Strategic Alliances in a Veto Game: An Experimental Study[*]

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Abstract

In a veto game, we investigate the effects of "buyout" which allows non-veto players strategically form an intermediate coalition. First, our experimental findings show that the proportion of intermediate coalition formation is much lower than predicted by theory, regardless of the relative negotiation power between veto and non-veto players. Second, allowing coalition formation among non-veto players does not affect the surplus distribution between veto and non-veto players, which diverges from core allocations. These findings contrast to the literature, which views the ability to form an intermediate coalition as a valuable asset for non-veto players in increasing their bargaining power.

Keywords: game theory; coalition bargaining; veto game; experiment; non-core allocation; intermediate coalition formation.
JEL: C72; C78; C92; D72; D74.

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1 Introduction

In many economic, political, and managerial institutions, veto players are prevalent.[1] Some well-known examples include the permanent members in the UN Security Council and the US President's veto power over legislative actions. In the super-majority provision, a majority party cannot control the whole body yet still has veto power against others. Since von Neumann & Morgenstern (1944), collective decision-making problems with veto players have been formally studied in the frame of game theory.[2]

In such veto games, the central question is on the distribution of power among the players and the allocation of the surplus. The *core* property, which is the best-known game-theoretic solution concept for stability, requires that veto players extract all the surplus.[3] On the other hand, other well-known cooperative power indices put forth by Shapley & Shubik (1954), Banzhaf (1964), Deegan & Packel (1978), Johnston (1978), Nowak & Radzik (1994), and Lee & Driessen (2012) assign a substantial value to non-veto players.[4] Moreover, experimental results have consistently observed non-core allocations since Maschler (1965).

One of the rationales behind such non-core allocations is a possibility of an agreement between non-veto players or intermediate coalition formation: a block-

[1]A veto player has the ability to decline a choice being made (Tsebelis, 2002).

[2]In this paper, we focus on simple games. In a simple game, a set of *veto player*s is the intersection of all winning coalitions (Nakamura, 1979). A simple game is a *veto game* if it has a veto player. See von Neumann & Morgenstern (1944) and Shapley (1962) for details.

[3]A feasible allocation is said to be in *core*, if it cannot be blocked by any coalition. In particular, for any game with a single veto player, there exists a unique core allocation, which coincides with many other cooperative solution concepts, such as the bargaining set (Kahan & Rapoport, 1974) and the coalitional Nash bargaining solution (Compte & Jehiel, 2010). The core allocation also has a clear strategic foundation, as it is selected by an equilibrium in "random-proposer" non-cooperative bargaining models (Selten, 1981; Baron & Ferejohn, 1989; Okada, 1996; Winter, 1996; Kim & Jeon, 2009) when the bargaining friction is "negligible" or the environment is "competitive." However, "rejector-becomes-proposer" models such as Chatterjee et al. (1993) may select non-core allocations as non-veto players retain bargaining power by rejecting an offer from the veto player.

[4]To be specific, in a three-player simple game with a single veto player, those indices allocate different values to each non-veto player: the Shapley-Shubik index and the Johnston index (1/6), the Banzhaf index (1/5), the solidarity value assigns (5/18), and the Deegan-Packel index and the sequentially two-levelled egalitarianism (1/4).

ing coalition of non-veto players can behave as a "collective veto player" if they can commit, although the worth of the coalition is zero in the original game. Specifically, Maschler (1963) argues that "when an intermediate coalition is formed, it may partition itself into subcoalitions, who enter the next stage of the game as single players" and that non-veto players would "flip a coin under the condition that the loser would go out of the game," to enforce one of the non-veto players to bargain with the veto player; Murnighan & Roth (1980) also point that the non-veto players have an option to "attempt to form a coalition with the veto players."[5]

In experiments, both Maschler (1965) and Murnighan & Roth (1977) find that the results are significantly different from the core allocation, observing the occasional occurrence of intermediate coalitions between non-veto players.[6] However, the role of intermediate coalition formation has not been rigorously tested in the literature.[7] Based on the advances in non-cooperative coalition bargaining models developed for the last decades, we design experiments to test the role of buyout options in a veto game and discuss whether allowing intermediate coalition formation yields a substantial amount of payoff to non-veto players.

In Section 2, we provide theoretical predictions based on the model developed by Lee (2018).[8] The model is suitable to study the interactions among multiple players

[5] The idea of intermediate coalition formation has been developed as formal non-cooperative bargaining models. Gul et al. (1986) allow buyout in a randomly selected bilateral meeting to characterize the Shapley value as an equilibrium outcome. On the other hand, Seidmann & Winter (1998), Okada (2000), Gomes (2005), and Lee (2018) consider coalition bargaining models with intermediate coalition formation where players can strategically choose their bargaining partners.

[6] Maschler (1965) reported a higher incidence of coalitions between non-veto players (or weak players) than Murnighan & Roth (1977). Note Maschler (1965) allowed the players to meet face to face outside of the laboratory; while Murnighan & Roth (1977) conducted the experiment with a computerized procedure.

[7] As Maschler (1965) stated, his paper was "neither intended originally to be a scientifically well-planned experiment, nor, in fact was executed in accordance with the high rigor now achievable by the best available procedures." Murnighan & Roth (1977) focused on the effects of communication and information availability, and Murnighan & Roth (1980) concerned the numbers of non-veto players, rather than the role of intermediate coalition formation.

[8] We follow non-cooperative legislative bargaining models in which a proposer is randomly selected in each period. In earlier models, such as Baron & Ferejohn (1989) and Winter (1996), players can generate a positive surplus only from winning coalitions, and hence they have no incentive to form non-winning coalitions. Therefore, due to the lack of strategic unionization, only veto players are expected to take positive shares in equilibrium. The notion of buyout in non-cooperative coali-

and the effects of allowing coalition formation. Specifically, the model presents two types of players, i.e., veto and non-veto players, where the veto player has stronger negotiation power in the sense that the surplus cannot be realized without the veto player's agreement. The most important element of the model for our purpose is whether strategic coalition formation among non-veto players is allowed. In particular, we study two different versions of the model depending on whether non-veto players can form a coalition. If they have the ability to form a coalition, a non-veto player can make a coalition offer (i.e., "buyout" offer) to the other non-veto player by offering upfront transfers, and a coalition is formed if the proposal is accepted. The model provides us with theoretical predictions for our experiments. First, non-veto players are more likely to form a coalition as their negotiation power against the veto player diminishes. Second, the ability to form a coalition among non-veto players is expected to benefit them by increasing their shares in negotiation. The model also predicts that non-veto players obtain larger shares as the veto player's negotiation power diminishes.

