Multilateral Bargaining over the Division of Losses*

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Abstract

Many-player divide-the-dollar (DD) games have been a workhorse in the theoretical and experimental analysis of multilateral bargaining. If we are dealing with a loss, that is, if we consider many-player divide-the-penalty (DP) games, e.g., the location choice of noxious facilities, the allocation of burdensome chores, or the reduction of carbon dioxide emissions at a climate change summit, the theoretical predictions are not simply those from DD games with the sign flipped. We show that the stationary stage-undominated equilibrium (SSUE) is no longer unique in payoffs. The most "egalitarian" equilibrium among the stationary equilibria is a mirror image of the essentially unique SSUE in the Baron–Ferejohn model. The allocations in that equilibrium are sensitive to changes in parameters, while the most "unequal" equilibrium is less affected by such changes. Experimental evidence clearly supports the most unequal equilibrium: Most of the approved proposals under a majority rule involve an extreme allocation of the loss to a few members. Other observations such as no delay, the proposer advantage, and the acceptance rate are also consistent with predictions based on the most unequal equilibrium.

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1 Introduction

Multilateral bargaining refers to a situation in which a group of agents with conflicting interests tries to bargain under a predetermined voting rule. Many-player divide-the-dollar (DD) games wherein a group of agents reach an agreement on a proposal dividing a dollar have served well as an analytic tool for understanding multilateral bargaining behavior (Baron and Ferejohn, 1989). However, we claim that this model sheds light on only one side of multilateral bargaining: The other side addresses the distribution of a loss or a penalty. Our contribution is twofold: We (1) demonstrate that multilateral bargaining over the distribution of bads is theoretically different from that over goods and (2) provide experimental evidence that clearly diverges from the standard findings of the experimental multilateral bargaining literature.

Real-life situations dealing with the distribution of a loss are as common as those addressing a surplus. Taxation for public spending could be understood as a distribution of burdens. A location choice of a noxious facility is an example of the allocation of a loss, as those closer will suffer more from the disutility of the facility than those in other areas. A climate change summit is another example of a case of dividing a penalty in the sense that the participating countries share the global consensus on the need to reduce carbon dioxide emission levels, but no single country wants to be responsible for the whole burden, as it may be harmful to its economic growth. Despite its relevance to many policy issues, little attention has been given to multilateral bargaining over the division of losses.[1] Such inattention might be due to the conjecture that the theoretical predictions of a many-player divide-the-penalty (DP) game would be exactly the inverse of those of the DD game. We claim that this is not the case, and our claim does not rely on any behavioral/psychological assumptions, including loss aversion.

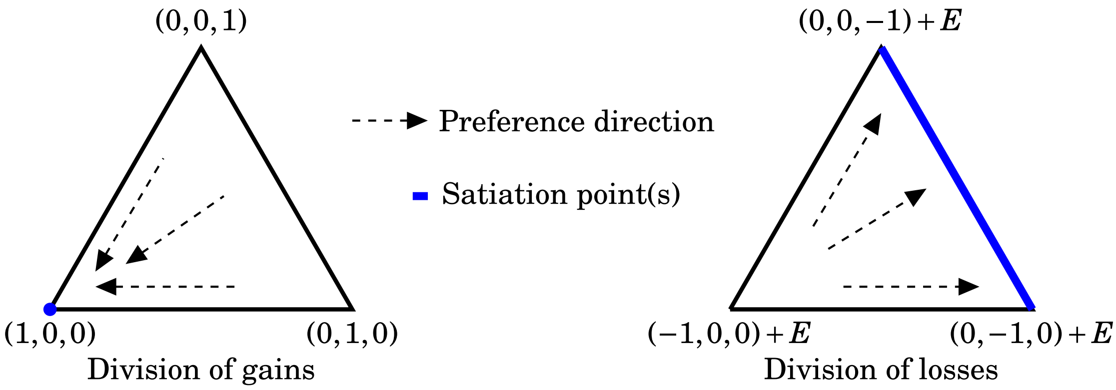


Figure 1: Different Preference Directions and Satiation Points

Figuratively speaking, comparing the DD game to the DP game is *not* analogous to comparing the allocation of a "half-full" cup of water to that of a "half-empty" cup; instead, it is analogous to comparing the allocation of a full cup of "clean" water when everyone is thirsty to that of a full cup of

[1]Some studies, including Aghion and Bolton (2003), Aghion et al. (2004), Harstad (2005), and Harstad (2010), examine coalition formation games concerning the participation constraint. In that the core idea of these studies is related to the question of how the cost of a public project should be split among participants, the division of losses itself is not a new question. Multilateral bargaining games consider both coalition formation and the allocation of resources to the coalition.

"filthy" water when everyone is fully saturated. The latter example addresses fundamentally different objectives that have opposite preference directions. A 2-dimensional unit simplex, which captures the allocation of resources (normalized to one) among three players, can also illustrate this analogy. In Figure 1, player 1 at the bottom-left vertex has a unique satiation point over the division of gains, but she prefers any linear combination of the other two vertices over the division of losses. Although the procedure for dividing a fixed amount of resources would be identical in both situations, the preference directions on the object are not merely flipped. This difference is not due to the domain of utilities: Even if every subject is endowed with an external payoff E that is sufficient to enjoy a positive level of utility overall, the division of losses is still different from the division of gains regardless of the value of E.[2] Thus, the fundamental difference does not rely on the framing effect on the loss. Even if there is a joint benefit or a side transfer derived during the course of the division of the costs, the fundamental difference still remains unchanged.

Another key difference comes from a proposer advantage in the division of losses: Whoever holds the position with more bargaining power cannot seize an advantage that is greater than gaining zero losses. In the DD game, a proposer exploits rent from being the proposer by forming a minimum winning coalition (MWC) to the extent that the number of "yes" votes is only sufficient for the proposal to be approved and by offering the members in the MWC their continuation value such that rejecting the offer would not make them better off. Altogether, a significant amount of the proposer advantage is predicted in the DD game. However, the proposer in the DP game, who will at best enjoy no losses, may not be better off than those in the MWC, who could also enjoy no losses. If we define a "free surplus" as the difference between the equilibrium payoff and the continuation value of one MWC member, then the uniqueness (in payoff) of the equilibrium in the DD game is described by the zero free surplus that the proposer can add to the others. Meanwhile, in the DP game, the proposer can make a strictly better offer than the continuation value of the MWC member. That is, in the DP game, the natural cap of the proposer (who cannot do better than zero losses) allows free surplus to the MWC members.[3]

The fact that the proposer cannot enjoy an advantage greater than zero losses is a source of the primary theoretical difference between the DD game and the DP game. While the DD game has a unique stationary subgame-perfect equilibrium with stage-undominated strategies (or stationary stage-undominated equilibrium, SSUE, for short)[4] in payoffs (Eraslan, 2002),[5] the DP game has a con-

[2]Our experimental design is based on the implementation of this idea.

[3]Focusing on this "free surplus" may be worth examining further because theoretical equivalence between the DD game and the DP game can be achieved either (1) if we restrict the proposer's free surplus in the DP game or (2) if we force the proposer in the DD game to have free surplus. For more discussions, see Appendix D.

[4]The literature more often refers to the stationary subgame-perfect equilibrium (SSPE) rather than the SSUE, but in the DD game with $\delta < 1$, subgame perfection is implied by stage undominatedness, as it satisfies the single-deviation principle. The single-deviation principle is not sufficient for subgame perfection in the DP game with $\delta \geq 1$, but stage undominatedness prevents any profitable multi-round deviations, so every SSUE is a SSPE. For consistency, we use the term SSUE, instead of the SSPE, to refer to the equilibrium both in the DD and the DP games. See Section 2 for more details.

[5]More specifically, with identical players and the same recognition probability, the SSUE on the DD game has a unique ex-post distribution of payoffs. For example, with three players, no discount, and a simple majority rule, the distribution of payoffs is (2/3, 1/3, 0), although we do not know the identities of the proposer and the MWC member. Eraslan and

tinuum of stationary stage-undominated equilibria (SSUEa) with different ex-post distributions of the payoffs. The strategy of one SSUE, which we call the utmost inequality (UI) equilibrium, is for the proposer to assign the total penalty to one randomly chosen member: The other members without a penalty will accept the proposal because the continuation value (the expected payoff from moving to the next bargaining round) would be strictly less than 0. At the other extreme, the strategy of another SSUE, which we call the most egalitarian (ME) equilibrium, is for the proposer to distribute the penalty across all of the members except herself such that MWC members will be indifferent between accepting and rejecting the current offer. Of course, any intermediate strategy between these two extreme strategies can constitute an SSUE. Therefore, the primary goal of this paper is to comprehensively investigate the DP game and compare it to the DD game both theoretically and experimentally.

Laboratory experiments have been a useful tool in the multilateral bargaining literature.[6] We claim that the use of lab experiments is more critical for the DP game. Even if we narrow our focus to stationary strategies, theory is silent in guiding us toward the equilibrium that is more likely to be consistent with our observations. Instead of searching for empirical evidence, we preferred to conduct experiments that are based on our theoretical analysis. Anecdotal empirical evidence might be sporadically available, but we cannot ensure that the environment under which the empirical data are obtained matches well with the theoretical environment we considered. Moreover, it is challenging, if not impossible, for experimenting policymakers to test different situations where an actual loss would be distributed.

We design our experiments with two main treatment variables—the group size (either 3 or 5) and the voting rule (either majority or unanimity)—because they are more frequently revisited in previous studies on multilateral bargaining experiments. We thus have a total of four treatments. Theoretical predictions based on the ME equilibrium were used as null hypotheses because this equilibrium resembles the essentially unique SSUE in the DD game, and it approaches the unique equilibrium under unanimity as the qualified number of voters for approval goes to the group size. Experimental evidence clearly rejects the ME equilibrium. Instead, the UI equilibrium is the most consistent with our experimental observations. Most of the approved proposals under a majority rule involve an extreme allocation of the loss to a few members. That is, in three-member bargaining, one member exclusively receives all the losses, and in five-member bargaining, either one member receives the total loss or two members receive half each. Utilitarian efficiency, meaning no delay in reaching an agreement, and the proposer advantage are well observed.

The experimental results of the DD games in the previous studies had overall been in line with the theoretical predictions, except for the proposer's full rent extraction.[7] If the observed patterns

McLennan (2013) extend Eraslan (2002) by showing the uniqueness of the expected payoffs of the stationary equilibria in more general games. In the DP game considered in this paper, the ex-ante expected payoff is simply $-\delta/n$ in any of the stationary stage-undominated equilibria, so it is still unique.

[6]See Baranski and Morton (2022) for the summary of all (up to 2018) experimental studies on legislative bargaining.

[7]According to Palfrey (2016), three major predictions of the essentially unique SSUE in the DD game are (1) the formation of the minimum winning coalition, (2) utilitarian efficiency (that is, no efficiency loss due to delays), and (3) proposers' full rent extraction. All of these predictions are consistent with the experimental findings. Perhaps the proposer advan-

were close to the mirror image of the essentially unique SSUE over the division of gains, although we identify other SSUEa over the division of losses, we could conclude that the many-player divide-the-dollar game is still sufficiently appropriate for studying multilateral bargaining over the division of losses. Since we find crucial differences both theoretically and experimentally, it is worth revisiting all the important studies on multilateral bargaining where the main motivating situations focus on the division of losses.

The rest of this paper is organized as follows. In the following subsection, we discuss the related literature. Section 2 presents the DP game model, and Section 3 describes the theoretical properties of the model. The experimental design, hypotheses, and procedure are discussed in Section 4. We report our experimental findings in Section 5. Section 6 concludes the paper. Omitted proofs, experimental instructions, supplementary figures and test results, and further discussions are in the Appendix.

