-ante expected payoff of each player is $1/3 - e^*$ in equilibrium.*

Proof: See Appendix A.

Note 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 the ex-ante expected share in bargaining with random proposer selection (1/3) minus the resource spending (e^*). Hence, social inefficiency due to the proposer selection contest is $3e^*$.

[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, otherwise, he cannot have a positive share in the bargaining stage. In general, if we allow any asymmetric mixing strategies in forming a minimum winning coalition, there will be a continuum of equilibria. We claim that this asymmetric type of equilibrium cannot be a proper ground for the experiment where subjects are randomly re-matched in every round, and the identification codes are reassigned.

3.2 Heterogeneous Reservation Payoffs

We now 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 denote the player with v_h as the high type, and the other players as 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 a favorable vote from everyone, the proposer has an incentive to form a minimum winning coalition, that is, to "buy" only one vote, which is the cheapest. Therefore, a high-type player would never be selected as a coalition member because $v_h > v_l$. Another observation worth mentioning is that the expected payoff is again the equal-split share minus the equilibrium investment level. The expected payoff of 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 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, 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 the following 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 the one hand, a positive α makes the players asymmetric. Because a high-type player is to be excluded from the winning coalition when lost, he/she 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 incentive of the low-type players 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.

Another notable feature is that the equilibrium investment level is irrelevant to the information about other players' investment levels. Although it is evident from the theoretical perspective, we formally state it in Corollary 1 because we doubt it.

Corollary 1. *With knowing e_j^* for all $j \neq i$, player i's best response is e_i^*. When players make decisions without knowing the actions of other players, player i's equilibrium action is e_i^*.*

Proof: Trivial.

On the equilibrium path, that is, when one player knows that the investment decisions of all other players coincide with their equilibrium investment levels, it is natural that the player's best response is equivalent to the equilibrium investment level. However, the theory is silent on situations where the information about other players' investment decisions is available, and the information *deviates* from what one would expect in equilibrium. What would happen when a proposer turns out to be a lucky one, in the sense that she made a smaller investment than other players but was selected as a proposer? How would a proposer treat non-proposers who spent more/less than the optimal investment level? How would a non-proposer who made the largest investment but could not be a proposer respond to the proposal? How would non-proposers respond to the proposal when they realize that the proposer spent more/less than the optimal investment level? We believe that these are important but under-explored questions to better understand the relationships between competition and bargaining, which is why one of the main treatments in the experiment deals with the availability of information on resource spending in the contest stage.

4 Experimental Design and Procedure

The basic procedure of an experimental session was as follows. Each subject was endowed with 400 tokens[6] in his/her account. A session consisted of 15 bargaining rounds. In each round, each subject was randomly assigned to a group of three and randomly assigned a color (Red, Green, or Blue) ID. Then, a group was given 150 tokens, which were to be divided among them. Each subject could spend up to 40 tokens to increase the probability of being a proposer, and the tokens spent 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. If the proposal received two or more votes, then it was accepted, and the members earned tokens according to the proposal. When the proposal was rejected, each member of the group received his/her reservation payoff. 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. The final accumulated tokens[7] are converted to Euros at the rate of 1 token to €0.015 (1.5 euro cents). At the end of the 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 about 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 an (un)equal division affect the intensity of competition? Under which condition is wasteful spending minimized and the proposal less likely to be rejected?

[6] This endowment prevents subjects from having negative earnings in the end. In the worst possible situation, a subject could spend 40 tokens in each bargaining but not be selected as a proposer. Since her probability of becoming a proposer is at least 1/3, she could lose 40 tokens for ten rounds (2/3 of 15 rounds) when she is excluded from the winning coalition every round. Even if she is exceptionally generous and allocates only 40 tokens for herself as a proposer, 400 tokens are sufficient to prevent negative earnings. On average, the subjects ended up having 795 tokens. We do not believe that loss-aversion played an important role in the sense that no subjects practically experienced a constant decrease in the endowment. If it did, it would have resulted in under-investment in the contest game.

[7] We deliberately decided to pay for all rounds instead of paying for one randomly selected round, which might help avoid potential wealth effects. On top of the fact that the traditional approach in experiments with multiple decisions is to pay for all outcomes (Charness et al., 2016), one distinctive advantage of paying for all rounds is to minimize undesirable effects of risk preferences and to induce risk-neutral (or less risk-averse) behavior (Walker et al., 1990). Since our theoretical benchmark considers risk-neutral agents, we believe that controlling for risk preferences is more important than controlling for the wealth effect. If wealth mattered, we might have found that wealthier subjects were more aggressive in the contest game and more generous in the bargaining game than poorer subjects. Ex-post, we did not find any significant wealth effect.

Table 1: Experimental Design

		Reservation payoffs	
		Homogeneous	**Het**erogeneous
Information	**Pub**lic	PubHom	PubHet
	Private	PriHom	PriHet

Each session consisted of 15 rounds. In each round, 150 tokens were given to be divided among a group of three. Each subject could spend up to 40 tokens to increase his/her chances of being 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.

In total, we have four treatments, which are summarized in Table 1. The four treatments differ in the following two dimensions: the heterogeneity of the reservation payoffs and whether the levels of resource spending at the contest stage are publicly disclosed. Each of those treatments is called PubHom (**Pub**lic information of resource spending + **Hom**ogeneous reservation payoffs), PubHet (**Pub**lic + **Het**erogeneous), PriHom (**Pri**vate information + **Hom**ogeneous), and PriHet (**Pri**vate + **Het**erogeneous). PubHom and PubHet are collectively called the public treatments, and PubHet and PriHet are called the heterogeneous treatments. The private treatments and the homogeneous treatments are defined analogously.