Section 3 explains our experimental setting. In the main stage of our experiment, subjects played a game called *Deer Hunting Game* in a group of three members, in which a veto player possesses an indispensable item for hunting the deer whereas two non-veto players possess a dispensable item each. We implemented a 2×2 design in our experiment: one dimension is whether non-veto players are allowed to form a coalition, and the other dimension is the strength of negotiation power of the veto player.

Section 4 presents our experimental findings. First, non-veto players did utilize

tion bargaining was first introduced by Gul (1989). In his model, however, as players bargain in a randomly selected bilateral meeting, coalition formation is not a part of strategic decision making. Seidmann & Winter (1998); Okada (2000); Gomes (2005); Gomes & Jehiel (2005) introduce coalition bargaining models with intermediate coalition formation where players can strategically choose their bargaining partners, yet they focus on the results on efficiency and strategic delay. Lee (2018) considers a model in which players can form an intermediate coalition by "buying out" other players. Importantly, Lee (2018) fully characterizes the equilibrium outcomes of three-player simple games with buyout options, which provide theoretical prediction related to the role of intermediate coalition formation.

the opportunity to form a coalition when they were allowed, but not as often as predicted by theory. Moreover, in contrast to theory, the frequencies of coalition formation were not correlated with players' negotiation power. Second, in contrast to the theoretical prediction, we found that the power to form a coalition had no effect on non-veto players' shares in negotiation. Instead, our experimental data support non-core allocations, in which even non-veto players obtained a substantial amount of share, *no matter whether* they were allowed to form intermediate coalitions. This observation contrasts with the hypothesis in earlier literature, which views the ability to form an intermediate coalition as an important factor behind the prevalence of non-core allocations in veto games.

In the literature on veto game experiments, researchers have studied various factors influencing bargaining outcomes, including information availability (Murnighan & Roth, 1977), group size (Murnighan & Roth, 1980; Montero et al., 2008; Drouvelis et al., 2010), and voting rule (Bouton et al., 2017; Agranov & Tergiman, 2019).[9] But we are not aware of an experiment that explicitly tests the effect of the ability of non-veto players to form a coalition.[10]

Our paper is also related to the experimental works showing that non-core allocations, such as bargaining sets (Medlin, 1976; Rapoport & Kahan, 1976) and the Shapley value (Murnighan & Roth, 1977; Bachrach et al., 2011), better describe actual human decision making. In relation to this literature, we also find that our participants frequently choose non-core allocations. More importantly, we show that non-veto players' ability to form a coalition may not be an important factor behind the occurrence of non-core allocations reported in the literature.

In general, our experiment is related to the growing literature on multilateral

[9] Bouton et al. (2017) found that majority rule with veto power dominates unanimity rule, in which all players hold veto power, in terms of information aggregation, and Agranov & Tergiman (2019) considered committee decision making with unanimity rule to study the effects of communication.

[10] See also Kagel et al. (2010) who investigated the effects of veto power in committee decisions experimentally and found that veto power lowers efficiency. Nunnari (2020) studied a dynamic setting with veto power in which an infinitely repeated divide-the-dollar game is played with an endogenous status quo policy.

bargaining experiments based on Baron & Ferejohn (1989): open and closed amendment rules (Fréchette et al., 2003), public good provision (Fréchette et al., 2012), preplay communication among players (Agranov & Tergiman, 2014), endogenous production of surplus (Baranski, 2016, 2019), proposer selection contest (Kim & Kim, 2017; Hahn et al., 2020), and legislative bargaining of cuts versus increases in government spending (Christiansen & Kagel, 2019). However, to the best of our knowledge, no experiment has investigated the effect of intermediate coalitions among a subset of players. In particular, we contribute to this literature by testing the effect of buyout options of non-veto players.

The rest of the paper is organized as follows. Section 2 provides the standard model in the literature and derives our theoretical predictions. Section 3 explains our experimental setting and Section 4 shows our experimental findings. Section 5 concludes our paper. The experimental instruction can be found in Appendix A.1 and robustness checks for the main regression result in Appendix A.2.

2 Theoretical Prediction

2.1 Game Description

Let $N = \{1,2,3\}$ be a set of players, where its typical element is referred by i, j, and k, distinctively. We consider a three-player simple game in which $\mathbf{W} = \{\{1,2\},\{1,3\},N\}$ is the set of winning coalitions. That is, all winning coalitions contain player 1 and another player. Player 1 is called a *veto* player, while the other two players are *non-veto* players. A non-cooperative bargaining game $(N,\mathbf{W},p,\delta)$ requires two more components: $p \in \Delta(N)$ is a recognition probability and $\delta \in (0,1)$ is a common discount factor. A bargaining game proceeds as follows:

- *Proposal:* Each player $i \in N$ writes a proposal $s_i = (j,m)$ indicating a bargaining partner $j \in N \setminus \{i\}$ and a coin offer $m \in [0,1]$.[11] Given $s_i = (j,m)$, denote $j(s_i) = j$

[11] One may consider a model that allows proposers to choose multiple bargaining partners to form

and $m(s_i) = m$.

- *Recognition:* Among the three proposals $\{s_i\}_{i\in N}$ submitted, one proposal is randomly selected according to the recognition probability: s_i is selected with a probability of p_i.

- *Response:* Given s_i selected, $j(s_i)$ either accepts or rejects. If $j(s_i)$ rejects, the same three-player game is repeated with a probability of δ but it is terminated with a probability of $1-\delta$. If $j(s_i)$ accepts, i forms a coalition $\{i, j(s_i)\}$ paying $m(s_j)$ to $j(s_i)$. In case of $\{i, j(s_i)\} \in \mathbf{W}$, i receives a unit surplus and the game ends. Otherwise:

  - (No Buyout Allowed) The game ends without the surplus realized.
  - (Buyout Allowed) Without loss of generality, say player 2 buys out player 3. The remaining players, i.e., player 1 and player 2, play a subsequent two-player bargaining game. The subsequent game proceeds in a similar way, but s_2 is now selected with a probability of $p_2 + p_3$.