1.1 Related Literature

This study stems from a large body of literature on multilateral bargaining. A legislative bargaining model initiated by Baron and Ferejohn (1989) has been extended (Eraslan, 2002; Norman, 2002; Jackson and Moselle, 2002), adopted for use with more general models (Battaglini and Coate, 2007; Diermeier and Merlo, 2000; Volden and Wiseman, 2007; Bernheim et al., 2006; Diermeier and Fong, 2011; Battaglini et al., 2012; Ali et al., 2019; Kim, 2019), and experimentally tested (Diermeier and Morton, 2005; Fréchette et al., 2003, 2005; Fréchette et al., 2012; Agranov and Tergiman, 2014; Kim, 2023).[8] Our contribution to this literature is to show that the theoretical predictions of the DP game under a majority rule could be significantly different due to the natural restriction of the proposer advantage: In the DP game, the maximum advantage available to the proposer is to receive no penalties.[9]

This study is also connected to the literature documenting behavioral asymmetries between the gain and loss domains. From the many studies about loss aversion, we know that human behavior when dealing with losses is different from that when experiencing gains. In this regard, Christiansen and Kagel (2019) is a study philosophically related to ours: The authors examine how framing changes three-player bargaining behavior. In particular, based on the model studied by Jackson and Moselle (2002), they study two treatments that are isomorphically the same in theory but framed differently. Since the theoretical predictions of the two treatments are identical, their primary purpose is to observe the framing effect. Their study is rather related to the literature on the discrepancies between the willingness to pay and willingness to accept. The crucial difference between our study and theirs is

tage is not remarkably consistent with the theoretical predictions, as proposers tend to take a smaller advantage than they can fully exploit (Fréchette et al., 2003). Nevertheless, several follow-up studies, including Agranov and Tergiman (2014) and Baranski and Kagel (2015), provide evidence suggesting that the proposers' partial rent extraction is mainly due to uncertainties particularly existing in the laboratory setting, which could be mitigated via anonymous pre-bargaining communications.

[8] For a more complete review, see Eraslan and Evdokimov (2019).

[9] In the sense that only one voting rule—unanimity—is considered in two-person bargaining, our analysis under a unanimity rule is related to Weg and Zwick (1991). These authors provide experimental evidence that there are no differences between the division of gains and losses, which is consistent with our findings under a unanimity rule treatment.

that we deal with different incentive structures, so framing does not play an important role. The experimental design considered in Christiansen and Kagel (2019) can be regarded as a comparison of a 'half-full' versus 'half-empty' glass of water, figuratively speaking. In the sense that we indirectly compare an economic outcome on a gain domain to that on a loss domain, Gerardi et al. (2016) is another closely related study. The authors compare the penalty of not turning out to vote with a lottery for those who turn out, show that these two incentive structures are theoretically similar, and provide experimental evidence that voters are more likely to turn out under a lottery treatment than under a penalty treatment.

In the sense that legislative bargaining in the frame of losses is examined in the laboratory, our study shares some similarities with Christiansen et al. (2018) in terms of experimental design. What we do in this project is distinguished from Christiansen et al. (2018) in many ways. Their main experimental design is as follows: In a treatment called Gains, three players decide how to distribute \$30 among them. In another treatment called Costs, each of the three players is endowed with \$30, and they decide how to impose the costs of \$60, with limiting the maximum charge to one player to be \$30. That is, the possible outcomes from the two treatments are identical in terms of the final payoffs—in both treatments, each player can end up receiving a payoff between \$0 and \$30—and hence the economic incentives. With this isomorphic setup, which is more discussed in Appendix D, their experiment primarily examines the framing effect. They also focus on the role of pre-play communication, as in Agranov and Tergiman (2014) and Baranski and Kagel (2015), which is orthogonal to what we do in this project.

Although it may appear that the comparison between public bad prevention and public good provision (Andreoni, 1995) is somewhat related, the comparison between the DD game and DP game is distinctively different from the comparison between public good provision and public bad prevention because the former does not involve any form of externality. Regarding the treatment of public bads, a political economy examination of a "not in my back yard" (NIMBY) conflict could also be related to this paper. Levinson (1999) demonstrates that local taxes for hazardous waste disposal can be inefficient because of the tax elasticity of polluters' responses. Fredriksson (2000) shows that a centralized system for siting hazardous waste treatment facilities is suboptimal compared to a decentralized system because of lobbying activities. Feinerman et al. (2004) adopt a model of a competitive real estate market between two cities and provide suggestive evidence that if all cities in the region form political lobbies, the political siting is geographically close to the socially optimal location. To the best of our knowledge, political procedure and equilibrium outcomes under a qualified voting rule have not been investigated in previous studies.

2 A Model

We consider a many-player DP game. As the many-player DD game à la Baron and Ferejohn (1989) aims to understand multilateral bargaining over a surplus, the DP game will serve as a theoretical tool to understand multilateral bargaining over a loss.

There are n (an odd number greater than or equal to 3) players indexed by $i \in N = \{1, \ldots, n\}$. A feasible allocation share is $p = (p_1, \ldots, p_n) \in \{[-1, 0]^n | \sum_i p_i = -1\}$, and the set of feasible allocation shares is denoted as P. We consider a q-quota voting rule: The consent of at least $q \leq n$ players is required for a proposal to be approved. The voting rule is called a dictatorship if $q = 1$, a (simple) majority if $q = \frac{n+1}{2}$, unanimity if $q = n$, and a supermajority if $q \in \{\frac{n+3}{2}, \ldots, n-1\}$.

The amount of the loss increases as time passes, so delay is costly. The cost of delay is captured by the growth rate of the loss, which is $g \in [1, \infty)$ per delay. At the same time, delay also dilutes the disutility of the penalty. Let $\beta \in (0, 1]$ denote the rate at which the disutility is diluted in each period. When the penalty allocation is made in round t, player i's utility is $U_i^t(p) = (\beta g)^{t-1} p_i$. For notational convenience, $\delta \equiv \beta g$, which can be larger or smaller than 1.[10] Over the division of losses, these two factors, β and g, lead to different incentives. When time discounting dominates the growth rate of the penalty, that is, when $\delta < 1$, players have an incentive to postpone the actual allocation of the loss perpetually. Otherwise, players want to make a decision as quickly as possible. We focus on $\delta \geq 1$ because it can capture more pertinent situations: If the nature of bargaining drives the relevant parties to postpone their agreement as long as possible, such bargaining may deal with relatively trivial issues.[11] To complete the model, we assume that each player earns the utility of -1, the lowest possible static payoff, upon not reaching an agreement for infinite rounds of bargaining. This assumption merely corresponds to the assumption in the DD game in which each player earns 0, the lowest possible static payoff, when disagreeing forever.[12] It is worth noting that the utility of the perpetual disagreement does not need to be negative one. As long as it is less than the ex-ante expected payoff in the second round, $-\delta/n$, the equilibria are sustained even when $\delta < 1$ such that the loss exponentially decreases to zero.[13]

Players bargain over the loss until they reach an agreement. The timing of the game is as follows:

1. In round $t \in \mathbb{N}_+$, one player is randomly recognized as a proposer with equal probability. The selected player proposes an allocation share $p \in P$.

[10] A discount factor in the standard dynamic models, $\delta \in [0, 1)$, can be understood as the depreciation rate (the inverse of the growth rate), $1/g$, times the subjective time-discount factor, β. In this case, δ is always less than 1, so the distinction between the depreciation rate and time preference is not crucial.

[11] The stationary subgame-perfect equilibria are sustained in $\delta < 1$, but the equilibria involve socially inefficient outcomes. More details with $\delta < 1$ are discussed in Appendix D.

[12] If we interpret the zero utility of a perpetual disagreement in the DD game as $\lim_{t \to \infty} \delta^t$ with $\delta < 1$, then the corresponding utility of a perpetual disagreement in the DP game would be the limit of $-\delta^t$ with $\delta > 1$, which is negative infinity. We do not need this strong penalty to derive our theoretical results.

[13] It may be easier to deal with the utility of the perpetual disagreement in the following alternative interpretation. Suppose that we still have the same growth rate $g \geq 1$ and the discount factor $\beta \leq 1$. Instead of assuming that utility is accrued either when an agreement is reached or when infinite disagreements occur, assume that each disagreement renders a disutility of $\frac{g-1}{n}$ (the equal split of the increased amount of loss) to all players. One can imagine that each delay in an environmental policy agreement leads everyone to gain a (marginal) disutility from the untreated environmental damage. Then, the utility of infinite disagreements is the sum of the geometric sequences, $\sum_{t=0}^{\infty} -\beta^t \frac{g-1}{n} = \frac{1-g}{n(1-\beta)}$. To characterize the SSUEa in which disagreeing forever is not incentivized, it is sufficient to assume that $\frac{1-g}{n(1-\beta)}$ is lower than the ex-ante expected payoff of bargaining, $-\frac{1}{n}$. In other words, the parametric assumption we have essentially in mind is $\frac{1-g}{n(1-\beta)} < -\frac{1}{n}$, or $g + \beta > 2$, and not exponentially increasing losses. This assumption holds with the entire set of parameter values we have considered except for the indeterministic case $g = \beta = 1$.

2. Each player votes on the proposal. If q or more players accept the proposal, then it is approved and implemented. $U_i^t(p)$ is accrued, and the game ends. Otherwise, the proposal is not accepted, and the game progresses to round $t+1$.

3. In round $t+1$, a player is randomly recognized as the proposer. The game repeats at $t+1$.

Let h^t denote the history in round t, including the identities of the previous proposers and current proposer. Let $\{p^{it}(h^t), x^{it}(h^t)\}$ denote a feasible action for player i in round t, where $p^{it}(h^t) \in \Delta(P)$ represents the decision rule of player i as the proposer and $x^{it}(h^t) \in [0,1]$ represents that of player i as a nonproposer in round t. Precisely, $p^{it}(h^t)$ is the (possibly mixed) proposal offered by player i where $\Delta(P)$ is the set of probability distributions of P. $x^{it}(h^t)$ is a voting decision threshold, where the player votes for the proposal if $p_i \geq x^{it}(h^t)$ and votes against otherwise, where p_i is the amount offered to player i. As is conventional in the literature (Baron and Ferejohn, 1989; Palfrey, 2016), we assume that a player votes for a proposal when she is indifferent between voting for and against it. With the tie-breaking rule, the voting threshold is sufficient to fully describe the decision rule of player i as a nonproposer because her utility linearly increases in p_i. A strategy s_i is a sequence of actions $\{p^{it}(h^t), x^{it}(h^t)\}_{t=1}^{\infty}$, and a strategy profile s is an n-tuple of strategies, with one for each player.

Concerning the DD game, virtually all allocations can be supported as a subgame perfect equilibrium under majority rule (Baron and Ferejohn, 1989). A similar folk theorem can be applied to the DP game.

Proposition 1. *Assume $n \geq q+1 \geq 3$ and $\delta \geq 1$. For any $p \in P$, there exists a subgame-perfect equilibrium for which p is the allocation shares proposed and accepted in round 1.*

Proof: See Appendix A.

The result of Proposition 1 delivers a rationale for restricting our attention to a set of strategies satisfying a few additional, stronger conditions. We consider symmetric stationary stage-undominated strategies. A strategy profile is symmetric if each player treats all other players symmetrically which rules out the possibility of asymmetric pregame coalitions.[14] A strategy profile is *stationary* if it consists of time- and history-independent strategies. A strategy profile is *stage-undominated* if the voting decision is to always accept the proposal if the offer in the proposal is greater than or equal to the continuation value of the game.[15] In words, stage-undominatedness does not allow the players to reject the current offer when it is greater than or equal to the expected payoff of moving to the next round. The strategy then boils down to (1) the proposal p when a member is recognized as a proposer

[14] If strategies, especially the coalition formation aspect, are asymmetric, then one may construct other stationary equilibria. For example, in three-player bargaining, if player 1 and player 2 always pick each other as coalition partners and player 3 picks one randomly, then the continuation value would differ. In general, if we allow any asymmetric mixing strategies in forming an MWC, there will be a continuum of stationary equilibria (Norman, 2002). We claim that this asymmetric type of equilibrium cannot be proper grounds for the experiment where subjects are randomly rematched and their ID numbers are reassigned in every period. In this paper, we define equilibria as symmetric equilibria unless stated otherwise.

[15] The term, stage undominatedness, was introduced in Baron and Kalai (1993) and Kalandrakis (2006).

and (2) the voting decision threshold x at which a nonproposer accepts. For theoretical analysis, we characterize symmetric stationary stage-undominated strategy equilibrium/equilibria (SSUE/SSUEa, hereafter).

3 Analysis

While the DD game has a unique SSUE in payoffs (Eraslan, 2002), the DP game has a continuum of SSUEa that involve different payoffs. For a brief illustration (only for Propositions 2 and 3), we start with a particular case in which simple majority rule is applied, and $\delta = 1$. Perhaps the most intuitive SSUE involves the allocation of the whole penalty to only one member.

Proposition 2 (Utmost inequality equilibrium). *The following strategy profile constitutes an SSUE:*

- *Player i, being recognized as a proposer in round t, randomly picks one player $j \neq i$ with equal probability and proposes $p_j = -1$. The proposer offers 0 to the rest. She keeps 0 for herself.*
- *If a player is offered a share $x \geq -1/n$, he accepts the proposal, and he rejects it otherwise.*

In this equilibrium, the proposal made by the first-round proposer is approved.

Proof: See Appendix A.