In the public treatments, both the number of tokens that each member of the group spent and the color identity of the proposer were disclosed publicly, while in the private treatments, only the color identity of the proposer was announced. In the homogeneous treatments, each member's reservation payoff was 25 tokens, that is, $(v_R, v_G, v_B) = (25, 25, 25)$. Therefore, when the proposal was rejected, every group member received 25 tokens minus his/her spending in the proposer selection contest. In the heterogeneous treatments, Blue's reservation payoff was 45 tokens, while that of the other two members (Red and Green) was 15 tokens, that is, $(v_R, v_G, v_B) = (15, 15, 45)$.[8] Each member's reservation payoff was publicly known. Table 4 summarizes some relevant theoretical benchmarks. In Section 2, we normalize the size of the surplus to 1 but consider 150 tokens in the lab. Theoretical benchmarks are appropriately scaled by 150.[9]

All the experimental sessions were conducted at the Mannheim Laboratory for Experimental Economics (mLab) at the University of Mannheim in April 2018 and in February

[8] Note that the sum of the reservation payoffs was always 75, half of the 150 tokens. Although Blue subjects in the heterogeneous treatments had a larger reservation payoff for the round, ex-ante no subject was favored or discriminated because, in each round, every subject was randomly assigned a new color ID.

[9] For example, the Red subject's reservation payoff in the heterogeneous treatment is 15 tokens, which is 1/10 of 150 tokens. Thus, $e^* = [(2-3(1/10))^2]/[18(1-1/10)] = 0.1784$; therefore, the equilibrium investment level is around 26.8 ($\approx 0.1784 * 150$) tokens.

Table 2: Treatments and the Corresponding Theoretical Benchmarks

Treatment	(e_R^*, e_G^*, e_B^*)	Pr(Coalition)	Proposer's Payoff
PubHom PriHom	(25.0, 25.0, 25.0)	$(\frac{1}{2}, \frac{1}{2}, \frac{1}{2})$	125
PubHet PriHet	(26.8, 26.8, 31.5)	$(1,1,0)$	135

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, and Blue) given that he/she is not selected as a proposer. A proposer's share is the number of tokens that the proposer obtains in equilibrium.

2020.[10] The participants were drawn from the mLab subject pool. A total of 261 subjects participated in one of the sessions. Each treatment was conducted in four sessions at four different time slots. We used Python and its application Pygame 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, the instructor read the instructions for the experiment out loud. The subjects were also asked to carefully read the instructions before they took a quiz to prove their understanding of the experiment. Those who failed the quiz were asked to re-read the instructions and to retake the quiz until they passed. An instructor answered all 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 look around the room. It was also emphasized to participants that their allocation decisions would be anonymous. At the end of the experiment, they filled out a survey that asks gender, age, and degree of familiarity with the experiment. The subjects' risk preferences were also measured. The total amount of tokens that each subject earned was converted into Euros at the rate of €0.015/token.[11] Payments (€11.92 on average) were made in private, and subjects were asked not to share payment information. Each session ran less than an hour.

[10]Eight additional sessions were conducted in February 2020 to provide more robust results. With or without the new session data, the main messages remain unchanged. The sample populations in 2020 were similar to those in 2018, in terms of female ratio (52.67% and 55.56%) and average age (22.83 and 22.17, top coded at 27).

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

5 Results

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 stage. Resource Spending/Benchmark is the percentage of resource spending from the theoretical benchmark. Rejection Rate is the proportion of rejected proposals. Proposer Share is the percentage taken by the proposer from the entire surplus, that is, 150 tokens. Rejected proposals are excluded when calculating the proposer's average share. Proposer Share/Benchmark is the percentage of the proposer share from the theoretical benchmark, 125 in Homogeneous treatments, and 135 in Heterogeneous treatments. MWC refers to the proportion of proposals that explicitly excluded one member to form a minimum winning coalition (MWC). More precisely, we count a proposal as an MWC proposal if it gave one member less than his/her reservation payoff.[12]

Table 3: Data Summary

Treatment	PubHom	PubHet	PriHom	PriHet
# of Subjects	66	66	69	60
# of Sessions	4	4	4	4
Resource Spending	20.07	18.70	21.75	22.86
Resource Spending/Benchmark (%)	80.29	65.92	86.99	80.59
Rejection Rate (%)	8.48	10.91	12.75	13.67
Proposer Share (accepted, %)	63.82	65.32	65.29	70.11
Proposer Share/Benchmark (%)	76.58	72.58	78.35	77.90
MWC (%)	80.61	73.33	75.94	80.67

Resource spending refers to the average investment levels per subject across the whole session. Proposer Share is the percentage of tokens taken by the proposer from the entire surplus, that is, 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.