2.2 Equilibrium with No Buyout

As in the literature, we focus on a cutoff strategy equilibrium, as it represents the payoff induced by any stationary subgame-perfect equilibrium. A cutoff strategy profile (x, q) consists of $x \in \Delta(N)$ and $q = \{q_i\}_{i\in N}$ where $q_i \in \Delta(N \setminus \{i\})$. For simplicity, denote $q_{ij} = q_i(j)$. A strategy profile (x, q) specifies the behaviors of any player i in the following way: 1) player i writes a proposal $s_i = (j, m = x_j)$ with probability $q_i(j)$, that is, she chooses her bargaining partner according to q_i; and 2) whenever player i gets an offer m, she accepts it if and only if $m \geq x_i$. A strategy profile (x, q) gives

a grand coalition immediately. In equilibrium, however, proposers always make a strictly positive offer to only one partner. To simplify the strategies in experiments, we thus explicitly assume that proposers indicate only one partner.

player i a continuation payoff $u_i(x, q)$:

$$u_i(x,q) = p_i \sum_{j \in N \setminus \{i\}} q_{ij} e_{ij} + \sum_{j \in N \setminus \{i\}} p_j q_{ji} x_i, \tag{1}$$

where $e_{ij} = \mathbb{1}(\{i,j\} \in \mathbf{W}) - x_j$ refers the excess surplus of forming a coalition $\{i,j\}$. When buyout is not allowed, a strategy profile (x,q) constitutes an equilibrium if and only if it satisfies the two conditions below:

- *Optimality:* Player i chooses $j(s_i)$ to maximize $u_i(x,q)$, that is,

$$q_{ij} > 0 \implies e_{ij} \geq e_{ik}. \tag{OPT}$$

- *Indifference:* Player i is indifferent between accepting and rejecting, that is,

$$x_i = \delta u_i(x,q). \tag{IND}$$

In our experiment, we consider the two cases of recognition probabilities, $p = (1/3, 1/3, 1/3)$ and $p = (2/3, 1/6, 1/6)$. Abusing notations for simplicity, the former is referred to by $p = 1/3$ and the latter by $p = 2/3$, when there is no danger of confusion. Solving the two conditions, for any p and δ, there is a unique equilibrium which consists of

- $x = \left(\frac{(2-\delta)\delta p}{2-(2-p)\delta}, \frac{(1-p)(1-\delta)\delta}{2-(2-p)\delta}, \frac{(1-p)(1-\delta)\delta}{2-(2-p)\delta}\right)$; and
- $q_{12} = q_{13} = 1/2$; $q_{21} = q_{31} = 1$.

Note that only a (minimum) winning coalition immediately forms.

2.3 Equilibrium with Buyout

With buyout options, as players take subsequent two-player games into account, we first consider a two-player bargaining game. It is well-known that there exists a unique equilibrium in which the payoff vector is equivalent to the recognition probability $(p, 1-p)$. Hence, we assume that whenever buyout occurs (i.e., a non-winning coalition $\{2,3\}$ forms), the two players play accordingly.

Taking the equilibrium strategy profile of the two-player subsequent game as a part of the equilibrium of the original three-player game, we focus on the cutoff strategy profile (x, q) with three players as in the case of no buyout. However, the existence of subsequent games affects the players' continuation payoff $\hat{u}_i(x, q)$:

$$\hat{u}_i(x,q) = p_i \sum_{j \in N \setminus \{i\}} q_{ij} \hat{e}_{ij} + \sum_{j \in N \setminus \{i\}} p_j q_{ji} x_i, \tag{2}$$

where $\hat{e}_{ij} = e_{ij} + \delta(1-p_1)\mathbb{1}(\{i,j\} = \{2,3\})$ is the excess surplus of forming $\{i,j\}$ with buyout. Note that $\hat{e}_{23} \geq e_{23}$ as a non-winning coalition $\{2,3\}$ can expect $(1-p_1)$ in the following period (i.e., with a probability of δ); while $\hat{e}_{1j} = e_{1j}$ as forming a winning coalition does not continue to subsequent games. As in the case of no buyout, a strategy profile (x, q) forms an equilibrium if and only if it satisfies the two conditions, *Optimality* with buyout

$$q_{ij} > 0 \implies \hat{e}_{ij} \geq \hat{e}_{ik} \tag{OPT-B}$$

and *Indifference* with buyout

$$x_i = \delta \hat{u}_i(x, q). \tag{IND-B}$$

There exist two types of equilibria, depending on p and δ. For $\delta \leq \bar{\delta} := \frac{3-\sqrt{-8p^2+8p+1}}{2(p^2-p+1)}$, no buyout occurs, and hence, the equilibrium is the same as that in the case of no buyout. However, if $\delta > \bar{\delta}$, a non-winning coalition forms as an intermediate bargaining step in equilibrium, i.e., $q_{23} > 0$.[12] Table 1 summarizes the equilibrium

[12] For $\delta \geq \bar{\delta}$, as $q^B_{12} = q^B_{13} = 1/2$ and $q^B_{23} = q^B_{32} > 0$, x^B_1 and x^B_2 solves

$$\begin{aligned} x_1 &= \delta\Big[p(1-x_2) + (1-p)(q^B_{23}\delta p + (1-q^B_{23})x_1)\Big] \\ x_2 &= \delta\left[\frac{1-p}{2}(q^B_{23}(\delta(1-p)-x_2) + (1-q^B_{23})(1-x_1)) + p\left(\frac{1}{2}x_2 + \frac{1}{2}0\right) + \frac{1-p}{2}(q^B_{23}x_2 + (1-q^B_{23})0)\right]. \end{aligned}$$

For $p = 1/3$, as $q^B_{21} = 1 - q^B_{23} > 0$ and $q^B_{23} > 0$, x^B_1 and x^B_2 are determined by an additional equation $\hat{e}_{21} = \hat{e}_{23}$, or equivalently, $1 - x_1 - x_2 = \delta(1-p) - 2x_2$. For $p = 2/3$, x^B_1 and x^B_2 are fixed by $q^B_{23} = 1$.

Table 1: Equilibria for No Buyout and Buyout

		$\delta = 0.95$		$\delta \to 1$	
		$p = 1/3$	$p = 2/3$	$p = 1/3$	$p = 2/3$
No Buyout	x_1^N	0.798	0.907	1	1
	$x_2^N = x_3^N$	0.076	0.022	0	0
	q_{23}^N	-	-	-	-
Buyout	x_1^B	0.558	0.787	0.556	0.833
	$x_2^B = x_3^B$	0.191	0.073	0.222	0.083
	q_{23}^B	0.340	1	0.500	1

Note: x_i is the amount of coin offered to player i in equilibrium. q_{23} is the probability that buyout occurs when non-veto players are selected.

for each cases of buyout, (x^B, q^B), and the equilibrium for no buyout, (x^N, q^N), for $p = 1/3, 2/3$, as well as for $\delta = 0.95$ and $\delta \to 1$.[13] Note that $\bar{\delta} = 6/7$ for both $p = 1/3$ and 2/3. Thus, buyout occurs with a positive probability.