We call this equilibrium the utmost inequality (UI) equilibrium because only one member will be given the total burden of the penalty. Another equilibrium described by the next proposition is the most egalitarian (ME) equilibrium among SSUEa.

Proposition 3 (Most egalitarian equilibrium). *The following strategy profile constitutes an SSUE:*

- *Player i, being recognized as the proposer in round t, randomly picks $\frac{n-1}{2}$ players from $N \setminus \{i\}$ with equal probability and offers $-1/n$ to each of them. The proposer offers $-\frac{n+1}{n(n-1)}$ to the rest. She keeps 0 for herself.*
- *If a player is offered a share $x \geq -1/n$, he accepts the proposal, and he rejects it otherwise.*

In this equilibrium, the proposal made by the first-round proposer is approved.

Proof: See Appendix A.

In the ME equilibrium, the distribution of penalty is spread across nonproposers, but it does not involve an equal split of the penalty across players. Here the players offered $-1/n$ form the winning coalition in the sense that they jointly approve the proposal. We say that players form the minimum winning coalition (MWC) when the number of the winning coalition members is minimal for approval. The allocation in this equilibrium is most egalitarian in the sense that the total share of the penalty for players not in the MWC is the lowest among all possible SSUEa. Table 1 juxtaposes how the theoretical predictions of the DP game are different from those of the DD game under a simple majority rule when the discount factor is 1.

Table 1: Equilibrium Shares under Simple Majority, $\delta = 1$

Game	Proposer Share	MWC Share	non-MWC Share	Proposer Advantage†
DD	$1 - \frac{n-1}{2n}$	$\frac{1}{n}$	0	$\frac{n-1}{2n}$
DP (UI)	0	0	1 (one of them)	0
DP (ME)	0	$\frac{1}{n}$	$\frac{n+1}{n(n-1)}$	$\frac{1}{n}$

†: The proposer advantage is the difference between the payoff of the proposer and that of the MWC member.

There are other SSUEa that take an intermediate form between the UI equilibrium and ME equilibrium. For example, in one equilibrium, the proposer picks $\frac{n-1}{2}$ members randomly and offers $-\frac{2}{n-1}$ to each, and the other $\frac{n-1}{2}$ members who were offered no penalty accept the proposal. Proposition 4 provides the full characterization of the SSUEa in the DP game with $q < n$ for any $\delta \geq 1$.

Proposition 4. *Assume $q < n$. Every SSUE can be described by the following strategy profile:*

- *Player i, being recognized as the proposer in round t, randomly picks $q-1$ players from $N \setminus \{i\}$ with equal probability. Denote such a set of picked players as MWC. The proposer offers $p_j \geq -\delta/n$ to player $j \in MWC$ and offers $p_k \leq 0$ to player $k \in N \setminus MWC \setminus \{i\}$ such that $\sum_{j \in MWC} p_j + \sum_{k \in N \setminus MWC \setminus \{i\}} p_k = -1$. She keeps zero for herself.*

- *If a player is offered a share $x \geq -\delta/n$, he accepts the proposal, and he rejects it otherwise.*

In this equilibrium, the proposal made by the first-round proposer is approved. In addition, every SSUE is a stationary subgame perfect equilibrium.

Proof: See Appendix A.

The ME equilibrium and UI equilibrium can be described as special cases of the SSUEa constructed in Proposition 4. It is easy to characterize an equilibrium with respect to the payoff of an MWC member. The second bullet point of Proposition 4 specifies the maximum amount of loss that nonproposers are willing to accept, $-\delta/n$, so a proposer can offer as little as $-\delta/n$ to the MWC members. Any offer of between 0 and $-\delta/n$ to every MWC member is feasible, while it still allows the proposer to enjoy zero losses if $q < n$, as there is always at least one member who receives the remainder. The ME equilibrium arises when the MWC members are offered $-\delta/n$, while the UI equilibrium occurs when the MWC members are offered 0. If MWC members are offered an intermediate value of between $-\delta/n$ and 0, then another SSUE of between the UI and the ME equilibria is obtained.

Proposition 4 also states that every SSUE is a stationary subgame-perfect equilibrium. In the DD game with $\delta < 1$, stage undominatedness implies that there is no profitable one-shot deviation, which is sufficient for subgame perfection. However, in the DD game with $\delta = 1$ or in the DP game with $\delta \geq 1$ where the "continuity at infinity" condition does not hold, we need to check there do not exist any profitable multi-stage deviations. In the proof, we show that in every equilibrium with stationary stage-undominated strategies, no player can find a profitable multi-round deviation.

Proposition 5 describes the unique SSUE under a unanimity rule. From the perspective of the MWC members, the decision rule remains the same as in other voting rules: accept a proposal if it offers $x \geq -\delta/n$. Under a unanimity rule, however, the proposer's desire to minimize her own loss share drives her to offer the MWC members the maximum willingness to suffer, $x = -\delta/n$.

Proposition 5. *Assume $q = n$.*

- *If $\delta \geq \frac{n}{n-1}$, player i, being recognized as the proposer in round t, offers $p_j \geq -\delta/n$ to all $j \neq i$ and keeps zero for herself. If $\delta < \frac{n}{n-1}$, the proposer offers $p_j = -\delta/n$ for all $j \neq i$ and keeps $\frac{(n-1)\delta - n}{n}$ for herself.*
- *If a player is offered a share $x \geq -\delta/n$, he accepts the proposal, and he rejects it otherwise.*

In this equilibrium, the proposal made by the first-round proposer is approved. In addition, the SSUE is a stationary subgame perfect equilibrium.

Proof: See Appendix A.

4 Experimental Design and Procedure

Transitioning from our theoretical analysis to an experiment with (possibly nonrational) human participants, two remarks are made regarding the multiplicity of SSUEa and the issue of which equilibrium outcome is likely observed in practice. First, preferences for utilitarian efficiency do not help argue in favor of one equilibrium because both the UI equilibrium and the ME equilibrium are optimal from a utilitarian perspective. On the one hand, the proposer may want to choose the ME strategy because the ME equilibrium can be better from a Rawlsian perspective in some cases. On the other hand, there may be an incentive for her to choose the most unequal strategy. If the proposer is uncertain about how often other players will mistakenly make a wrong decision, she may want to secure strictly more votes than q so that her payoff is robust to other members' mistakes. For this purpose, she may want to allocate the penalty to the smallest number of players.[16] Taking inequity aversion (Fehr and

[16]Similarly, considering the potential occurrence of trembles or mistakes, proposers may opt to assign a penalty that is lower than their continuation value to increase the likelihood of acceptance by non-proposing members of the MWC. This phenomenon, wherein proposers allocate a larger share to non-proposing MWC members than their continuation value in the DD environment, has been well documented in the literature, e.g., Diermeier and Gailmard (2006) in the context of ultimatum games and Lee and Sethi (2023) in the context of two-period legislative bargaining.

Schmidt, 1999) into account does not help us refine the set of equilibria.[17] From the perspective of members who are offered a zero penalty in the UI equilibrium, although accepting the offer brings the most disutility from the advantageous inequity perspective, it involves the smallest disutility from the disadvantageous inequity perspective.[18]

Second, the possible disconnect between the proposer's advantage and the MWC members' payoff in SSUEa other than the ME equilibrium makes us question the plausibility of the ME equilibrium. The equilibrium is not strict in the sense that it must rely on the tie-breaking assumption that players will vote for the proposal with a probability of 1 when indifferent between accepting and rejecting it. Even if the proposer decides to offer a loss to the MWC members that is "ε-less" than the continuation value, each player's "ε" may not be common knowledge, so choosing the ME strategy may not guarantee the approval of the proposal when such a tie-breaking assumption is not maintained. The cognitive cost for each player to coordinate on the ME equilibrium is also high: it requires each player to precisely calculate the continuation value given that other members also use the same stationary strategy, which varies by the voting rule, the size of the group, and the discount factor. In other words, the ME equilibrium is less robust given strategic uncertainty. Another notable observation is that when $\delta \geq \frac{n}{2(q-1)}$, the continuation value, the amount offered to the MWC members, can be *smaller* than the ex-ante payoff of the other members.[19] That is, the MWC members can be treated worse than other members in the ME equilibrium. In such a situation, the notion of the "minimum" winning coalition itself becomes questionable, as all the members receive an offer more attractive than their continuation value. Thus, the ME equilibrium, although it corresponds more directly to the unique equilibrium outcome in the DD game, is fragile in that it requires a stronger assumption about voting behavior and a higher coordination cost.

Which equilibrium would have better empirical validity? In this section, we present our experimental design that aims to answer this question.

4.1 Design and Hypotheses

We tailored laboratory experiments to examine how people behave to determine the distribution of losses, especially in terms of the choices of the winning coalition. The main treatment variables

[17] Similarly, taking loss aversion (Kahneman and Tversky, 2013) into account does not significantly help further refine the set of equilibria, as we do not know the reference point of the players. If the reference point is set to zero, the "gain domain" is never achieved, so loss aversion does not play a role. If the reference point is set to an equally split loss, this implies that the reference point changes over time, which has little support. If the reference point is set to the ex-ante expected utility in the first round, there is still a continuum of equilibria, and the set could be *larger* than what we have, depending on the loss aversion parameters. Loss aversion could encourage coalition members (who fear the possibility of losing more in the next round) to accept the less attractive offer now.

[18] Montero (2007) showed that in the DD game, inequity aversion might increase the proposer's share in equilibrium, and the underlying intuition follows the same logic. From the perspective of the coalition member, the marginal disutility from the increased difference between the proposer's share and what he is offered may be smaller than the marginal utility from the decreased difference between what he is offered and what other non-MWC members receive (zero).

[19] For example, consider the ME equilibrium when $n = 5$, $q = 3$, and $\delta = 1.5$. Each of the MWC members is offered -0.3, while each of the other members is offered -0.2 on average. Considering this, we set δ for our experiment such that $\delta < \frac{n}{2(q-1)}$ under a majority rule.

address the group size ($n \in \{3,5\}$) and the voting rule ($q = (n+1)/2$ or majority; $q = n$ or unanimity). We set the appreciation factor δ to 1.2. Table 2 presents our 2×2 treatment design. Those treatments are called M3 (majority rule for a group of three), M5 (majority + five), U3 (unanimity rule for a group of three), and U5 (unanimity + five). M3 and M5 are collectively called the majority treatments, and U3 and U5 are called the unanimity treatments.

Table 2: Experimental Treatments

		Voting Rule	
		Majority	Unanimity
Group Size	3	***M3***	***U3***
	5	***M5***	***U5***

Figure 2 illustrates the theoretical predictions, which can be categorized into two qualitatively different types. The first type of prediction (Hypotheses 1 and 2) includes those that hold for any SSUE. The second type (Hypothesis 3) includes those that vary depending on which equilibrium is played.

The first set of hypotheses regards proposer advantage and bargaining efficiency, which are true regardless of which equilibrium is played in all treatments.

Hypothesis 1 (Proposer Advantage and Full Efficiency)**.**

(a) The proposer receives the smallest loss in all treatments.

(b) The first-round proposals are approved in all treatments.

The second set of hypotheses addresses the distribution of the loss. The agreed-upon shares of the proposer may vary across different group sizes depending on the voting rule. First, given the majority rule, the proposer's agreed-upon share is always zero regardless of the group size. Second, for a given group size, the proposer's agreed-upon share is larger under the unanimity rule than under the majority rule. Third, given the unanimity rule, the proposer's agreed-upon share is larger when the group size is smaller.

Hypothesis 2 (Share of Loss)**.**

(a) In the majority treatment, the proposer keeps zero losses regardless of the group size.

(b) The proposer keeps a smaller loss in the majority treatment than in the unanimity treatment.

(c) The proposer keeps a larger share of the loss in the U3 treatment than in the U5 treatment.