The main takeaway message from our experimental findings is that there is a *positive relationship between equity and efficiency*. The third to the fifth rows in the table show variables related to efficiency, whereas the sixth to the eighth are related to equity. Note first that the level of resource spending is lower in the public information treatments than in the private information treatments, and is lower in the heterogeneous treatments

[12]The definition of a minimum winning coalition (MWC) we used is different from the measure that is typically used in the experimental literature on multilateral bargaining. The literature often uses a relaxed definition that allows non-MWC players to receive from zero to a small positive payoff (e.g., at most 5% of the pie). We claim that our definition is appropriate in the environment considered in this study because the reservation payoff works as a clear lower bound to accept. We also found that changing the definition does not qualitatively alter our observations.

than in the homogeneous treatments. The rejection rate, another (in)efficiency measure, is low in the public treatments than in the private treatments. Next, let us turn our attention to equity. Since the proposers can claim the entire surplus minus whatever given to the non-proposers, a larger proposer's share implies a more unequal allocation. If an MWC is formed, one player gets below his/her reservation payoff; thus, a larger percentage of MWC may imply more unequal allocation. Proposer's share appears to be smaller in the public treatments than in the private ones. This observation becomes evident when we compare the proposer's payoff to the theoretical benchmark (see row 7). The order in MWC does not seem well aligned with that in Proposer Share, but we can still see that MWC is the smallest in PubHet. Not all differences across treatments are statistically significant, but most of them are significant once the theoretical benchmarks are taken into account. See Section 5 for more detail.

To sum up, in the treatments where the surplus was less unequally allocated, the average resource spending tended to be lower (i.e., less wasteful spending). PubHet, in particular, turns out to be the environment in which the average amount of resources wasted in the competition was the smallest, and the proposers distributed the surplus less unequally than in others.

A few more observations are worth noting: In all treatments, the average number of tokens spent in the contest (18.7–22.86 tokens) was smaller than the theoretical benchmark (25–31.5 tokens). However, taking into account that the proposer's share (63.82–70.11%) was significantly smaller than the theoretical benchmark (83.3–90%), the number of tokens spent in the contest turns out to be significantly larger than the empirically optimal level. A proposer who had spent more at the contest stage offered a smaller amount of tokens to non-proposers, which suggests an entitlement effect. High acceptance rate (86.33–91.52%) and the frequent formation of the minimum winning coalition (73.33–80.67%) are consistent with the typical findings of the previous multilateral bargaining experiments.

The following subsections discuss our experimental findings in detail.

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 stable over the rounds, at least at the aggregate level. The dashed line marks the theoretical predictions (25 tokens). The overall levels of spending were significantly[13] lower than the theoretical benchmark at the 5% level of significance.

[13] We report test results with the robust standard errors clustered at the individual level. Since we ask the subjects to make choices in the same environment repeatedly, the experimental design inherits

The average investment level of the last five rounds in PriHom was not statistically different from the theoretical benchmark (p-value= 0.269). The average investment level of PubHom is 20.07 tokens, while that of PriHom is 21.75 tokens.

Figure 2: Average Investment Level by Round: Homogeneous Treatments

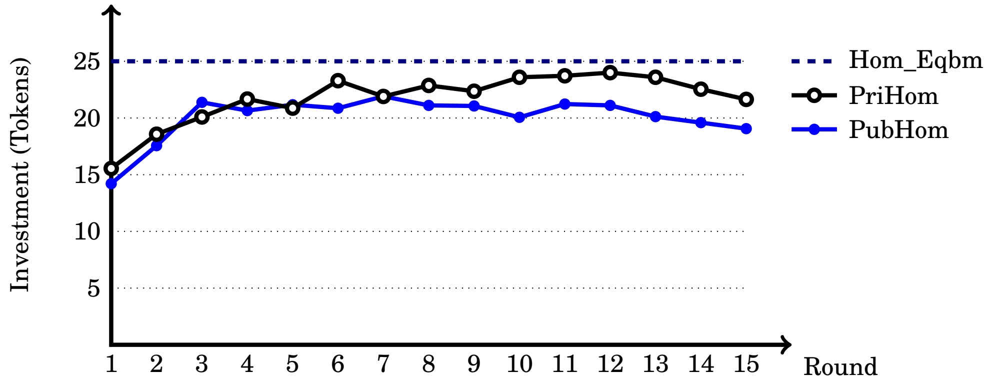
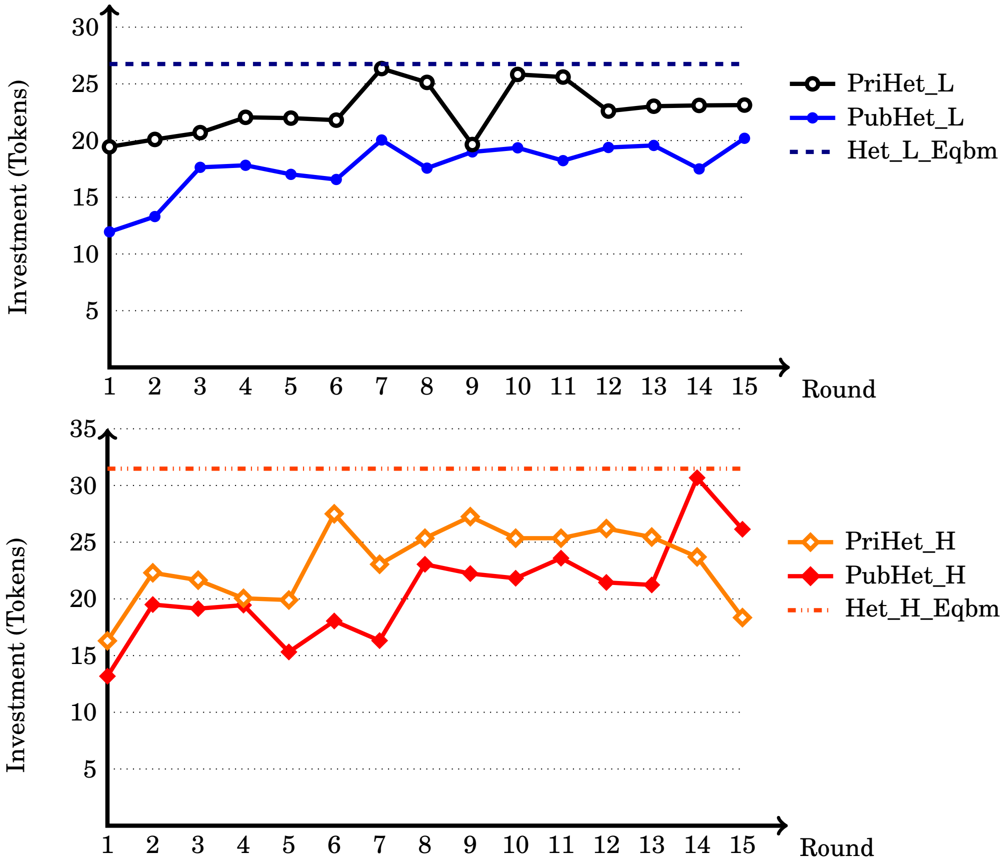