2.4 Hypotheses

Based on the equilibrium outcomes, the theory provides three main hypotheses:

H1. The less likely the non-veto players are recognised (the higher p), the more likely they exercise the buyout option (the higher q_{23}).[14] In particular,

$$q_{23}^B(p = 1/3) < q_{23}^B(p = 2/3).$$

H2. Reducing the veto player's recognition probability reduces inequality, that is,

$$x_1^N(p = 1/3) < x_1^N(p = 2/3) \quad \text{and} \quad x_1^B(p = 1/3) < x_1^B(p = 2/3).$$

[13] We implement $\delta = 0.95$ in our experiment.

[14] To be concrete, for any $\delta > 0.9105$ and any $p < \bar{p} := \frac{1+3\delta-\delta^2+\sqrt{\delta^4-2\delta^3-13\delta^2+38\delta-23}}{2\delta(3-\delta)}$, q_{23}^B is non-decreasing in p. For instance, for $\delta = 0.95$, the weak monotonicity holds for any $p < \bar{p} \approx 0.9322$. As δ closes to 1, however, $\bar{p}$ converges to one and it holds for any $p \in (0, 1)$.

Table 2: Deer Hunting Game

Game	Round	Format
Game I	1-3	2 person bargaining
Game II	4-6	3 person bargaining
Game III	7-9	2 person bargaining

H3. Allowing buyout reduces inequality, that is, for $p \in \{1/3, 2/3\}$,

$$x_1^N > x_1^B.$$

3 Experimental Design

We conducted our experimental sessions at the laboratory managed by the Center for Research in Experimental and Theoretical Economics (CREATE) at Yonsei University in Korea in May 2019, and one of the authors conducted all sessions. Our experiment was computerized using oTree (Chen et al., 2016). We recruited 144 undergraduate students from our subject pool, and each subject participated in one treatment (between-subject design).

Our subjects played the Deer Hunting Game with each other for nine rounds as in Table 2. We first explain *Game II*, which is our main part, and then discuss the roles of *Game I* and *III* in our experiment.

In each round of Game II, we implemented three-person multilateral bargaining games by randomly forming groups of three members.[15] In each group, one member was endowed with one *bow* and each of the others with one *arrow*. Each member was endowed with 600 coins in his/her virtual account, and the member who was successful in hunting the deer obtained additional 600 coins. To hunt the deer and obtain additional 600 coins, a subject needed at least one bow and one arrow. As no member was endowed with sufficient items for deer hunting, subjects must trade

[15]Thus, participants were randomly re-matched in every round for Games I, II, and III.

Table 3: Experimental Design

	Buyout Allowed	Buyout Not Allowed
$p = 1/3$	BL	NL
$p = 2/3$	BH	NH

Note: There are 36 subjects and 3 sessions in each treatment. Whether buyout is allowed or not matters only in Game II.

items with each other using their coins. Moreover, we can see that the member with one bow is the veto player and others are the non-veto players because the veto player can hunt the deer by buying an arrow from either non-veto players, whereas non-veto players cannot hunt the deer without the bow from the veto player.

More precisely, each round proceeded as follows. Each member submitted his/her offer on the computer terminal. Here, the offer refers to the amount of coins that a member offered to another member in exchange for the items. Thus, in our experiment, a buyout offer is an offer of a member with one arrow to another member with one arrow. After all members submitted their offers, one member's offer was randomly selected by the server computer such that the offer of the member with one bow was selected with probability p and the offer of the member with one arrow with probability $(1 - p)/2$. The selected offer was shown to the offeree, who then decided whether to accept or reject the offer. If the offeree accepted, the offeree obtained the promised coins from the offeror, and the offeror obtained all items of the offeree. If the offeror collected sufficient items for deer hunting, he/she obtained additional 600 coins, and the round ended. Otherwise, the bargaining continued with probability 95% and was terminated with the complementary probability. This continuation probability corresponds to the discount factor equal to 0.95 in theory.

We implemented 2×2 design in our experiment as in Table 3. The first dimension is whether non-veto players are allowed to make buyout offers (B vs. N). The second dimension is the veto player's recognition probability p, which is either 1/3 or 2/3 (L vs. H). Thus, if $p = 1/3$, all three members are equally likely to be recognized, and if

$p = 2/3$, the veto player is recognized with probability 2/3 and each non-veto player with probability 1/6. Thus, we implemented four treatments in our experiment, i.e., BL, BH, NL, and NH, with 36 subjects in each treatment. By comparing B-treatment and N-treatment, we can find the effect of whether non-veto players are allowed to make buyout offers. We can also study the effect of recognition probability by comparing L-treatment and H-treatment.

We now discuss the roles of Game I and III. The only difference from Game II is that Game I and III are two-person bargaining games. To be specific, in each round, groups of two members were randomly formed, and one member was endowed with one bow and the other with two arrows. As in Game II, the bow is associated with probability p for recognition and one arrow with probability $(1-p)/2$ for recognition. Because deer hunting requires both types of items, this is a typical bargaining experiment between two individuals with recognition probabilities of p and $1-p$ for the bow player and the arrow player, respectively. Other than this difference, Game I and III were conducted in exactly the same way as Game II.

We implemented Game I before the main game, Game II, for two reasons. First, the main game was conceivably difficult, so we wanted to provide some experience of bargaining to our subjects in a simpler environment. Second, and more importantly, we wanted to enhance our subjects' subgame perfection reasoning in Game II by having them experience Game I because Game I is identical to the subgame of Game II after a buyout occurred between non-veto players. As our experimental goal is to test theoretical predictions from the unique stationary subgame-perfect equilibrium, which requires a high degree of sequential rationality, it is conceivable that subjects do not play the equilibrium in our experiment because of failure to utilize sequential rationality reasoning. Thus, by implementing Game I before Game II, we wanted to minimize this possibility in our experiment to focus on other factors that could influence our subjects' behaviors.

Finally, Game III is identical to Game I. In Games I and III, we expect that subjects with a bow will obtain lower (higher) payoffs than subjects with two arrows

Table 4: Proportion of Buyout Offers

	First offer		All offers	
	BL	BH	BL	BH
Theory	0.358	1	0.358	1
Experiment	0.167	0.181	0.169	0.146

in BL and NL (in BH and NH) because the former subjects have a lower (higher) recognition probability.

After Game III ended, one round out of nine rounds was randomly chosen by the server computer, and each coin in a subject's account was converted to KRW 15 and given to him/her in cash. A session lasted about 70 minutes, and the average payment was around KRW 15,500 (around USD 13) including the show-up payment.