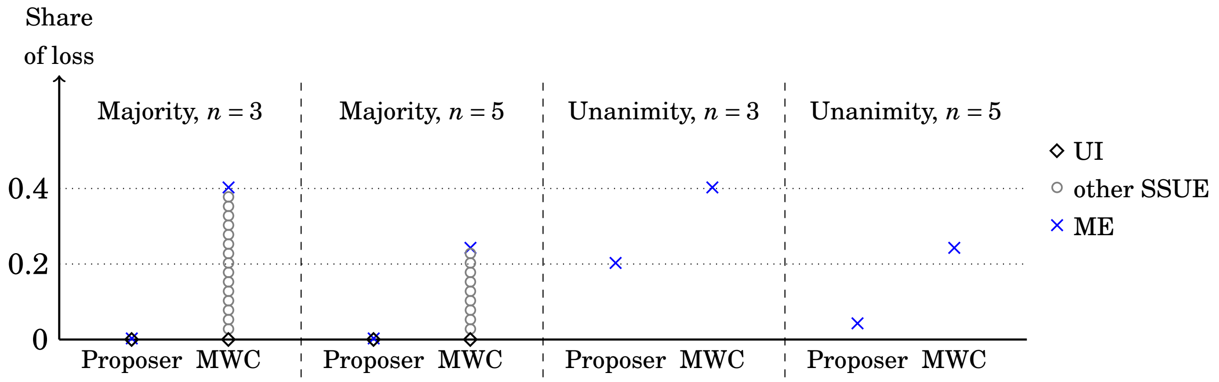


Figure 2: Hypotheses from Theoretical Predictions

This figure summarizes theoretical predictions corresponding to the experimental setup ($\delta = 1.2$). There is a continuum of other SSUEa between the UI equilibrium and the ME equilibrium, mainly described by the share of the loss allocated to an MWC member. The unique equilibrium under the unanimity rule corresponds to the ME equilibrium under the majority rule.

We now move on to discuss the second type of prediction, which is dependent upon equilibrium selection. First, the offers to the nonproposers vary based on the choice of an equilibrium. Especially in the majority treatment, players who are not the proposer are offered a share of the loss ranging from zero (to the MWC members in the UI equilibrium) to the full penalty (to the non-MWC members in the UI equilibrium). Second, under the majority rule, the range of shares that the MWC can receive in equilibrium varies by group size, but such theoretical variations are not allowed under the unanimity rule. Given that our primary objective is to observe behaviors in the lab and falsify/select some equilibria, we shall derive our next set of *null* hypotheses based on the assumption that the ME equilibrium is played in the lab. We do not mean that we are selecting the ME equilibrium as the most plausible candidate; instead, it plays a role as the benchmark for clearly stating the experimental hypotheses. We take the ME equilibrium as a benchmark for two reasons. First, it is the closest to the mirror image of the unique stationary equilibrium of the DD game. Second, it is the unique stationary equilibrium prediction under the unanimity rule (i.e., when $q = n$). By continuity, it is natural to take the same equilibrium when $q < n$. In Figure 2, the upper bound of the MWC share of the loss (and the implied lower bound of the non-MWC share) constitutes the ME equilibrium.

Hypothesis 3 (Winning Coalition and Nonproposers' Shares under Majority)**.**

In the majority treatments:

(a) The median share of the accepted proposal (or the largest share offered to the MWC members) is larger than the proposer's share.

(b) The agreed-upon share of the nonproposers who accept the proposal is larger in M3 than in M5.

(c) The number of nonproposers who accept the proposal is $(n-1)/2$. That is, one member rejects the proposal in the M3 treatment, and two members reject it in M5.

As we emphasized above, the predictions summarized in Hypothesis 3 do not hold for the UI equilibrium. Contrary to Hypothesis 3 (a), the MWC members' shares are the same as that of the proposer in the UI equilibrium. In addition, the share of accepting nonproposers is the same as zero in both majority treatments, so Hypothesis 3 (b) would be rejected under the UI equilibrium. While the ME equilibrium predicts that two members reject the proposal in the M5 treatment (Hypothesis 3 (c)), the UI equilibrium predicts that only one member will reject the proposal. Thus, testing Hypotheses 3 using the observed behaviors in the lab would enable us to justify one of the stationary equilibria.

4.2 Experimental Procedure

All of the experimental sessions were conducted in English at the experimental laboratory of the Hong Kong University of Science and Technology in November 2018. The participants were drawn from the undergraduate population of the university. Four sessions were conducted for each treatment. A total of 271 subjects participated in one of the 16 (= 4×4) sessions. Session sizes were 15 (in three M3 sessions, two M5 sessions, three U3 sessions, and one U5 session), 18 (in one M3 session and one U3 session), or 20 (in two M5 sessions and three U5 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, the instructor read the instructions for the experiment aloud. Subjects were also asked to carefully read the instructions, and then they took a quiz to demonstrate their understanding of the experiment. Those who failed the quiz were asked to reread the instructions and to retake the quiz until they passed. An instructor answered all questions until every participant thoroughly understood the experiment. Whenever a question was raised, the instructor repeated the question aloud and answered it such that every subject was equally informed.

We conducted many-person DP experiments. In structure, the game is a mirror image of a typical many-person DD game, and it proceeds as follows: At the beginning of each bargaining period (called a 'day' in the experiment), each bargainer is endowed with 400 tokens, with a token being the currency unit used in the laboratory. In each bargaining round (called a 'meeting' in the experiment), one randomly selected player proposes a division of $-50*n$ tokens, where n is the number of players in each group. The proposal is immediately voted on. If the proposal receives q or more votes, the bargaining period ends, and the subjects' endowment is reduced based on the approved proposal. Otherwise, bargaining proceeds to the second round, where the penalty increases by 20 percent: that is, in the second round, the players must determine an allocation of $-60*n$ tokens. A new proposer is randomly selected, and the new proposal is voted on. This process is repeated indefinitely until a proposal is passed.

Since the subjects were informed that they would eventually earn at least a participation payment of HKD 30 ($\approx$ USD 4), we implicitly limited the largest possible losses out of the equilibrium. As long as the largest out-of-equilibrium loss is sufficiently large, in particular, as long as it is larger than

$\delta * 50 * n$, no stationary equilibrium is restricted or ruled out. Thus, the theoretical analysis still serves as a benchmark for our experiments.[20]

Subjects in the U3 and M3 treatments participated in 12 bargaining periods and those in the U5 and M5 treatments participated in 15 bargaining periods.[21] We used the random matching protocol. Although new groups were formed every bargaining period, 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 were they allowed to look around the room. It was also emphasized to participants that their allocation decisions would be kept anonymous. Each subject participated in only one of the sessions. The experimental instructions for the M5 treatment are presented in Appendix B.

At the end of the experiment, the subjects were asked to fill out a survey about their gender and age as well as their degree of familiarity with the experiment. The subjects' risk preferences were also measured by the dynamically optimized sequential experimentation (DOSE) method (Wang et al., 2010). The number of tokens that each subject earned in one randomly selected period (Azrieli et al., 2018) was converted into HKD at a rate of 2 tokens = 1 HKD. The average payment was HKD 202.7 (≈ USD 26), including the HKD 30 guaranteed participation fee. The payments were made in private, and subjects were asked not to share their payment information. Each session lasted 1.5 hours on average.

5 Experimental Results

This section presents our main findings by combining some test results for the hypotheses posed in the previous section. To recapitulate the hypotheses, Hypotheses 1 and 2 are about the theoretical predictions commonly shared by any equilibrium in the continuum of the stationary stage-undominated equilibria, and Hypothesis 3 regards theoretical predictions based on the ME equilibrium.

For any formal statistical tests reported in this section, the standard errors for the reported p-values of test statistics are clustered at the individual level unless otherwise specified. We utilize data from the last five periods, which allows us to assign greater weight to converged behavior. However, the qualitative aspects of our findings remain unchanged even when we consider data from the last eight periods or all periods. Additionally, Table 4 in Appendix C presents the results from supplemen-

[20] In a few cases under the unanimity treatment, the bargaining rounds went beyond the point where the total value of the loss exceeded the sum of the group members' show-up payments, but there was no noticeable discrepancy around the threshold round. These periods were not selected as a paid period, so all subjects were paid strictly more than their show-up payment.

[21] The number of bargaining periods varied to increase the chances of every participant being able to play the proposer role. If there are 12 bargaining periods in treatments with $n = 5$, each subject could be recognized as a proposer 2.4 times on average, which is not high enough to observe variations by individual. We ex post checked that every subject played the proposer role at least twice. We did not use the strategy method (i.e., asking all subjects to submit their proposals, knowing that one of them would be randomly selected for voting afterward) because we were unsure whether the strategy method, in this particular context of the DP game, would work the same as the standard method. Brandts and Charness (2011) report that 15 out of 29 existing comparisons between the two methods show either significant differences or some mixed evidence.

tary tests using session-level averages aggregated over the last 5 periods as independent observations. Overall, the test results using the session-level averages align qualitatively with the test results reported in the main text, although some results lose statistical significance due to the limited number of session-level observations.

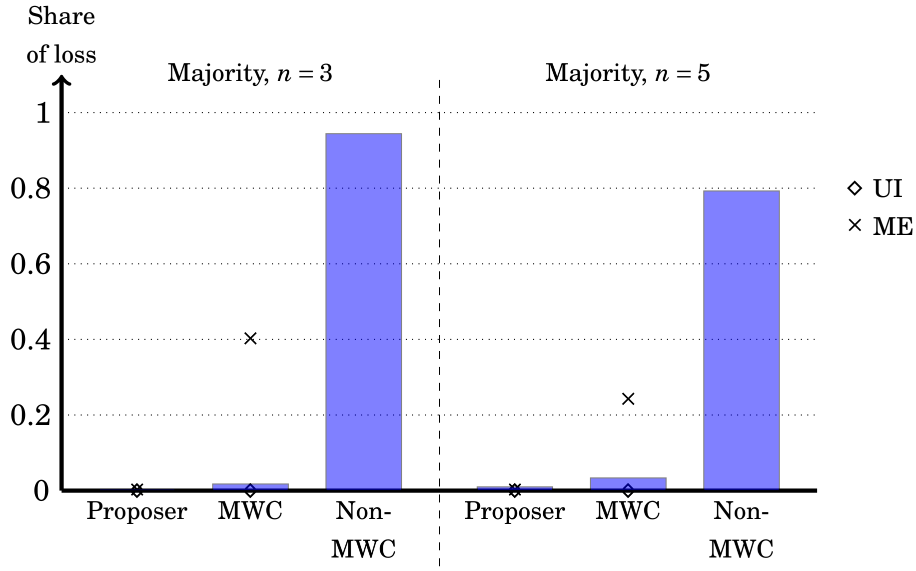


Figure 3: Proposed Shares, Majority
Approved proposals in the last 5 Periods

Figure 3, which juxtaposes the equilibrium predictions for the majority treatments and the observed average allocation of the loss from the approved proposals in the last five periods, represents the main findings. The share of the loss in the UI equilibrium is marked with $\diamond$, and that in the ME equilibrium is marked with $\times$. As clearly illustrated, the observations from both the M3 and M5 treatments reject the ME equilibrium predictions while supporting the UI equilibrium.

We reject[22] Hypothesis 3 (a) based on the ME equilibrium, as the MWC members in both the M3 and M5 treatments are offered almost zero shares of the loss. In the M3 treatment, the average share of the loss to the MWC member[23] in the last five periods is 0.01 (2.19 tokens out of 150) larger than that to the proposer, but the difference is statistically insignificant (t-test, $p = 0.08$), and the magnitude is insubstantial. In the M5 treatment, the average share of the loss to the MWC members in the last five periods is 0.01 (2.85 tokens out of 250) larger than that to the proposer, which is also statistically insignificant (t-test, $p = 0.36$).

The average MWC share in the last five periods of the M5 treatment is 0.02 larger than that of the M3 treatment, and the difference is weakly significant (t-test, $p = 0.0558$). This result strongly

[22]It may be more appropriate to say that we cannot reject the alternative hypothesis of Hypothesis 3 (a) rather than rejecting the null hypothesis.

[23]The MWC members are defined as nonproposers who receive a share of the loss that is less than or equal to the proposal's median share. For example, in the M5 treatment, if a proposer offers $\{0, 0, 0, 0.4, 0.6\}$, then the median is 0, and the two members who received 0 are defined as the MWC. In the M3 treatment, a member receiving 0.3 from a proposal $\{0, 0.3, 0.7\}$ is defined as the MWC.

rejects Hypothesis 3 (b) based on the ME equilibrium in which the MWC member in the M3 treatment receives a larger share than the MWC members in the M5 treatment (t-test, one-sided, $p = 0.97$).

In regard to the loss share allocated to the non-MWC members, the rejection of the ME equilibrium predictions is even more evident. In the M3 treatment, one (non-MWC) member is offered almost the total loss, and such allocation is distinctively different from 0.6, the ME equilibrium share of the loss to the non-MWC member (t-test, $p < 0.001$). The share of the non-MWC members is significantly larger than the ME equilibrium share of the loss (t-test, $p < 0.001$).[24] In the M5 treatment, 62% of the approved proposals allocate almost the entire loss to one member, as only one member is offered a share of the loss larger than the proposal's median share. A total of 27% of the approved proposals distribute the almost entire loss to two members, as a share of the loss that is larger than the proposal's median share (which is near zero) is distributed to two members.[25] The average non-MWC share of the loss is approximately 0.74, and the average number of non-MWC members is 1.16, which leads us to reject Hypothesis 3 (c), as the number is significantly smaller than 2 (t-test, $p < 0.001$).