Figure 3 shows the average investment levels in the heterogeneous treatments over time. The investment behavior in the heterogeneous treatments appears to be less stable than that in the homogeneous treatments, which is partly because we separate the sample into two subsamples, the high-type (Blue) subjects, and the low-type (Red and Green) subjects. For instance, PubHet_H is the trajectory of the average resource spending of the high-type subjects in PubHet, and PubHet_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 the low-type subject (26.75 tokens). As before, the actual levels of spending were significantly lower than the theoretical benchmarks, except for the last five rounds of the low type in PriHet (p-value=0.103); the average investment level of the low type in PubHet is 17.68 tokens, and that in PriHet is 22.70 tokens. The average investment level of the high type in PubHet is 20.74, and that in PriHet is 23.18.

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 seemingly under-investment was likely driven by the prospect of a "fair" division of the surplus. By taking the generous empirical proposals into account, subjects indeed spent too much in the contest (i.e., over-investment). To observe this, recall that a non-proposer in the SPNE accepts any offer greater than (or equal to) one's reservation payoff; therefore, the proposer offers an amount marginally greater than the reservation payoff to

clustering at the individual level. Also, since the individual choices are positively correlated across rounds, the standard errors clustered at the individual level are in general larger than those clustered at the session level, and the test results reject the null hypothesis more conservatively. We checked and found that the results remain the same, even with the standard errors clustered at the session level.

Figure 3: Average Investment Level by Round: Heterogeneous Treatments



maximize his/her own share. Expecting this large rent, the players compete fiercely to win the proposal right. However, in the experiment, the benefit of being selected as a proposer was not very 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)

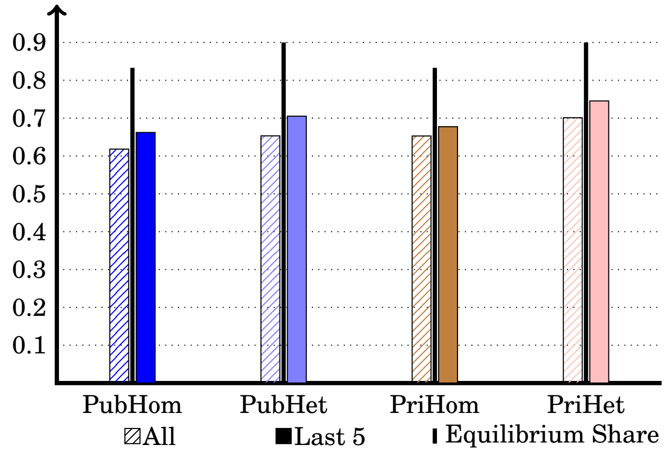


Figure 4 shows the proposer's average share in the accepted proposals. Consistent with the observations in previous studies of multilateral bargaining, in all treatments, the proposers did not fully extract their rent.[14] To consider this partial rent extraction, we construct another benchmark, which we call "empirically optimal investment," as follows:

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

$$\begin{aligned}\text{Expected earnings} = & Pr(\text{Accepted}) \times E(\text{Proposed payoff} \mid \text{Accepted}) \\ & + Pr(\text{Rejected}) \times (\text{Reservation payoff}).\end{aligned}$$

(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.[15] If we compare the data with the theoretical bench-

[14]See Palfrey (2016), who reviewed experimental studies reporting partial rent extraction in multilateral bargaining, and Kim (2018), who examined driving factors of the partial rent extraction.

[15]The empirical expected earnings may be different from what subjects indeed expected. However, the observed behavior seems to suggest that subjects did take the expected earnings into account when investing. This might be because they learned what to expect over time or because they had more or less correct prior beliefs from the beginning.

mark, (D)−(T), we will have to conclude that the subjects spent too little. If, however, we compare it with the empirically optimal level, (D)−(O), the conclusion will be reversed entirely; 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 experimental studies on contests.

Table 4: Empirically Optimal Investment and Over-investment

Treatment	**Expected Earnings**		**(O) Optimal**	**(T)**	**(D)**	**(D)−(T)**	**(D)−(O)**
	Proposer	**Non-Proposer**	**Investment**	**Theory**	**Data**		
PubHom	89.73	26.95	13.95	25.00	20.07	-4.93^{***}	6.12^{***}
PubHet_L	85.83	26.41	12.29	26.75	17.68	-9.07^{***}	5.38^{***}
PubHet_H	96.79	24.76	17.50	31.48	20.74	-10.74^{***}	3.25^{***}
PriHom	88.63	25.90	13.94	25.00	21.75	-3.25^{***}	7.81^{***}
PriHet_L	91.84	25.29	13.77	26.75	22.70	-4.05^{***}	8.93^{***}
PriHet_H	98.70	18.12	19.57	31.48	23.18	-8.30^{***}	3.62^{***}

Expected Earnings are the empirical average earnings of proposers and non-proposers. Optimal Investment refers to the empirically optimal investment level based on the empirical average earnings. *, **, and *** indicate statistical significance at the 10% level, 5% level, and 1% level, respectively.