4 Experimental Results

To test our first hypothesis, we collected data on the frequency of buyout decisions in Game II (i.e., Rounds 4-6). The first two columns in Table 4 show the proportions of buyout offers made by non-veto players in their first decisions. Pooling all three rounds in BL, 16.7% of non-veto players began their negotiations with buyout offers; p-value for the difference between theory and data is 0.21.[16] The corresponding percentage in BH is about 18.1%; p-value for the difference between theory and data is 0.014. The last two columns in Table 4 show the corresponding numbers based on all offers made by non-veto players; corresponding p-values are 0.176 and 0.013, respectively. The data show that non-veto players utilize buyout opportunities, but they make buyout offers far less often than theoretical predictions, particularly so in BH. Moreover, there is no difference in the buyout rates between BL and BH; p-values are 0.918 and 0.856 for first offers and all offers, respectively, which contrast

[16]We present p-values from the results of OLS regressions with standard errors clustered at session levels.

Table 5: Average Offer Amounts

Player type	Offer type	BL	BH	NL	NH
Veto	-	215	196	226	166
Non-veto	Buyout	178	205	-	-
Nov-veto	Non-buyout	281	311	282	249

Note: The average offer amount is given by player type and offer type.

with our hypothesis.

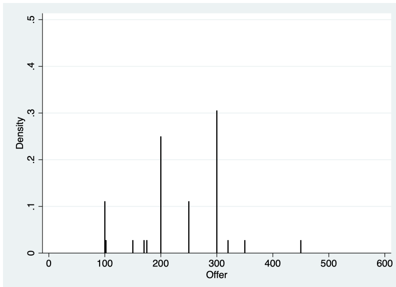
Result 1. *The frequencies of a buyout in BL and BH are higher than 0 but lower than the theoretical predictions. Pooling the data, there is no statistical difference between the frequencies of a buyout in BL and BH.*

Table 5 shows the average offer amounts by types of offers. In response to the higher recognition probability of the veto player in BH than in BL, non-veto players increase their offer amounts–both buyout and non-buyout offer amounts–whereas veto players reduce their offer amounts. When comparing NL and NH, both veto and non-veto players reduce their offers to each other when the veto player's recognition probability increases.

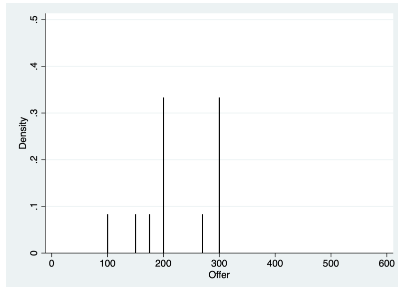
Figure 1 shows histograms for offer amounts in each treatment. Although there was no restriction in players' choices, we found a few spikes in the graphs with 300-coins and 200-coins offers standing out in the figure. In particular, the 300-coins offer, or the equal-split offer, was the most frequently chosen offer in non-veto players' choices, which suggests that players had a strong sense of equality when making offers. Thus we expect that offers less than 300 coins were more likely to be rejected in bargaining, which we verify in the next table.

Table 6 shows the relative frequencies with which a player accepts an offer from a proposer. In each cell, the first (resp., the second) percentage is the relative frequency of accepting an offer less than (resp., more than or equal to) 300 coins, and the following number inside the parentheses is the total instances of such offers. The first row titled "Veto" shows the relative frequencies of veto players accepting offers

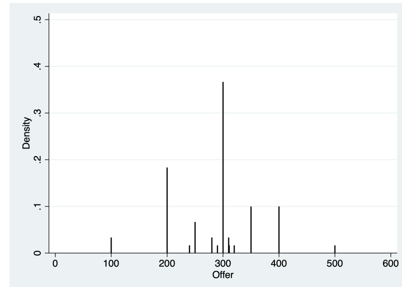
Figure 1: Histograms of Offer Amounts



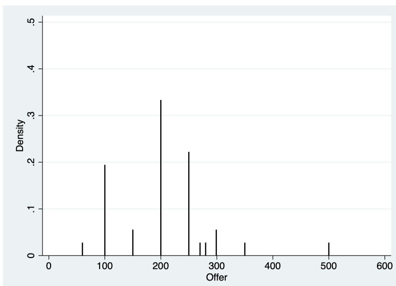
Veto in BL



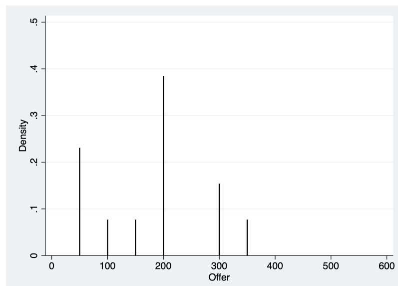
BO in BL



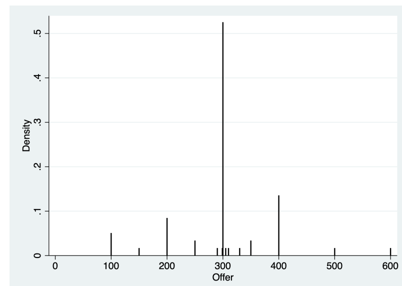
NonBO in BL



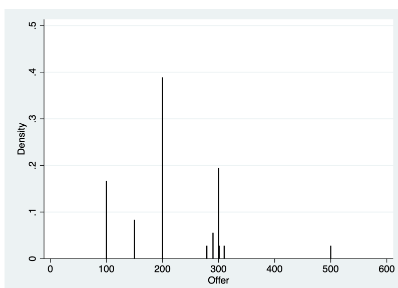
Veto in BH



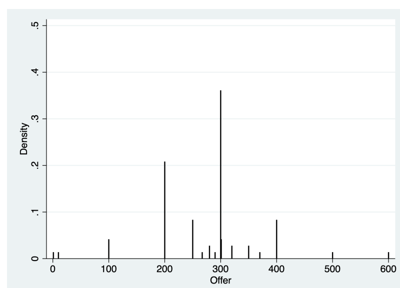
BO in BH



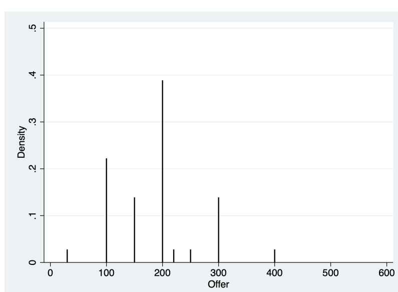
NonBO in BH



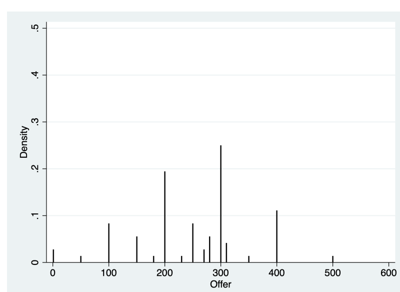
Veto in NL



NonBO in NL



Veto in NH



NonBO in NH

Note: The data for first offers in Rounds 4-6 are used to generate the figures. “Veto” denotes the veto players’ offers. “BO” denotes the non-veto players’ buyout offers. “NonBO” denotes the non-veto players’ non-buyout offers.