In both the M3 and M5 treatments, the proposer keeps virtually nothing for herself, consistent with the theoretical prediction (Hypothesis 2 (a)). In the M3 treatment, the proposer keeps, on average, 0.004 shares of the loss (0.6 tokens out of 150) for herself in the last five periods, which is insignificantly different from zero (t-test, $p = 0.33$). In the last five periods of the M5 treatment, the proposer keeps, on average, 0.02 shares of the loss (5.3 tokens out of 250) for herself. Although the average share of the loss is significantly different from zero (t-test, $p = 0.04$), the magnitude is not substantial. In addition, 60 out of the 70 approved proposals in the last five periods involve zero losses to the proposers.

Altogether, including the rejection of Hypothesis 3 and confirmation of Hypothesis 2 (a), our main finding from the majority treatments is the stark rejection of the ME equilibrium and strong support of the UI equilibrium.[26]

Result 1. *In the majority treatments, experimental evidence rejects the ME equilibrium and supports the UI equilibrium.*

In the unanimity treatments, the allocation in the approved proposals is weakly consistent with the unique SSUE predictions. Figure 4 shows the theoretical predictions and the average share of the loss in the last five periods. The proposer's share is, on average, larger than the equilibrium level in both unanimity treatments. At the same time, the proposers offer a share of the loss to nonproposers that is smaller than the equilibrium level. The observation that the proposer keeps a significantly larger loss in the unanimity treatment than in the majority treatment is consistent with Hypothesis 2 (b). In addition, the proposer keeps a significantly smaller share of the loss than the other members in both unanimity treatments (t-tests, $p = 0.02$ in U3 and $p < 0.001$ in U5). Together with the majority

[24]Alternatively, we also test if the average loss share of the member who rejects the proposal is the same as that in the ME equilibrium. In both the M3 and M5 treatments, the test results confirm that the difference is significant at $p < 0.001$.

[25]Approximately 11% of the approved proposals feature a grand coalition, where every member receives a share less than or equal to the proposal's median share of the loss. The proportion of such a grand-coalition proposal gradually decreases to 7% in the later periods.

[26]We discuss the selection of the UI equilibrium in more detail in Appendix D.

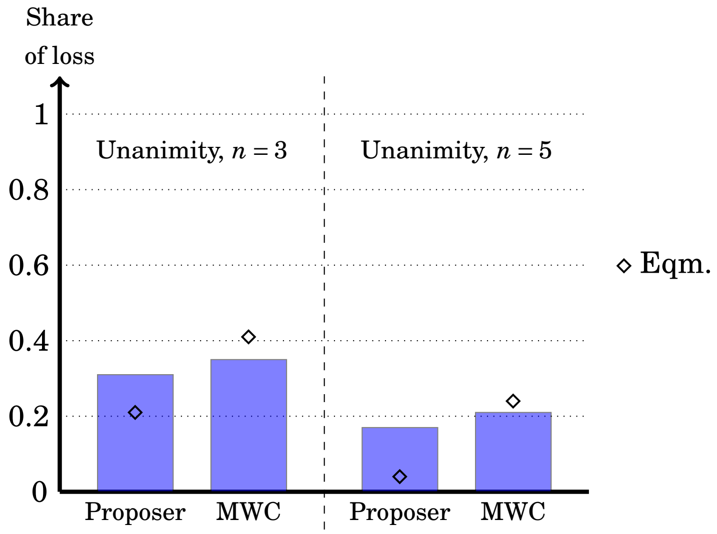


Figure 4: Proposed Shares, Unanimity
Approved Proposals in the last 5 Periods

treatments, we find that the observations are consistent with Hypothesis 1 (a). The nonproposers in the U3 treatment are offered a 0.14 larger share of the loss than in the U5 treatment, and the difference is statistically significant ($p < 0.001$), which confirms Hypothesis 2 (c). From the confirmations of Hypotheses 1 (a), 2 (b), and 2 (c), we draw our second result.

Result 2. *In the unanimity treatments, the allocations in the approved proposals are consistent with the theoretical predictions.*

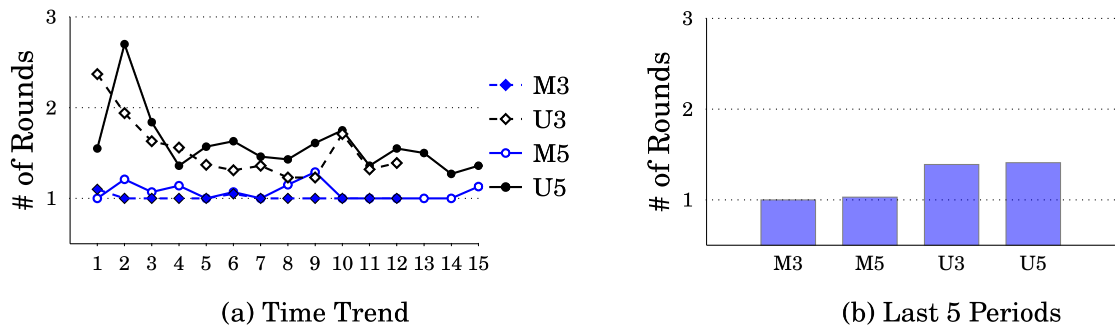
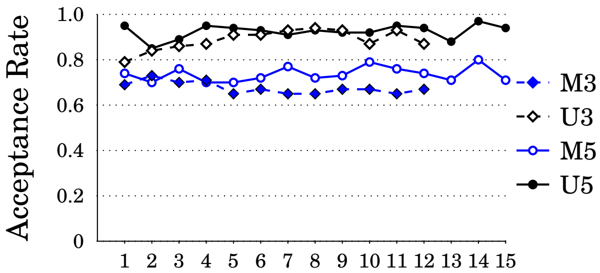


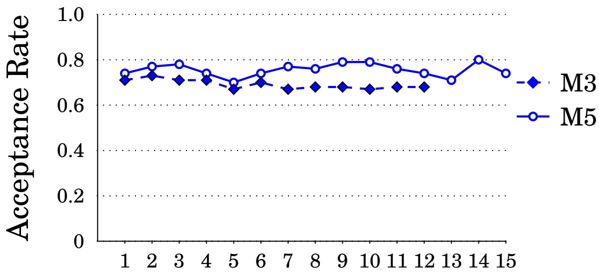
Figure 5: Average Number of Rounds

Figure 5 shows the average number of rounds by period. In the majority treatments, nearly all of the first-round proposals are approved, which is consistent with our theoretical prediction (Hypothesis 1 (b)). Even in the unanimity treatments, although the first three periods are somewhat varied (Figure 5 (a)), the average number of rounds in the last five periods is fewer than 1.5 (Figure 5 (b)). Albeit small, efficiency loss under a unanimity rule is one of the common findings of multilateral bargaining experiments, such as Kagel et al. (2010), Miller and Vanberg (2013), and Kim (2023).

Result 3. *The vast majority of the proposals are approved in the first round.*



(a) All Proposals



(b) Approved Proposals

Figure 6: Average Acceptance Rate

Figure 6 shows the average proportion of subjects who accept a given proposal. In the M3 treatment, two-thirds of the subjects (two out of the three members) accept the proposal, which is consistent with the theoretical prediction for the size of the winning coalition. However, in the M5 treatment, nearly 80% of the subjects (four out of the five members) vote for the proposal. This observation is another way of rejecting Hypothesis 3 (a), in which two members reject the proposal.

Result 4. *In the majority treatments, the proposers form the winning coalition to minimize their losses. The size of the winning coalition is not necessarily minimal.*

Table 3 reports regression results to examine whether individual characteristics affect the outcomes of the experiments. The regressions reported in Table 3 use only proposals that were approved in the first round. To summarize, we did not find any strong impact from individual characteristics. The dependent variable in the first three regressions is the proposer's own share, and the dependent variable in the last two regressions is the nonproposer's voting decision. Some explanatory variables are from the post-experiment survey. We collected self-reported gender and age. The subjects' risk preferences were measured by at most two survey questions, where the second question is dynamically adjusted based on the answer to the first question, which asks the subject to compare a simple lottery to a certain payment. This method enables us to categorize a subject into one of seven types of risk preferences. Familiarity is a subjective assessment of how familiar a subject was with the underlying game in the experiment. QuizFailed is a dummy variable indicating whether the subject had to retake the quiz after failing to pass, serving as a proxy for how well subjects understood the experiment. As control variables, we include treatment dummies and a time trend (labeled Period) for regressions on the proposer's own share. We also include the offered share and the standard deviation of the proposal for regressions on the nonproposer's voting decision. The standard deviation of the proposal is added to examine whether the proposal's distributional shape matters in the subject's vote.[27] In all regressions, M3 is set as the baseline treatment. We focus on the approved proposals in round 1 only. Since the individual choices are positively correlated across periods, standard errors are clustered at the individual level.[28]

[27]For example, consider proposals (0.2, 0, 0.8) and (0.2, 0.4, 0.4). For member 1, these two proposals offer the same amount of losses, 0.2, but the proposal's distribution varies. The standard deviation of the proposal will capture the impact of the distribution of the proposal if the subjects' voting decision is indeed affected by it.

[28]The standard errors clustered at the session level were overall smaller (that is, less conservative) than those at the

Table 3: Individual Characteristics

Dep.Var.	Proposer's Own Share			Nonproposer's Vote		StDev(Proposal)
	(1)	(2)	(3)	(4: LPM)	(5: Logit)	(6)
M5	0.0170	0.0174*	0.0159	−0.0834***	−1.6503***	0.3182
	(0.0103)	(0.0100)	(0.0100)	(0.0222)	(0.4879)	(4.6753)
U3	0.2768***	0.2720***	0.2720***			−74.1292***
	(0.0116)	(0.0091)	(0.0092)			(1.9761)
U5	0.1522***	0.1523***	0.1503***			−76.7516***
	(0.0073)	(0.0071)	(0.0073)			(1.7611)
Share				−0.9659***	−7.7228***	
				(0.0249)	(0.7866)	
StDev				0.0006	0.0077	
				(0.0004)	(0.0047)	
Period	−0.0035***	−0.0039***	−0.0039***	−0.0019	−0.0186	1.3230***
	(0.0008)	(0.0008)	(0.0008)	(0.0022)	(0.0263)	(0.2992)
Female		0.0166**	0.0152**	−0.0171	−0.2057	−8.8552***
		(0.0067)	(0.0068)	(0.0273)	(0.3802)	(2.6477)
Age			−0.0063	0.0535**	0.7272*	3.6051
			(0.0088)	(0.0262)	(0.3712)	(4.0365)
RiskAversion			0.0020	0.0066	0.0894	−0.4723
			(0.0018)	(0.0063)	(0.0802)	(0.7085)
Familiarity			−0.0001	−0.0556	−0.9365	0.0337
			(0.0072)	(0.0347)	(0.4394)	(2.8944)
QuizFailed			−0.0050	0.0209	0.4068	0.6037
			(0.0071)	(0.0305)	(0.4615)	(2.6803)
_Cons.	0.0478***	0.0425***	0.0440***	0.9039***	3.0777***	73.0042***
	(0.0108)	(0.0099)	(0.0150)	(0.0555)	(0.7724)	(5.2324)
R^2	0.7058	0.7392	0.7434	0.6875	0.6360	0.7353
N	781	735	728	1239	1239	728

Only approved proposals in Round 1 are considered. In parentheses are standard errors clustered at the individual level. *, **, and *** indicate statistical significance at the 10% level, 5% level, and 1% level, respectively.

The risk preferences, familiarity, and comprehensibility of the experiment did not significantly affect the proposer's decisions or the nonproposer's voting. We found that females allocate slightly more (approximately 1.52% to 1.66%, varying by the model specification) losses to themselves. Related to this observation, we also found that female proposers are more egalitarian in how they allocate the losses: The standard deviation of the proposals offered by female proposers is, on average, 8.85 tokens smaller. Older subjects tended to accept the proposals more often, but the statistical significance was weak, and the age variance was not large, similar to what has been observed in many typical laboratory experiments.

Result 5. *Risk preferences, familiarity with the game, and comprehensibility were not significant factors affecting the outcomes of the experiments. Females tend to take a slightly greater share of the loss than males, and older subjects tend to accept the proposal.*

In summary, our experimental results are primarily consistent with the theoretical predictions based on the UI equilibrium, and individual characteristics do not lead to noticeably different experimental outcomes.