By comparing the values across the treatments, we add some more observations. First, the theory predicts that resource spending in the homogeneous treatments is smaller than that in the heterogeneous treatments, i.e., $e_h^* > e_l^* > e^*$. In the private treatments, the order appears as predicted, that is, $e_h^{Pri} \geq e_l^{Pri} > e^{Pri}$. However, in the public treatments, the subjects spent too many tokens when they were homogeneous, that is, $e_h^{Pub} \geq e^{Pub} > e_l^{Pub}$. Second, when the reservation values are heterogeneous, 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, the degree of over-investment (i.e., (D)−(O)) is the smallest in PubHet. Because the empirically optimal level of investment reflects the empirical allocation of the surplus, this observation means that in PubHet, where the surplus was more equally distributed, the efficiency loss due to the competition was lower. Also, it may suggest that subjects indeed considered bargaining outcomes when making investment decisions.

We test whether the actual investment level is statistically different from the empirically optimal level. In all subsamples, they are statistically different, with at least a 99% confidence level. Why then 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) specifying what is fair and who deserves how much. Subjects might put more tokens in the contest than the optimal level, expecting it to be justifying their rent-seeking behavior when selected as the proposer. To study this entitlement issue, we regress the number 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.

Table 5: Amount Offered to a Non-proposer

	All	PubHom	PriHom	PubHet		PriHet	
				Blue	Non-Blue	Blue	Non-Blue
Own	0.0100	0.1246	−0.0319	−0.0323	0.1963*	−0.0149	−0.0443
	(0.0301)	(0.0752)	(0.0548)	(0.0936)	(0.1053)	(0.0745)	(0.0549)
Proposer's	−0.2765***	−0.1928**	−0.2546***	−0.0570	−0.3159***	−0.2702**	−0.4410***
	(0.0344)	(0.0802)	(0.0680)	(0.1082)	(0.0878)	(0.1094)	(0.0715)
Blue	−9.2147***				−9.5170***		−13.053***
	(1.1944)				(2.3903)		(1.7911)
R^2	0.0481	0.0134	0.0242	0.0017	0.0718	0.0233	0.1663
N	2610	660	690	252	408	195	402

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 the amount of tokens spent by the selected proposer. Blue is a binary variable indicating whether the non-proposer was a Blue (i.e., high-type) player. The SEs clustered at individual level are in parenthesis. *, **, and *** indicate statistical significance at the 10% level, 5% level, and 1% level, respectively.

The first column shows the results of the estimation with the entire sample, and the remaining columns show the results by treatment. Furthermore, for the heterogeneous treatments, we separate the sample with Blue proposers from that with non-Blue (i.e., Red and Green) ones. Note that the proposers who invested more to win the competition assigned a smaller share for others and a greater share for themselves. Interestingly, such a tendency was very stable in all treatments, regardless of whether their investment level is publicly observable or not. This suggests an entitlement effect; the proposers justify themselves compensating their own loss at the contest stage. Note also that the proposers do not offer more/fewer tokens to those who spent more at the contest stage for all treatments, except for the case of non-Blue non-proposers in PubHet. This observation implies that the resource spending at the contest stage does not compensate non-proposers with a more generous offer.

Since the high-type player is offered zero shares in the SPNE, the coefficient of Blue is predicted to be negative, which is indeed the case in all subsamples.[16] However, the size of estimates differs substantially; in the private treatment, a Blue player was offered on average 13.05 fewer tokens than the others (recall that the reservation payoff of Red and Green players was 15 tokens), whereas those in the public treatment were offered 9.52 fewer tokens. This means that the distribution of the surplus was more egalitarian in PubHet than in PriHet.

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), and the PubHet treatment involves the smallest resource spending and the least unequal allocations. We further investigate how the remaining surplus was distributed *among the non-proposers*. A strong theoretical prediction is that the proposer will form an MWC that guarantees just the sufficient number of "yes" votes for the proposal to be accepted, i.e., the proposer offers an amount smaller than the reservation payoff or nothing at all to one of the non-proposers. We find experimental evidence consistent with the theoretical prediction. Figure 5 shows the proportion of the MWC-type proposals. The MWC-type proposals are observed most frequently across all treatments. In all treatments, about three quarters or more of the proposals were MWC proposals, especially in the last five rounds.