Table 6: Relative Frequencies of Accepting Offers

Amount	< 300	≥ 300	< 300	≥ 300	< 300	≥ 300	<300	≥ 300
Type	BL		BH		NL		NH	
Veto	29%(7)	90%(10)	100%(2)	40%(5)	43%(14)	85%(13)	38%(8)	50%(4)
BO	40%(5)	100%(1)	none		-		-	
NonBO	29%(7)	83%(6)	56%(27)	100%(2)	75%(8)	100%(1)	53%(19)	100%(5)

Note: In each cell, the first (resp., the second) percentage refers to the relative frequency of accepting a first offer less than (resp., more than or equal to) 300 coins, and the following number inside the parentheses is the total instances of such offers. In BH-treatment, although non-veto players made buyout offers, they were not chosen by the server computer, which leads to no observations on accepting buyout offers. The first row titled "Veto" shows the relative frequencies of veto players accepting offers, the second row titled "BO" shows the relative frequencies of non-veto players accepting buyout offers, and the third row titled "NonBO" shows the relative frequencies of non-veto players accepting offers from veto players.

from non-veto players, the second row titled "BO" shows the relative frequencies of non-veto players accepting buyout offers, and the third row titled "NonBO" shows the relative frequencies of non-veto players accepting offers from veto players. The data show that the 300-coins threshold matters for accept decisions: an offer higher than 300 coins is substantially more likely to be accepted than an offer lower than the threshold.

More formally, Table 7 shows regression results with BL as a base category.[17] The dependent variable in columns (1)-(2) is the indicator variable with value 1 if non-veto players made a buyout offer in their first decisions in a round. Two important variables in our experiment are included in the regression: *BH* is a dummy variable indicating the BH treatment, and *Round* is the variable indicating the round of play (i.e., Round is 4, 5, or 6). The results show that both variables have no effect on a non-veto player's first decision. In column (2), we find some effects of individual characteristics: an old, female non-veto subject is less likely to make a buyout offer

[17] We clustered standard errors at session levels. For robustness check, we also ran our regression with standard errors clustered at individual levels in Table 11 (which can be found in Appendix) and obtained similar results.

Table 7: Regression Results for Buyout Offers

Buyout	(1)	(2)	(3)	(4)
	First offer		All offers	
BH	0.014	−0.010	−0.127	−0.120
	(0.129)	(0.102)	(0.129)	(0.110)
Round	−0.021	−0.017	−0.105***	−0.087***
	(0.027)	(0.023)	(0.023)	(0.015)
Age		−0.028**		−0.032*
		(0.010)		(0.015)
Female		−0.154**		−0.067**
		(0.052)		(0.020)
Economics		−0.117		−0.217**
		(0.068)		(0.068)
Atheist		−0.081*		0.126
		(0.035)		(0.106)
Constant	0.271	1.071**	0.808**	1.436***
	(0.140)	(0.308)	(0.316)	(0.465)
R^2	0.002	0.088	0.070	0.130
N	144	144	313	313

Note: *: $p < 0.1$; **: $p < 0.05$; ***: $p < 0.01$. Standard errors are clustered at session levels.

in the first decision.

In columns (3)-(4), we use the entire decisions of non-veto subjects. *BH* still has no effect in our regression result. The coefficients on *Round* show that a non-veto player is less likely to make a buyout offer in a later round. The coefficients are quite stable regardless of the inclusion of control variables. Considering that the coefficients on *Round* are consistently negative across columns (1)-(4), it seems that learning has a negative effect on a non-veto player's buyout decisions. Column (4) shows that a non-veto subject's age reduces the buyout rates; the Female dummy still has a negative coefficient; and a non-veto subject whose major is Economics is less likely to make a buyout offer.

Table 8 shows the proportion of immediate minimum winning coalition (MWC) between the veto player and one of the non-veto players. In BL, the theoretical pro-

Table 8: Proportion of Immediate Minimum Winning Coalition in Game II

	BL	BH	NL	NH
Theory	0.778	0.667	1	1
Experiment	0.528	0.528	0.667	0.556

portion is equal to

$$\underbrace{\frac{1}{3}}_{(A)} + \underbrace{\frac{2}{3} \times 0.667}_{(B)} = 0.778$$

where (A) is the probability that the veto player is recognized (in which case an immediate MWC is formed in equilibrium) and (B) is the probability that a non-veto player is recognized and makes a non-buyout offer. In BH, the proportion is equal to the recognition probability, $p = 2/3 (\approx 0.667)$, because an immediate MWC is formed only when the veto player is recognized. As buyout offers are not possible in the N-treatment, the theoretical proportion is equal to 1. As predicted by theory, we found that an immediate MWC was more likely to arise in N-treatment than in B-treatment, where the average proportions were 0.611 and 0.528, respectively, although this difference was not statistically significant when standard errors were clustered at session levels. In contrast to the theoretical predictions, the data show that there was no difference in the proportion between BL and BH, and an immediate MWC was formed less often than predicted by theory in the N-treatment.

To test our second and third hypotheses, we analyze the data of veto players' average surplus in Game II. To exclude the possibility that subjects obtain lower payoffs due to random termination, we look at only successful bargaining cases.

Table 9 shows that the average surplus of veto players increases in the veto player's recognition probability as predicted by theory, although the veto player's share is lower than the theoretical predictions. In particular, in N-treatment, the average surplus is only 52% in NL and 61% in NH, whereas theory predicts 80% and 90%, respectively, for $\delta = 0.95$. In B-treatment, the average surplus is only 51% in BL

Table 9: Average Surplus of Veto Players in Game II

	BL	BH	NL	NH
Theory	0.56	0.80	0.80	0.90
Experiment	0.51	0.60	0.52	0.61
MWC	0.52	0.60	0.50	0.59

Note: We calculated average surplus for the cases in which an agreement is reached.

and 60% in BH, whereas theory predicts 56% and 80%, respectively. The average surplus of veto players is significantly different across the recognition probability dimension: p-value is 0.027 for BL and BH and 0.021 for NL and NH. In the last row, we report the average surplus of veto players when an immediate MWC was formed and find similar results.