6 Concluding Remarks

We examine the DP game to better understand multilateral bargaining when agents are dealing with the distribution of a loss. Although the literature on multilateral bargaining is substantial, both theoretically and experimentally, multilateral bargaining over the division of losses has received less attention. This may be perhaps because we have naïvely conjectured that the theoretical properties of the DP game are a mirror image of those from the DD game due to their structural resemblance. We theoretically show that there are fundamental differences. The SSUEa in the DP game are no longer unique in payoffs, unlike the DD game. One extreme among the continuum of stationary stage-undominated equilibria, which we call the ME equilibrium, is characterized similarly to the unique SSUE in the DD game. The other extreme equilibrium, which we call the UI equilibrium, predicts that the proposer concentrates the penalty on a few members. Although the ME equilibrium shares many properties with the SSUE in the DD game, experimental evidence is primarily consistent with the predictions based on the UI equilibrium.

Our results have at least two implications. First, multilateral bargaining over the division of losses should not be understood through the lens of the typical DD game because both the theoretical properties and the experimental evidence deviate from those of the DD game. Second, many interesting studies in multilateral bargaining on a gain domain are worth revisiting. Bargaining among asymmetric players, dynamic multilateral bargaining, the allocation of public bads produced for the agents'

individual level, so more estimated coefficients appear to be significant at the session level. Unless a subject randomly changes strategies over time, the individual choices are more correlated than the whole observation at the session level. Here, we report more conservative standard errors. Similar claims are made in the context of randomized field experiments (de Chaisemartin and Ramirez-Cuellar, 2024).

private gains, and changes in bargaining protocols, including competitions for recognition, are some, but not all, subjects that can extend this study. The direction of research should distinguish simple behavioral/psychological framing effects from more fundamental differences.

We conclude by acknowledging a caveat regarding the interpretation of our results in real-world scenarios. It is important to note that our analysis assumes players have unlimited capacity to bear losses. However, this assumption may not hold in various practical situations, such as in the context of climate change, where individual countries alone cannot sufficiently reduce emissions to meet global emission targets. Considering the implementation of individual loss caps becomes crucial in such cases. We recognize the significance of this aspect and suggest it as a potential area for further research.

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A Proofs

Proof of Proposition 1: This proof is analogous to the proof of Proposition 2 in Baron and Ferejohn (1989). Fix a strategy profile with the following statements.

1. For all $i \in N$ and $t \in \mathbb{N}_+$, if i is recognized in t, i proposes $p^{it} = p$, and all individuals vote for p.
2. If p is rejected under the $q-$quota rule in t, $j \in N$ recognized in $t+1$ proposes $p^{j(t+1)} = p$.
3. If, in any period t, the chosen proposer i offers an alternative to p, say $p^{it} = y \neq p$, then
   - (3.a) a set $M(y)$ of at least q individuals rejects y;
   - (3.b) the period $t+1$ proposer, say j, offers an allocation z such that $z_i = -1$ and all individuals in $M(y)$ vote for z against y.
4. If, in (3.b), the period $t+1$ proposer j offers some alternative $y' \neq z$, repeat (3) with y' replacing y and j replacing i.

Statement 1 specifies what happens along the equilibrium path. Statements 2, 3, and 4 describe off-the-equilibrium path behavior. That is, they jointly specify the consequences of any deviation from the behavior specified in 1.

For notational simplicity, relabel players such that player n is the period t proposer who offers $p^{nt} = y \neq p$, where $p_n < 0$, and $y_j \leq y_{j+1}$ for all $j = 1, \ldots, n-2$. Note that if $p_n = 0$, there is no way for player n to be better off, so $p_n < 0$ is without loss of generality. It is trivial that $y_n > -1$ because player n does not have an incentive to deviate from p to keep all of the loss from the beginning. Under (3.a) and (3.b), players in $M(y)$ reject y, and the next proposer offers an alternative proposal z with $z_n = -1$ such that $M(y)$ approves. Under such a distribution z, (3.a) and (3.b) describe the best response behavior to y. We divide situations into two cases: Assume first that the proposer conditional on y being rejected is some individual $j \neq n$. Let $M^*(y) = \{1, \ldots, q\}$, let $Y^* = \sum_{i \in M^*(y)} y_i$, and let $m^* = |\{i \in M^*(y) : y_i < 0\}|$. By construction of $M^*(y)$, $Y^* < 0$ and $m^* > 0$. This is because $Y^* = 0$ (and hence $m^* = 0$) implies that $p_n = -1$ and thus $p = z$. If $y_i < 0$, then z is strictly preferred because $\delta z_i = 0 > y_i$. If $y_i = 0$, then z is as preferred as y because the payoff of i is unaffected. If z is rejected, then under strategy statement 4, it will simply become the next proposal and so on.

Now, we assume that player n is again recognized as a proposer in the next period. Our goal is to show that player n cannot benefit from proposing any allocation other than p. In such a case, (3.b) specifies that player n proposes the allocation z, which "punishes" herself for her initial deviation. Should she fail to do this and instead propose some $y' \neq z$, strategy statement 4 requires a q-majority to reject y' and the period $t+2$ agenda-setter to offer z, which then passes. Therefore, the only circumstance under which the period t proposer n can avoid having z proposed and accepted in response to an initial deviation to $y \neq p$ is when player n is chosen in every period as the proposer. Such probability $(1/n)^t$ approaches zero, and the size of the penalty for the deviation is nondecreasing. Therefore, player

n is not better off by deviating from proposing p, as her hope to eventually attain a higher payoff than proposing p and accepting p_n is futile. Note that this strategy profile is a Nash equilibrium for every subgame starting at arbitrary period t, so this is by definition a subgame-perfect equilibrium. □

Proof of Proposition 2: Suppose that for every round, players have an identical stationary strategy as described above. A member who received an offer of zero penalties this round will accept the proposal if moving to the next round does not make him better off. In the next round, with probability $(n-1)/n$, he will be a proposer or a member who receives no penalty. With probability $1/n$, he will be randomly selected by a proposer in that round and take all the penalties. Thus, the expected payoff of moving to the next round is $-1\frac{1}{n}+0\frac{n-1}{n}=-\frac{1}{n}$. Since the utility from the current offer (zero) is strictly larger than the continuation value ($-\frac{1}{n}$), he will accept the offer. The proposer, who keeps no penalty for herself, cannot be better off by any other proposal. The player who gets offered -1 vote against the proposal, but it does not alter the outcome of the game. Thus, no one would be better off by deviating from this stationary strategy profile for any round. □

Proof of Proposition 3: Consider player i who received an offer of $-1/n$. If the game moves to the next round, his expected payoff is

$$\frac{1}{n}0-\frac{n-1}{2n}\frac{1}{n}-\frac{n-1}{2n}\frac{n+1}{n(n-1)}=-\frac{n-1}{2n^2}-\frac{n+1}{2n^2}=-\left(\frac{2n}{2n^2}\right)=-\frac{1}{n}.$$

Therefore, he will not be better off by rejecting the current offer. From the perspective of the current proposer, there is no strategy to make her better off than receiving zero penalties. □

Proof of Proposition 4: First, we show that under any voting rule except for unanimity, there is no stationary equilibrium where the proposer keeps a strictly negative payoff.

Lemma 1. *For any $q<n$, the proposer's share in the proposal of any SSUE is zero.*

Proof: Without loss of generality, relabel member 1 as the proposer in the first round, and $p_i \geq p_{i+1}$ for $i=1,\ldots,n-1$. The case with $p_1 > p_i$ can be trivially ruled out because if it is the case, the proposer could have reallocated her loss to a member who votes against her proposal. Suppose for the contradiction that $p_1 < 0$. There could be at most $n-q$ members who vote against the proposal. Define $M(p)$ as a set of members who vote against the proposal. If $M(p)$ is nonempty, consider an alternative proposal p' that subtracts p_1 from p and adds p_n to one randomly selected member in $M(p)$. p' would make the proposer better off, while the members who vote for the proposal are not affected because the continuation value under a symmetric stationary proposal p' is identical to that under p, that is,

$$\delta\sum_{i=1}^{n}\frac{1}{n}p_i=-\frac{\delta}{n}=\delta\frac{1}{n}\sum_{i=1}^{n}\frac{1}{n}p'_i.$$

Therefore, the proposer has an incentive to deviate from the equilibrium proposal, which contradicts the supposition of stage undominatedness. $\square$

Next, for any symmetric stationary strategy, the continuation value in round t is $-\frac{\delta^t}{n}$. Suppose that a proposer in the next round offers $(p_1,\ldots,p_n)$. For any player i, the expected payoff of moving to the next round $t+1$ is equal to the payoff of accepting the current proposal, v_i, if:

$$\delta^{t-1}v_i = \delta^t\left(\frac{1}{n}p_1+\cdots+\frac{1}{n}p_n\right) \quad \Leftrightarrow \quad v_i = \frac{\delta}{n}\sum_{i=1}^{n}p_i = -\frac{\delta}{n}.$$

Therefore, players offered a share smaller than $\frac{\delta}{n}$ of the loss are willing to accept the current proposal. Since the proposer, who keeps zero (Lemma 1), wants her proposal to be approved, she must offer a share of loss less than or equal to $\frac{\delta}{n}$ to $q-1$ players. The allocation of the remaining share of losses, $1-\sum_{j\in MWC}p_j$, must be allocated to the other members who are not included as an MWC.

Our last goal is to verify that there exists no profitable multi-round deviation from any equilibrium with stationary stage-undominated strategies in the DP game with $\delta \geq 1$. If this claim is true, then we show that on the equilibrium path with stationary stage-undominated strategies, players can find neither single-round nor multi-round profitable deviations, which further implies subgame perfection.

Let $s=(s_i,s_{-i})$ denote the stationary stage-undominated strategy profile, and consider a multi-period deviation s_i' by player i. As a non-proposer, the only possible deviation is to reject $p_i \geq -\delta/n$. If player i becomes the proposer in the next round with probability $1/n$, he will make the most profitable proposal that can be accepted immediately, so no future deviations matter as these will not be exercised. As shown above, the expected payoff of moving to the next round is $-\delta/n$, so rejecting offer p_i for $-\delta/n$ is not profitable.

If player $j\neq i$ becomes the proposer in the next round, she can form a winning coalition without i, so the game ends, and player i ends up with a worse payoff. If the next-round proposer forms a winning coalition with i again, the game ends when player i accepts the same offer, which leads to the lower payoff due to $\delta \geq 1$. It is possible that player i is included in the winning coalition for multiple consecutive rounds, but the probability of being not recognized as a proposer and being included in the minimum winning coalition indefinitely is zero. $\square$

Proof of Proposition 5: As long as players use a stationary strategy, the continuation value of the first round is $-\frac{\delta}{n}$. If the proposer offers $-\frac{\delta}{n}$ to every player, then $-1+\frac{(n-1)\delta}{n}$ is the remaining loss that she would take. If $\delta \geq \frac{n}{n-1}$, then $-1+\frac{(n-1)\delta}{n}>0$. That is, the proposer still has room to keep zero for herself and allocate the losses unevenly to other players as long as the offer made to other players is greater than or equal to $-\frac{\delta}{n}$. If $\delta<\frac{n}{n-1}$, however, the proposer must keep $\frac{(n-1)\delta}{n}-1$ for herself and offer $-\frac{\delta}{n}$ to the other members.

Our next goal is to verify that there exists no profitable multi-round deviation from the SSUE with $\delta \geq 1$ and $q=n$. When $q=n$, every player is pivotal, so it is possible for player i to reject offers in multiple 'consecutive' periods with probability one. Note that the multi-period deviations must be consecutive because if the deviations—rejections—are sporadic, the game ends before the next deviation. If the number of consecutive periods where player i deviates from the equilibrium strategy is $T < \infty$, the game ends after T periods, which results in no better payoffs than accepting the continuation value immediately. The only remaining multi-period deviation under unanimity is to reject all offers indefinitely. This perpetual disagreement would lead to a payoff of -1 to every player, as described in the model. Thus, this strategy cannot be a profitable deviation from the equilibrium strategy: If one is offered a loss of less than the ex-ante expected loss progressing to the next round, then accepting the offer, that is, deviating from the current "reject everything" strategy, is at least weakly beneficial. $\square$

B Experimental Instructions (M5)

Welcome to this experiment. Please read these instructions carefully. The cash payment you will receive at the end of the experiment will depend on the decisions you make as well as the decisions other participants make. The currency in this experiment is called "tokens."

Overview

The experiment consists of 15 "Days." In each Day, every participant will be endowed with 400 tokens, and you will be randomly matched with four other participants to form a group of five. The five group members need to decide how to split a DEDUCTION of (at least) 250 tokens from group members' endowments.