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

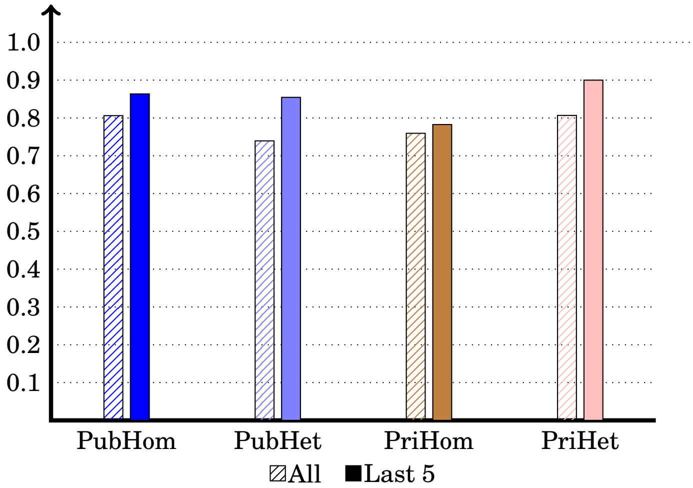
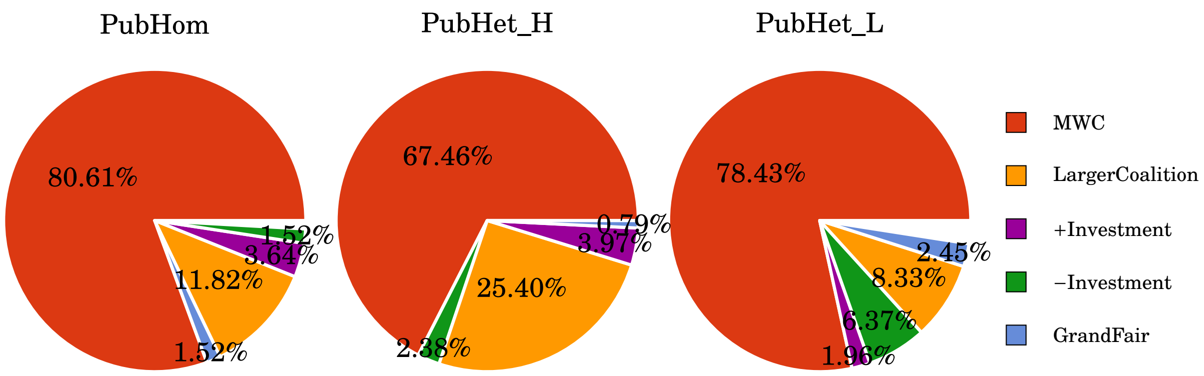


Figure 6 shows the other types of proposals made in the public information treat-

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

ments.[17] In PubHet, the proposal pattern of the subjects with the larger reservation payoff (i.e., Blue) was slightly different from the others, so we examine them separately. PubHet_H denotes the case where a Blue subject became the proposer, and PubHet_L denotes the other cases. We categorize the proposals as follows:

Figure 6: Proposal Types in Public Treatments



An 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 additional amount—but smaller than the proposer's— to the non-proposers' reservation payoffs. A +Investment proposal allocates more tokens to the non-proposer with the greater investment, and a −Investment proposal is defined similarly.

- An *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, $(p_R, p_G, p_B) = (52, 49, 49)$, we code such a proposal as GrandFair.
- A *LargerCoalition* proposal allocates the same "top-up" amount—but smaller than the proposer's— to both the non-proposers. That is, if a proposer offers both non-proposers $v_i + x$, we call it a LargerCoalition proposal. For example, $(p_R, p_G, p_B) = (70, 40, 40)$ in PubHom is coded as a LargerCoalition proposal. $(20, 20, 110)$ in PubHet when Blue is the proposer, and $(20, 80, 50)$ when Green is the proposer are also coded as LargerCoalition proposals.

[17] Among the total 660 proposals in the public treatments, eight proposals are not included in the pie charts as they are unclassified. Two proposals in PubHom and one proposal in PubHet offer both non-proposers who happen to spend the same amount of tokens for competition more than the reservation payoffs in an asymmetric manner, and one proposal in PubHom and four proposals in PubHet offer both non-proposers lesser than the reservation payoffs. These proposals did not fit into our classification.

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

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

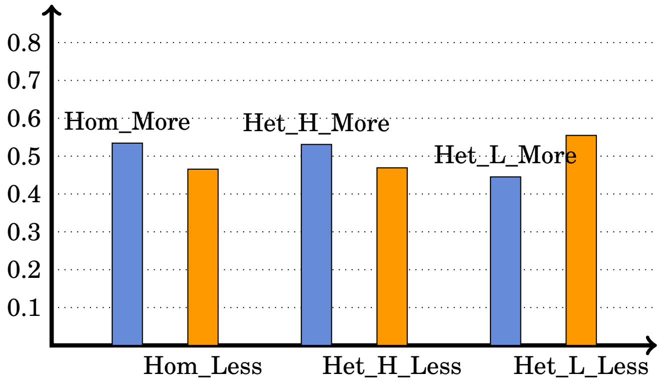
It turns out that LargerCoalition is the second-most frequent type of proposal, and GrandFair is the least popular one.[18] In addition, there is a noticeable difference between the behavior of Blue proposers in PubHet and that of the others; Blue proposers made MWC-type proposals less often, and instead, LargerCoalition-type proposals were made more frequently. This is mostly because offering both of them more than the reservation payoff does not cost too much. Since the reservation payoff of the low type was 15 tokens, offering 15 tokens to both members would cost the proposers 30 tokens in total, which is close to 25 tokens, the reservation payoff of one member in the homogeneous treatments.

Next, we focus on whom a proposer would choose as a coalition partner if the proposer comes to know that one member spent more resources at the contest stage than the other member. The theory does not provide any prediction for the question of who should be the coalition member; however, behavioral justification could work in both ways. On the one hand, the proposer may infer the eagerness of each member to be a proposer and how demanding he/she will be from the investment levels. Since the one who spent more is likely to have a high reference point, the proposer may want to choose a 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. Alternatively, 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 for the loss of the member.