Result 2. *Reducing the veto player's recognition probability reduces inequality.*

However, in contrast to our third hypothesis, the veto player's share is remarkably similar and does not vary with respect to the buyout dimension: p-value is 0.240 for BL and NL and 0.988 for BH and NH. Thus, our experimental data suggest that an important factor behind inequality between veto and non-veto players is not the ability to make buyout offers but the recognition probability.

Result 3. *Allowing buyout does not influence inequality.*

Finally, we report our experimental data for Game I and III (i.e., Rounds 1-3 and 7-9) to see how subjects played bilateral bargaining games[18] where one player has a bow and the other player has two arrows. Note that both players are symmetric in this situation because both of them need the other player's item to win. Table 10 shows the average surplus of veto (bow) players and non-veto (arrow) players, respectively. As there is no difference between B-treatment and N-treatment in bilateral bargaining, we expect veto players obtain the same amount of surplus in BL

[18]We pooled the data for Game I and III for analysis after verifying no difference between the data from the two games.

Table 10: Average Surplus in Game I/III

	BL	BH	NL	NH	All
Veto (bow)	0.47	0.53	0.50	0.53	0.51
Non-veto (arrow)	0.53	0.47	0.50	0.47	0.49

Note: We calculated average surplus for the cases in which an agreement is reached.

and NL, and in BH and NH, respectively, which can be confirmed in the table; p-values are 0.284 for BL vs. NL, and 0.989 for BH vs. NH. The table also shows that veto players obtain a higher surplus when their recognition probability is high, which is also intuitive; p-values are 0.042 for BL vs. BH, and 0.191 for NL vs. NH.

We also expect that veto players will obtain lower (resp., higher) payoffs than non-veto players in L-treatment (resp., H-treatment) because the former players have a lower (resp., higher) recognition probability. When we pool the data for BL and NL, veto players obtained a lower surplus on average as their recognition probability is lower than their counterparts although the difference is not statistically significant; p-value is 0.323. When we pool the data for BH and NH, a higher average surplus accrues to veto players; p-value is 0.034.

The last column in Table 10 shows average surplus of players when data from all treatments are pooled. Because veto and non-veto players are symmetric in Games I and III, we expect them to obtain the same amount of surplus on average. This can be confirmed by an OLS regression; p-value is 0.321. This suggests that framing effects are weak in our experiment; that is, although a bow can remind players of veto power from Game II, they are not influenced by the experience.

5 Discussion

We implemented a veto game experiment to test whether allowing non-veto players to form an intermediate coalition affects on surplus distribution between veto and non-veto players. From the standard model in the literature based on the random-proposer bargaining by Baron & Ferejohn (1989), we derived a set of theoretical predictions. First, the proportion of coalition formation among non-veto players increases as their negotiation power against the veto player diminishes. Second, non-veto players obtain a higher share of surplus when they are allowed to form an intermediate coalition. Lastly, the model predicts that the larger negotiation power of the veto player reduces the non-veto players' shares of surplus.

Our experimental findings offer a stark contrast to the theoretical predictions obtained from the standard model in the literature:

1. Although the proportion of coalition formation among non-veto players is positive throughout sessions, the proportion is much lower than predicted by theory.

2. The proportion is not correlated with power distribution between the veto and non-veto players.

3. More importantly, allowing non-veto players to form a coalition does not affect their shares of surplus.

As such, our experiments do not confirm the prevailing hypothesis that the possibility of strategic alliances between non-veto players yields an egalitarian tendency in allocation. For the remaining section, identifying limitations of our experimental study, we offer possible explanations for the behavioral patterns and explore directions for future research.

5.1 Possible Explanations

First, the efficiency loss caused by random termination could alter the payoff distribution. In our experiment, the bargaining could terminate with a probability of 0.05 regardless of whether a buyout occurred or not, which implements the discount factor of 0.95 in our theoretical model. Thus, even when non-veto players successfully cooperate to form an intermediate coalition, the bargaining could end without the surplus being realized, thereby discouraging non-veto players from utilizing buyout strategies. This loss of efficiency in buyout could explain why non-veto players were reluctant to utilize buyout options in our experiment. However, we could not verify this effect in our experimental data.

Moreover, if non-veto players are risk averse, it could further reduce their willingness to utilize buyout options because they would be afraid of random termination even after spending resources for buyout. Although we did not explicitly measure our participants' risk aversion, we could use their demographic information as a proxy for their risk aversion. In our experimental data, two variables, i.e, *Age* and *Female*, could serve these roles because these variables are known to be positively correlated with risk aversion (e.g., see Falk et al. 2018).[19] For future research, to test whether these factors could explain the behavioral patterns of intermediate coalition formation, it would be useful to implement an experiment in which loss of efficiency and risk aversion are minimized. For instance, to reduce efficiency loss, one could implement additional treatments in which the game is terminated only when offers are rejected.

Another possibility is that social preferences (Bolton & Ockenfels, 2000; Fehr & Schmidt, 1999) could have played a role. Our data showed that veto players make quite generous offers to non-veto players. Then non-veto players have lower incentives to make buyout offers because veto players' generous offers reduce the value of intermediate coalition formation. Therefore, incorporating social preferences such as inequity aversion to bargaining models with intermediate coalition formation could enhance their predictive power.

It is worth mentioning that the inequity aversion of players could increase inequality among non-veto players. If a coalition is formed among non-veto players, all non-veto players end up with a positive amount of surplus each, either through upfront transfers or through direct bargaining with the veto player. In contrast, if

[19] In Table 7, these two variables have negative coefficients which are statistically significant, thereby suggesting that risk aversion could have discouraged the use of buyout in our experiment.

strategic alliance of non-veto players is never formed because of inequity aversion, the non-veto player excluded obtains zero surplus, which exacerbates inequality between non-veto players considering a substantial amount of surplus going to the other non-veto player due to generosity of the veto player.[20]

5.2 Extensions and Future Research

In our current study, we learned that intermediate coalition formation is not effective in changing the bargaining outcomes in contrast to the predictions of the standard model in the literature. An important limitation of our study is that our experiment does not provide a way to modify the model to organize the data, although we provided a few possible explanations above. For future research, one could cleverly introduce an experimental design testing each component of the standard model in explaining the effect of intermediate coalition formation.