How the groups are formed

In each Day, all participants will be randomly assigned to groups of five members. Each member of a group is assigned an ID number (from 1 to 5), which will be displayed on the top of the screen. In a given Day, once your group is formed, the five group members will not change. Your ID is fixed throughout the Day.

Once the Day is over, you will be randomly re-assigned to a new group of five, and you will be assigned a new ID. Check your ID number when making your decisions.

You will not learn the identity of the participants you are matched with, nor will those participants learn your identity. Identities remain anonymous even after the end of the experiment.

How a deduction of tokens is divided

In each Day, you and your group members will decide how to split a deduction of (at least) 250 tokens across group members. Each Day may consist of several 'Meetings.'

In Meeting 1, one of the five members in your group will be randomly chosen to make a proposal to split the deduction of 250 tokens as follows.

	Member 1	Member 2	Member 3	Member 4	Member 5
# of Tokens Deducted:	___________	___________	___________	___________	___________

The number of tokens deducted from each member must be between 0 and 250. The total number of tokens must add up to 250 tokens.

Each member has the same chance of being chosen to be the proposer. After the proposer has made his/her proposal, the proposal will be voted up or down by all members of the group. Each member, including the proposer, has one and only one vote.

- If the proposal gets three or more votes, it is approved. The tokens allocated to you are DE-

DUCTED from your endowment and then the day ends.

- Otherwise, the proposal is rejected and your group moves to Meeting 2.

In Meeting 2, one member will be randomly selected to be a proposer. Every member, including the proposer in Meeting 1, has an equal chance to be a proposer. The total amount of tokens to be deducted will increase by 20% of that in the previous Meeting. That is, the five members in Meeting 2 need to decide how to split a deduction of 300 tokens. After the proposer proposes how to split the deduction of 300 tokens, it will be voted up or down by all members of the group. If this new proposal is rejected in Meeting 2, then in Meeting 3, another randomly selected member proposes to how to split a deduction of 360 tokens (20% more of 300 tokens), and so on. Your group will repeat the process until a proposal is approved. The following table shows the size of the deduction of tokens for each meeting.

Meeting	1	2	3	4	5	6	7	···
Deduction (in Tokens)	250	300	360	431	518	622	746	20% Larger

The amount of tokens you need to deduct is growing

To summarize, if you are selected as a proposer, make a proposal of splitting the deduction of the current number of tokens, and move to the voting stage. If you are not a proposer, wait until the proposer makes a proposal, examine it and decide whether to accept or reject it. Previous proposers can be a proposer again. If a proposal is approved, the number of tokens offered to you will be DEDUCTED from your endowment.

Information Feedback

At the end of each Meeting, you will be provided with a summary of what happened in the Meeting, including the proposed split of the deduction, the proposer's ID, and the voting outcome. At the end of each Day, you will learn the approved proposal and your earning from the Day.

Payment

In each Day, your earning is

[400 tokens − the number of tokens offered to you in the approved proposal]

The server computer will randomly select one Day and your earning in that Day will be paid. Each day has an equal chance to be selected for the final cash payment. So it is in your best interest to take each Day equally seriously. Your total cash payment at the end of the experiment will be the number of tokens you earn in the selected Day converted into HKD at the exchange rate of 2 tokens = 1 HKD plus 30 HKD guaranteed show-up fee.

Summary of the process

1. The experiment will consist of 15 Days. There may be several Meetings in each Day.
2. Prior to each Day, every participant is endowed with 400 tokens and will be randomly matched with four other participants to form a group of five. Each member of the group is assigned an ID number.
3. At the beginning of each Day, one member of the group will be randomly selected to propose how to split a deduction of (at least) 250 tokens.
4. If three or more members in the group accept the proposal, the proposal is approved, and tokens offered to you will be DEDUCTED from your endowment.
5. If the proposal is rejected, then the group proceeds to the next Meeting of the Day and a proposer will be randomly selected.
6. The volume of the tokens that need to be deducted increases by 20% following each rejection of a proposal in a given Meeting.

Remember that tokens offered to you in the approved proposal are DEDUCTED, not added.

Quiz and Practice Day

To ensure your understanding of the instructions, we will provide you with a quiz below. After the quiz, you will participate in a Practice Day. The Practice Day is part of the instructions and is not relevant to your cash payment. Its objective is to get you familiar with the computer interface and the flow of the decisions in each Meeting. Once the Practice Day is over, the computer will tell you when the official Days begin.

Quiz

To ensure your understanding of the instructions, we ask that you complete a short quiz before we move on to the experiment. This quiz is only intended to check your understanding of the written instructions. It will not affect your earnings. We will discuss the answers after you work on the quiz.

Q1. In each Day, you will be assigned to a group of (A) members. In Meeting 1, each group will decide how to split a deduction of (B) tokens. What are appropriate numbers in (A) and (B)?

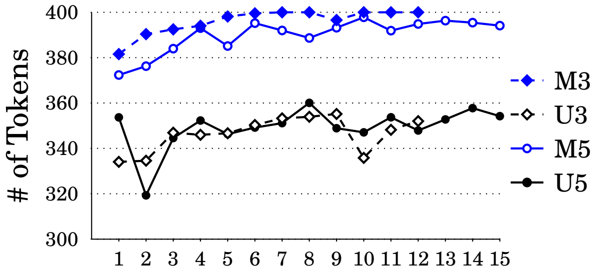
Q2. Suppose that in Day 1, your ID number is 3, and member 1 is selected as a proposer in Meeting 1. Which of the followings is NOT TRUE? (a) If member 1's proposal is rejected, member 1 can be a proposer in Meeting 2. (b) Even if I reject the proposal, it could be approved by majority. (c) In the next Day, my ID number must be 3 again. (d) In Meeting 2 of the current Day, my ID number is unchanged.

Q3. In Meeting 1, there are 250 tokens being divided. Which of the following exemplary proposals makes sense? (a) $(200, 50, 0, 0, 0)$ (b) $(20, 20, 20, 20, 20)$ (c) $(450, -50, -50, -50, -50)$ (d) $(300, 0, 0, 0, 0)$

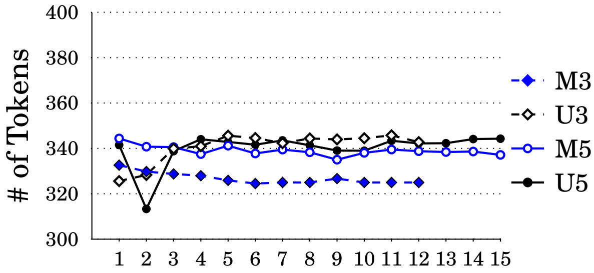
Q4. If a proposal in Meeting 1 is rejected, what will happen next? (a) Your group will move to Meeting 2. One member will be randomly selected as a proposer. (b) Your group will end the Day. The tokens that need to be deducted are equally distributed to each member. (c) The previous proposer will propose one more time. (d) Your group will end the Day. The tokens that need to be deducted will be added to the tokens for the next Day.

Q5. In each Day, you are endowed with 400 tokens. If the approved proposal offered you 100 tokens, what's your earning on that Day?

C Supplementary Figures and Test Results



(a) Proposers



(b) Nonproposers

Figure 7: Average Earnings

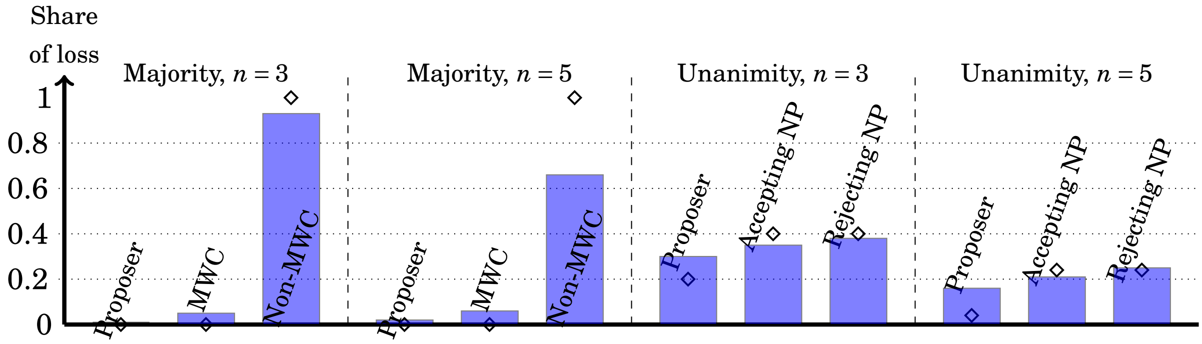
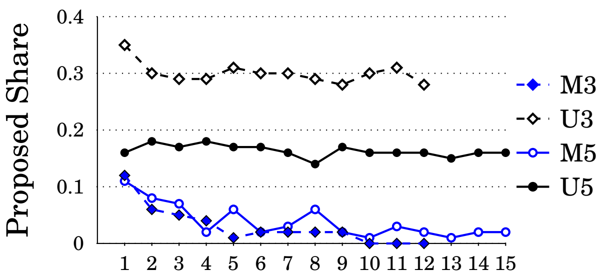
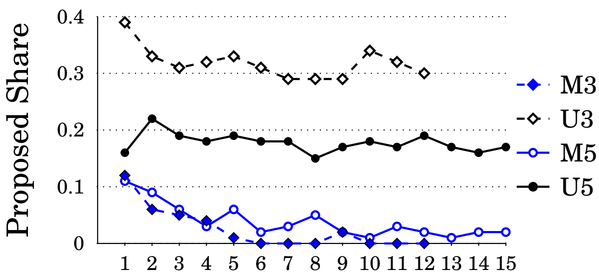


Figure 8: Proposed Shares
All (including rejected) proposals in all periods

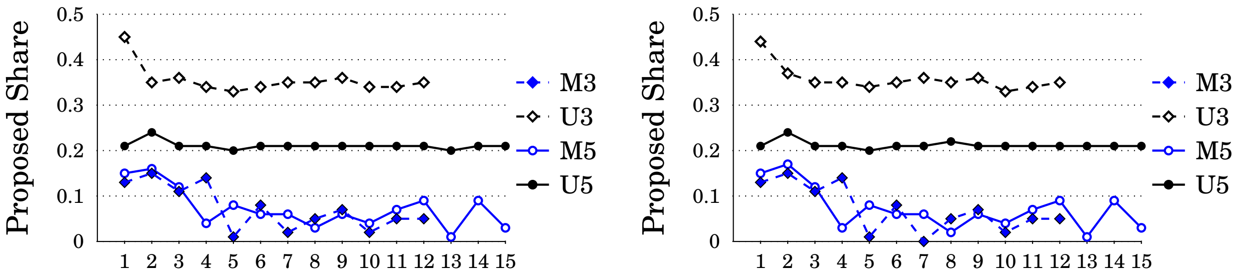


(a) All Proposals



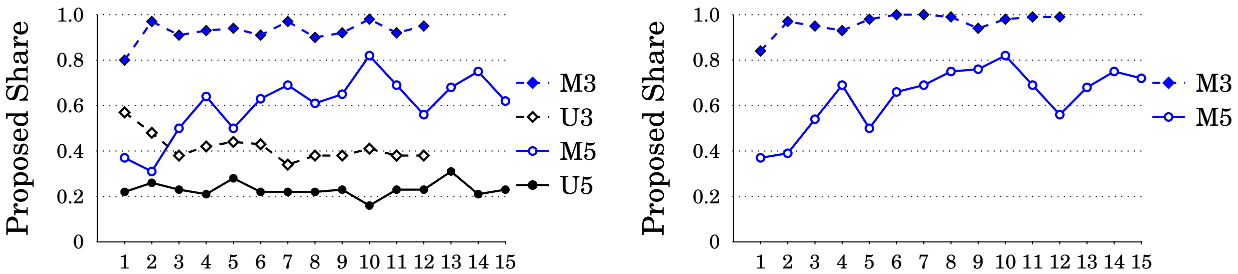
(b) Approved Proposals

Figure 9: Average Proposed Share - Proposer



(a) All Proposals (b) Approved Proposals

Figure 10: Average Proposed Share - Accepting Nonproposer



(a) All Proposals (b) Approved Proposals

Figure 11: Average Proposed Share - Rejecting Nonproposer

Table 4: Test Results using Session-Level Averages

	Hypotheses and Tests	Supported
H1(a)	The proposer receives the smallest loss in all treatments.	✓
Test	Wilcoxon Signed-rank test rejects the null hypothesis that the proposer's share is larger than the nonproposer's (p-value=0.00032).	
H2(b)	The proposer keeps a smaller loss in the majority treatment than in the unanimity treatment.	✓
Test	Mann-Whitney test rejects the null hypothesis that the proposer's share in the Majority treatment is larger than that in the Unanimity treatment (p=0.00047).	
H2(c)	The proposer keeps a larger share of the loss in the U3 treatment than in the U5 treatment.	✓
Test	Mann-Whitney test rejects the null hypothesis that the proposer's share in U3 is smaller than that in U5 (p=0.01429).	
H3(a)	In the majority treatment, the median share of the accepted proposal (or the largest share offered to the MWC members) is larger than the proposer's share.	✗
Test	Mann-Whitney test cannot reject the null hypothesis that the proposer's share is larger than that of median share (p=0.10383).	
H3(b)	In the majority treatment, the agreed-upon share of the nonproposers who accept the proposal is larger in M3 than in M5.	✗
Test	Wilcoxon Signed-rank test cannot be performed due to too small number of observations. T test cannot reject the null of no mean difference (p=0.362174).	
H3(c)	In the majority treatment, the number of nonproposers who accept the proposal is $\frac{n-1}{2}$. That is, two members reject the proposal in M5.	✗
Test	Nonparemetric tests cannot be performed due to too small number of observations. One-sample t test reject the null of no difference from 2 (p=0.002305).	