In the previous subsection, we show that the offers to non-proposers are not affected by their own investment level (Table 5). This tendency is found again in the choice of the MWC member. Although proposers tend to choose a member who spent more in the contest stage as a coalition member, the difference is not statistically significant. Figure 7 shows the proportions of proposals that select a member who spent more as a coalition member and those that select the other. Hom_More refers to the proportion of MWC members in PubHom who invested more than the other member. Similarly, Het_H_More refers to the proportion of MWC members in PubHet who invested more

[18] We find similar observations in the private information treatments. In PriHom, 95.35% of the whole accepted proposals were either MWC (74.42%) or LargerCoalition (20.93%). In PriHet, 93.82% were MWC (81.85%) or LargerCoalition (11.9%). Only 1.99% of the accepted proposals in PriHom (respectively, 1.93% in PriHet) were GrandFair.

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. Het_H_More refers to the proportion of MWC members in PubHet who invested more than the other member, when the proposer was of high type.

than the other member, when the proposer was of high type (i.e., Blue). In PubHet, the low-type proposers (i.e., Green and Red) chose the one who spent less at the contest stage, but this observation is compound because the one who spent more is more likely to be Blue, whose reservation payoff is higher than the other non-proposer.

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.

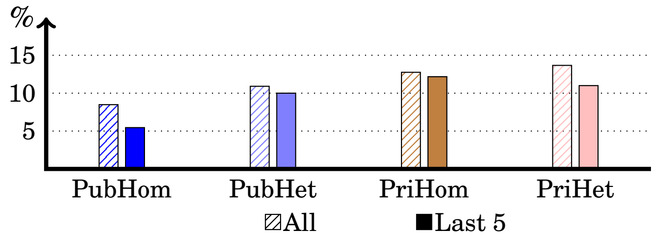
Let us first consider the aggregate investment. Recall that while the resources spent at the contest stage are wasted, at the bargaining stage, the entire surplus is shared among the players upon agreement. Therefore, $\sum_i e_i$ is the amount of the social cost that could have been avoided if the players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

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

Treatment	Data	Theory	Data/Theory
PubHom	60.22	75	0.8029
PubHet	56.10	85.1	0.6592
PriHom	65.25	75	0.8699
PriHet	68.58	85.1	0.8059

The social costs due to competition were lower than the benchmark in all treatments. Notably, the data/theory ratio is particularly low in PubHet. PubHet involves the largest amount of theoretical social cost, 85.1 tokens, but the actual expenditure was the lowest, even in level, among all the treatments, at 56.1 tokens.

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 shrank to half; the sum of reservation payoffs was 75 tokens in all treatments. Notice that the reservation payoffs in our model correspond to the continuation values in an infinite-horizon bargaining model. Thus, a rejection in this study is comparable with a delay in infinite-horizon bargaining, which many previous studies used as a measure of inefficiency. Figure 8 shows the proportion of rejected proposals by treatment. As predicted by theory, the vast majority of proposals were accepted. The rejection rate was significantly lower in the public treatments than in the private treatment, both in the whole rounds (diff=0.0348, p-value=0.002) and in the last five rounds (diff=0.0391, p-value=0.027). This could also be related to the entitlement effect. As shown in Table 5, a proposer who had spent one additional token at the contest stage tended to offer 0.5 fewer tokens to a non-proposer. This behavior might be easily justified when the amount of resource spending was publicly announced. Figure 8 shows that was not the case in the private treatments.

5.5 Regression Analysis

In this subsection, we provide statistical test results for the treatment effects and 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 number of tokens spent at the contest stage. For the next two columns, the number 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, that of non-proposers. For the rest, we use the ratio of the data and the theoretical benchmark as the dependent variables. These variables are interesting to look into as they show how much subjects' behavior diverged from the theoretical benchmark.

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. The subjects' risk preferences were measured by the dynamically optimized sequential experimentation (DOSE) method (Wang et al., 2010), in which we asked subjects to answer at most two questions, enabling us to categorize a subject into one of seven types regarding risk preference. We include treatment dummies, the investment level, and an indicator of the Blue player in the heterogeneous treatments. In all regressions, PubHet is set to be the baseline treatment. In columns 2, 3, 5, and 6, we focus on the accepted proposals to rule out *unacceptable* outliers. Since the individual choices are positively correlated across rounds, standard errors are clustered at the individual level.

Table 7: Regression Results

Dep.Var.	Resource Spending	Tokens taken by a proposer	Tokens given to a non-proposer	Resource Spending / Benchmark	Proposer Tokens / Benchmark	Non-proposer Tokens / Benchmark
PubHom	2.6091*	−1.6003	−1.8837	0.1483**	0.0438**	0.0021
	(1.5431)	(2.6144)	(1.3261)	(0.0589)	(0.0200)	(0.0101)
PriHom	5.2398***	−2.1300	−3.3926***	0.2535***	0.0424**	−0.0098
	(1.7363)	(2.7042)	(1.3083)	(0.0679)	(0.0208)	(0.0100)
PriHet	4.6227***	1.5276	−3.6014**	0.1692***	0.0107	−0.0269**
	(1.5771)	(2.5458)	(1.4219)	(0.0565)	(0.0188)	(0.0105)
Blue	2.3713**	1.9929	−9.3627***	−0.0342	0.0144	−0.0693***
	(0.9731)	(1.7388)	(1.4891)	(0.0343)	(0.0129)	(0.0110)
Age	0.3663	-0.3677	−0.3272	0.0137	−0.0035	−0.0026
	(0.6611)	(0.9196)	(0.4815)	(0.0253)	(0.0070)	(0.0036)
Female	−3.8993***	0.6371	0.3094	−0.1483***	0.0042	0.0029
	(1.1846)	(1.6812)	(0.8571)	(0.0448)	(0.0128)	(0.0065)
Familiarity	0.2873	3.8347**	0.6683	−0.0000	0.0164**	−0.0048
	(1.1900)	(1.7572)	(0.9627)	(0.0252)	(0.0072)	(0.0040)
Risk	−2.6444***	−5.5468***	0.8349	−0.0992***	−0.0433***	0.0060
	(0.8731)	(1.3067)	(0.6317)	(0.0337)	(0.0100)	(0.0048)
Investment		0.4663***	0.0002		0.0035***	0.0000
		(0.0643)	(0.0342)		(0.0004)	(0.0002)
R^2	0.0632	0.1592	0.0276	0.0707	0.1528	0.0329
N	3915	1156	2312	3915	1156	2312