Although we suggested efficiency loss, risk aversion, and social preferences as possible explanations for the behavioral patterns from our lab experiment, it is not clear how much these factors matter in complex economic and political institutions in reality; that is, external validity could be an issue. For example, when we consider a multilateral bargaining situation among political parties, risk aversion and social preferences might not be critical factors in explaining their behaviors. Moreover, another related issue in this regard is that multilateral bargaining often concerns interactions among groups instead of individuals as in our experiment.[21] It would be an interesting avenue for future research to investigate whether our experimental findings could survive in group-bargaining contexts.

In our experiment, we implemented a private offer design: that is, only the offeror and the offeree could observe the offer amount. If participants use offers as a

[20] Analyzing a model without buyout options, Montero (2007) also shows that inequity aversion may increase inequity.

[21] Considering a political-parties example just mentioned, a one-person party's (e.g., Independent such as Ross Perot) behavior would be quite different from a many-persons party's (e.g., Democratic party) because of strategic interactions among members inside the group.

communication device (Murnighan & Roth, 1977; Agranov & Tergiman, 2014), the bargaining outcomes could depend on whether the amount of offer is publicly revealed to all members. In particular, it could be interesting to investigate whether publicity of offers has an effect on the proportion of coalition formation among non-veto players.

Following Baron & Ferejohn (1989), our findings depend on the assumption that the amount of surplus is fixed. It is not clear whether our experimental findings would survive if the size of the surplus is endogenous instead (Baranski, 2016, 2019). On the one hand, taking the surplus created as given, participants may behave in the same way as in the fixed surplus case. On the other hand, their behaviors in the surplus creation stage could enhance the perception of social preferences such as reciprocity, thereby influencing coalition formation choices and, consequently, negotiation behaviors between veto and non-veto players. We leave these topics for future research.

6 Declarations

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Conflicts of interest

The authors have no conflicts of interest to declare that are relevant to the content of this article.

Availability of data

The authors will provide their experimental data to reviewers if necessary.

Code availability

The authors will provide their STATA code to reviewers if necessary.

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A Appendix

A.1 Experimental Instruction

(This is the experimental instruction for BL treatment.)

Thank you for participating in the experiment. Please read the following instruction carefully.

Your decisions will be anonymously collected and used only for research. No one will know what your decisions are in the experiment.

You will obtain KRW $3,000$ as a show-up fee. In addition to this show-up fee, you can earn additional cash depending on your decisions in the experiment. Thus, at the end of the experiment, you will obtain at least KRW $3,000$.

You will play the Deer Hunting Game with others in this room several times. In each time you play the Game:

- you are randomly grouped with others in this room (members do not know each other)
- 1 bow and 2 arrows are randomly distributed among group members
- everyone in your group is given 600 coins
- additional 600 coins are given to the person who hunts the deer
- the Game ends when someone in your group hunts the deer
- when no one is successful in hunting, the deer may disappear, in which case the Game ends

In order to hunt the deer, you need items:

- you are unable to hunt the deer if you have 1 bow
- you are unable to hunt the deer if you have 1 arrow

- you are unable to hunt the deer if you have 2 arrows
- you will be successful in hunting the deer if you have 1 bow and 1 arrow
- you will be successful in hunting the deer if you have 1 bow and 2 arrows

You can trade items with others by using coins. When the Game begins, you write a proposal indicating your offer of coins for one group member's items. For example, you can make an offer to group member A by offering X coins for member A's items.

After every member writes a proposal, one proposal will be selected by the server computer. The likelihood of your proposal to be selected depends on your items: 1 bow = 1/3 and 1 arrow = 1/3 and 2 arrows = 2/3. That is, for instance, if you have 1 bow, the chances that your proposal will be selected are 1 out of 3.

If a proposal is selected and presented to the group member whom the proposer is willing to trade with, the group member decides whether to accept the proposal. The other group member cannot observe how many coins the proposer offered. If the group member accepts, he/she gives all his/her items to the proposer and obtains coins from the proposer. If the group member rejects, no trade occurs.

For example, suppose the proposal is that the proposer is willing to obtain member A's items at X coins. In this case, member B cannot observe the value of X. If member A accepts the offer, the proposer obtains member A's items by giving X coins to member A. If member A rejects the offer, no trade occurs.

After trades end, the server computer verifies whether the proposer collected enough items for hunting. If the proposer collected enough items for hunting, he/she is successful in hunting the deer, earning 600 coins, and the Game ends. If the proposer could not collect enough items for hunting, the above process is repeated until someone is successful in hunting the deer (but only those who have items may write a proposal). But be aware: the deer may disappear when no one is successful in hunting, where the chances are 5 out of 100 (i.e., 5%), in which situation the Game ends without hunting (and therefore no additional 600 coins).

For example, after trades, suppose member A has 1 bow, and member B has 2 arrows (the other member has no item). Therefore, no one is successful in hunting the deer.

- If the deer remains (95 out of 100): the Game continues with members A and B writing new proposals (the other member does not write a proposal because he/she has no item).
- If the deer disappears (5 out of 100): the Game ends.

You will play the Game in the following sequence. Each game will be played three times (nine times in total).

- Game I: In Game I, you will be grouped with one person in this room and play the Game in a two-member group. One member will begin the Game with 1 bow and the other with 2 arrows.
- Game II: In Game II, you will be grouped with two persons in this room and play the Game in a three-member group. One member will begin the Game with 1 bow and others with 1 arrow each.
- Game III: In Game III, the situation is exactly the same as in Game I.

After Game III ends, the experiment ends. From the nine rounds in the experiment, one round will be chosen randomly, and the total amount of your coins in that round will be converted to KRW 15 each and given to you in cash. Please do not talk with others nor use your phones. Please take your time when making your decisions in the experiment; you do not have to hurry.

If you have any questions, please raise your hand. Please wait for further instruction.

A.2 Robustness Checks

Table 11: Regression Results for Buyout Offers

	(1)	(2)	(3)	(4)
Buyout	First offer		All offers	
BH	0.014	−0.010	−0.127	−0.120
	(0.072)	(0.071)	(0.093)	(0.089)
Round	−0.021	−0.017	−0.105*	−0.087*
	(0.034)	(0.034)	(0.053)	(0.045)
Age		−0.028**		−0.032**
		(0.012)		(0.014)
Female		−0.154**		−0.067
		(0.070)		(0.082)
Economics		−0.117		−0.217***
		(0.081)		(0.080)
Atheist		−0.081		0.126
		(0.082)		(0.100)
Constant	0.271	1.071***	0.808**	1.436***
	(0.181)	(0.373)	(0.316)	(0.465)
R^2	0.002	0.088	0.070	0.130
N	144	144	313	313

Note: *: $p < 0.1$; **: $p < 0.05$; ***: $p < 0.01$. This is a replication of Table 7 with standard errors clustered at subject levels.