D Discussions

In this section, we discuss some theoretical deviations to which we have paid less attention.

D.1 How to make the DD and the DP equivalent

We have claimed that the DD and DP games are fundamentally different, especially in terms of the number of SSP equilibria. Examining the conditions for those two games equivalent (except for the flipped signs and level shifts of the outcomes) would be worthwhile for illustrating the differences in another way. The difference between a growing penalty ($\delta \geq 1$) in the DP game and a discounting surplus ($\delta \leq 1$) in the DD game does not play an important role in leading to different theoretical results, as the theoretical differences remain unaffected when $\delta = 1$. Under a q-quota voting rule with $q < n$, there are two ways to make the theoretical predictions between the DD and the DP games similar.

1. In the DP game, if a maximum loss-share assigned to one player is capped at $\frac{n-\delta(q-1)}{n(n-q)}$, then only the ME remains as the SSPE.

2. In the DD game, if a maximum surplus share *to the proposer* (not every player) is capped at $\frac{\delta}{n}$, then there is a continuum of SSP equilibria where the equilibrium payoff of the MWC member varies from $\frac{\delta}{n}$ to $\frac{n-\delta}{n(q-1)}$.

If we define a "free surplus" as the difference between the equilibrium payoff and the continuation value of one MWC member, then the uniqueness (in payoff) of the equilibrium in the DD game is described by the zero free surplus that the proposer can add to the others. Meanwhile, in the DP game, the continuation value of the MWC member is $-\frac{\delta}{n}$, but the proposer can make a strictly better offer than $-\frac{\delta}{n}$ to his/her MWC members. That is, in the DP game, the natural cap of the proposer (who cannot enjoy more than zero losses) allows a free surplus to the MWC members. Thus, theoretical equivalence between the DD game and the DP game can be achieved either (1) if we restrict the proposer's free surplus in the DP game or (2) if we force the proposer in the DD game to have a free surplus.[29]

D.2 Incentive Compatibility of Participation

On a gain domain, the ex-ante expected payoff in the SSUE is $1/n$, so participating in bargaining is always incentive compatible. Therefore, adding a pre-stage for agents to make a participation decision does not lead to any theoretical differences. This pre-stage decision, however, matters in multilateral

[29] Although examining the conditions for making two games similar is theoretically entertaining, we are unsure whether we could find meaningful implications of this exercise. For example, to make the DP game be like the DD game, we should impose $\frac{n-\delta(q-1)}{n(n-q)}$ as a loss cap. When we ask ourselves about the use of this result or about the practical resemblance in distributive politics, it would not seem to add much value. Also, we admit that the DD game with the proposer's payoff capped at $\frac{\delta}{n}$ is not isomorphic to the DP game, as it includes equilibria where the MWC members are strictly better off than the proposer.

bargaining over the division of losses: If the members know that they are about to divide losses, and the ex-ante expected loss in any stationary equilibria is $-1/n$, simply quitting the bargaining process would be better. We implicitly assume here that a specific form of enforcement or sufficient benefits that can compensate the potential losses for participation exists. When addressing unavoidable issues, such as an allocation of the tax burden to different socioeconomic groups or the international agreement on greenhouse gas emissions abatement, this is relevant in the sense that members cannot easily choose to opt out the country or the planet. Even when the issue is avoidable, there are many ways to implement the full participation of members. For example, collectively agreeing that all losses go to some of those who do not participate in bargaining would prevent every member from doing so: Given that other members agree on this protocol, one would receive the entire loss by not participating. In this case, agreeing to participate makes one better off.

As we pointed in the Introduction, ensuring every player's participation constraint, for example, giving each player an endowment greater than $1/n$ so that the ex-ante expected payoff becomes positive, does not affect the fundamental differences between the division of gains and the division of losses.

D.3 Voting Rules Other Than Unanimity

Another issue may be the choice of voting rules other than unanimity. Since the UI equilibrium involves an extreme allocation of the loss to a few members, some risk-averse agents may demand unanimity. However, unanimity is not suitable for every situation. Implementation of a new policy would be one important example where a majority rule is applied. For example, the Tax Cuts and Jobs Act of 2017 in the United States was passed by the Senate on December 20, 2017, in a 51–48 vote. Assume for simplicity that a government wants to reform tax policy to cope with a budget deficit, and there are only three types of citizens with equal populations: the rich, the poor, and the middle-class. In this case, a policy victimizing one of the three distinct groups by allocating the tax burden to that group may be implemented, but we do not claim that we should change the voting rule to unanimity due to that possibility. In addition, although the stability of the voting rule is beyond our concerns in this paper, studies including Barbera and Jackson (2004) characterize a self-stable majority voting rule with the persuasive argument that the general trend is away from unanimity. Moreover, as our experimental evidence and many other similar experimental studies show, a unanimity rule leads to efficiency loss due to delay.[30] Risk-neutral agents who negotiate over a loss repeatedly may want to avoid unanimity because it might eventually be harmful to every agent.

D.4 Bargaining When Delay is Socially Desirable

We assume $\delta = \beta g \geq 1$ so that no one has an incentive to postpone their bargaining decision. However, in situations where $\delta < 1$, that is, β (the subjective discount factor of a future payoff) is sufficiently

[30] Bouton et al. (2018) discourage the use of a unanimity rule for a different reason: by showing that unanimity is Pareto-inferior to majority rules with veto power.

smaller than $1/g$ (the inverse of the growth rate of the penalty), the Pareto-optimal allocation is for everyone to reject any form of a proposal for any round t so that everyone will eventually have zero losses. In this situation, still, the stationary stage-undominated equilibria can be sustained as long as we maintain the assumptions that each individual is self-interested and that stage-undominated strategies are considered. For example, when a proposal allocating all losses to one member is put to a vote, a member who receives an offer of zero losses would accept the proposal because the continuation value of the next bargaining round is at least weakly smaller than the zero losses. If the qualified number of votes for approval is less than n, the proposal would be accepted immediately. Similar to the public goods game situation, the Pareto-optimal collective behavior can be distinctly different from the equilibrium behavior.

We have paid less attention to the case with $\delta < 1$ for several reasons. First, we have tried to make the structure of the DP game as similar to that of the DD game as possible. In the DD game, delay is discouraged, as it is in the DP game with $\delta \geq 1$. Second, the experimental evidence may be confounded because each subject's internalized social norms may be heterogeneous and unobservable (Kimbrough and Vostroknutov, 2016). If the primary purpose of this study has been to observe how subjects behave differently when the Pareto-optimal behavior and the equilibrium behavior diverge, a typical linear public goods game would have been more pertinent. Third, since it is unusual to have losses that will disappear as time passes if nothing is done, we claim that $\delta < 1$ is less relevant to real-life situations.

D.5 Regarding the Utility of Infinite Disagreements

In the DD game, the utility when disagreeing forever is assumed to be zero, which is the lowest possible earning in the first round. To have a corresponding form, we assume that the utility of infinite disagreements is negative one, which is the largest possible loss in the first round. However, the purpose of setting it to -1 is merely to have a corresponding form. As long as the utility is smaller than the continuation value of the second round, no stationary stage-undominated equilibria predict that players will move to the second round. As we explained in the previous subsection, the equilibria are sustained even when the loss exponentially decreases to zero.

It may be easier to deal with the utility of infinite disagreements in the following alternative interpretation. Suppose that we still have the same growth rate $g \geq 1$ and the discount factor $\beta \leq 1$. Instead of assuming that utility is accrued either when an agreement is reached or when infinite disagreements occur, assume that each disagreement renders a disutility of $\frac{g-1}{n}$ (the equal split of the increased amount of loss) to all players. One can imagine that each delay in an environmental policy agreement leads everyone to gain a (marginal) disutility from untreated environmental damage. Then, the utility of infinite disagreements is the sum of the geometric sequences, $\sum_{t=0}^{\infty} -\beta^t \frac{g-1}{n} = \frac{1-g}{n(1-\beta)}$. To characterize the stationary stage-undominated equilibria in which disagreeing forever is not incentivized, it is sufficient to assume that $\frac{1-g}{n(1-\beta)}$ is smaller than the ex-ante expected payoff of bargaining, $-\frac{1}{n}$. In other words, the parametric assumption we have essentially in mind is $\frac{1-g}{n(1-\beta)} < -\frac{1}{n}$, or $g+\beta > 2$, and not exponentially increasing losses. This assumption holds with the entire set of parameter values we have considered except for the indeterministic case $g = \beta = 1$.

D.6 Equilibrium Selection

Our primary purposes are to convince that the DP game is theoretically different from the DD game and to report that the experimental observations are quite distinct. However, it is worth discussing what the proper refinement of the equilibrium of giving zero losses to all winning coalition members is. Indeed there are many justifications for selecting the UI equilibrium.

Although we did not explicitly mention the quantal response equilibrium (QRE, McKelvey and Palfrey, 1995), one argument for why the ME equilibrium is fragile goes along with the assumption of QRE. If the winning coalition members might sometimes mistakenly reject the proposal, then the proposer needs to minimize the risk associated with such mistakes by providing them with more favorable offers. QRE has a property in which the probability of a mistake depends on the cardinal payoff that a player gives up, so it renders the proper incentives to choose a particular proposal for which approval depends least on the critical calculation of the indifferent offer.

While the idea of QRE can address why each of the winning coalition members could have the least losses, trembling hand perfection (THP, Selten, 1975) could explain why the size of the winning coalition could be larger than the minimum when it is possible. The possibility of nonproposers' mistakes will lead the proposer to demand a larger coalition. When $n = 5$, for example, among several stationary equilibria allocating zero losses to the winning coalition members, $(0,0,0,-x,-1+x)$, THP will select the most uneven allocation, $x = 0$, because this is the way to minimize the risk of rejection due to mistakes. This argument is consistent with our experimental findings in M5.

If we seek behavioral arguments, in-group favoritism can explain the selection of the UI equilibrium as well. In-group favoritism is one empirical similarity between our experimental observations and those in previous experiments involving the DD game (Fréchette et al., 2005). Gamson's Law, a popular empirical model that supports an equal split within a coalition, is often interpreted as evidence of in-group favoritism, which might lead to the proposer's partial rent extraction as opposed to the full rent extraction predicted by the Baron-Ferejohn model. In the sense that in the UI equilibrium, the proposer treats the MWC members most favorably, our observations might be consistent with the empirical interpretation of in-group favoritism. From the perspective of the proposer who has an epsilon concern regarding in-group favoritism, allocating zero to the MWC members is a corner solution, regardless of how negligible the in-group favoritism may be. Experimental evidence, including Efferson et al. (2008), suggest that in-group favoritism can evolve with arbitrary and initially meaningless markers. Although in our experimental setting, there are no clear distinctions between in-group and out-group, a sense that some members must vote "yes" for the proposer might be sufficient to form a notion of an in-group.

Last, if subjects are concerned about utilitarian social welfare and every subject has a concave utility on the losses, then the UI equilibrium is likely to be selected. If the marginal disutility of a loss is diminishing, as loss-averse utility functions are typically characterized, the disutility of one person's significant loss is smaller than the sum of disutilities of several persons' small losses. Then, selecting the UI equilibrium leads to the largest utilitarian social welfare. Although we believe those are plausible arguments, we admit that our experiments are not suitable for determining which arguments are more plausible than others.