Individual-specific random effects are considered. The SEs clustered at individual level are in parenthesis. *, **, and *** indicate statistical significance at the 10% level, 5% level, and 1% level, respectively.

As noted earlier, subjects in PubHet spent less in the contest stage than those in the other treatments (column 1). This pattern becomes distinctive once we take into account the benchmark (column 4). The amount of tokens taken by the proposer does not differ significantly across treatments (column 2). However, again it turns out that subjects in PubHet gave generously than those in PubHom and PriHom (column 5). The amount of tokens given to a non-proposer is significantly smaller in PriHom and PriHet (column 3), but the difference becomes insignificant once the benchmark is taken into consideration (column6). Blue players spent more than others in the contest stage and were offered less in the bargaining stage.

Age did not make any significant impact on the investment decision or in bargaining outcomes. We found that females and more risk-averse subjects spent a smaller amount of resources at the contest stage, and more risk-averse subjects tried to take a smaller amount of tokens in the bargaining stage. Subjects who answered that they are familiar with a similar type of experiment took more tokens. The comprehensibility of the experiment 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.

6 Discussion

6.1 Conditions for efficient bargaining

PubHet is the treatment in which the social cost due to competition was the lowest, and simultaneously, the surplus was less unequally distributed than in others. PubHet is also one of the two treatments that had a low rejection rate of proposals. These findings are particularly interesting since the theory predicts that the social cost will be largest in the heterogeneous treatments. To fully appreciate this finding, recall that when proposers' own resource spending at the contest stage was larger, they claimed a greater share in the bargaining stage (see Table 5). Moreover, such a claim earned sympathetic votes more easily in the public treatments. Thus, the public announcement of others' expenses could be a factor that *intensifies* the competition for the proposal right, and in turn, increases social cost. Then, how could PubHet 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 (e.g., Tiger Woods in golf) may discourage other players from trying hard to win. Similarly, Blue subjects in the heterogeneous treatments were expected to make a greater amount of investment and win the contest with a higher probability. Therefore, the other subjects might find that it was in their interest to let the Blue subject win the contest by making a small investment, which in turn leads to a generous proposal to the non-proposers. If successful, this could improve everybody's welfare. Therefore, the subjects might be willing and able to form a gift-exchange relationship in which Red and Green yielded the proposal right, and in return, Blue put a generous proposal to the vote. This might be why LargerCoalition, instead of MWC, proposals were frequently offered by Blue proposers in PubHet. In the experiment, public information might also facilitate forming such a gift-exchange relationship by making it easy to detect any significant deviation from the norm. Lastly, note that even when such a relationship was successfully formed, it was not optimal for Red or Green subject to invest nothing, because the rent for a non-Blue proposer was substantial.

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 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. In addition, 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 our experiment, even when the players are extremely patient, for example, when the discount factor, δ, is 0.99. The continuation value of the infinite-horizon game is low because subjects keep spending resources to increase the chances of being a proposer in each round. If we assume $\delta = 0.8$, as in many previous studies[19], 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 an unfair proposal was rather low, and therefore, the high acceptance rate in our data is a strong result.

7 Concluding Remarks

In this study, we investigated when the surplus is less unequally and less inefficiently distributed in multilateral bargaining with a proposer selection contest. When the reservation payoffs were heterogeneous, and the amounts spent for the competition were publicly disclosed, the amount of resource wasted for the competition was smallest, and the surplus was distributed less unequally, while more than 90% of proposals were accepted.

We also find that in all treatments, the average amount of resources spent in the contest was lower than the theoretical benchmark. However, considering the generous proposals, we show that subjects actually spent too much at the contest stage. For all treatments, a proposer who had spent more at the contest stage claimed a greater share of the surplus, and when resource spending is publicly known, the proposal is rejected

[19] 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.

less. Both observations imply that subjects form a consensus that those who spent more at the contest stage are entitled to have more in the bargaining stage. This entitlement effect seems to be an important reason why subjects over-invested. The heterogeneous reservation payoffs, along with the public information on resource spending, create room for coordination among subjects, which eventually make them all better off. Policymakers, who want to allocate the resources less unequally and inefficiently, may want to consider the rule of bargaining similar to the public-heterogeneous treatment.

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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. The high type player gets a positive payoff $1-v_l$ only when recognized as the proposer, so maximizes the following:

$$\max_e -e + \frac{e}{2e_l^*+e}(1-v_l)$$

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. Thus, the low type player maximizes:

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

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.

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

□

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 Euros at the rate of €0.015/token. (The server computer will calculate the final payment. 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?