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. We report two main experimental findings in this paper. First, the frequency 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. This finding contrasts 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. Alternatively, we discuss *inequity aversion* as a possible explanation to

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support the prevalence of non-core allocations in our data.

Keywords: coalition bargaining; veto game; buyout; strategic coalition formation; veto player; experiment.

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1 Introduction

Besides the prevalence of veto players[1] in economic, political, and managerial institutions[2], collective decision-making problems with veto players have been extensively studied in the frame of game theory since von Neumann and Morgenstern (1944) analyzed a game with one seller and multiple prospective buyers. In veto games[3], the central question is on the distribution of power among the players and the allocation of the surplus. In any core allocation, for instance, veto players extract all the surplus.[4] However, well-known cooperative power indices, such as Shapley and Shubik (1954), Banzhaf (1964), Deegan and Packel (1978), and Johnston (1978), assign a substantial value to non-veto players.[5] Furthermore, since Maschler (1965), experimental results have consistently observed non-core allocations.

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

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

[2] 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.

[3] In this paper, we focus on simple games: See von Neumann and Morgenstern (1944) and Shapley (1962) for details. 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. The notion of veto game can be extended to characteristic function form games (Bahel, 2016): a characteristic function form game (N,v) is a *veto game* if $v(S) \le v(S')$ for any $S \subseteq S' \subseteq N$ and there exists T such that $v(S) = 0$ for any $S \subseteq N \setminus T$.

[4] In particular, when the game has a single veto player, the core allocation is unique and coincides with many other cooperative solution concepts, such as the bargaining set (Kahan and Rapoport, 1974) and the coalitional Nash bargaining solution (Compte and Jehiel, 2010). The core allocation also has a clear strategic foundation, as it is selected by an equilibrium in many non-cooperative bargaining models (Selten, 1981; Baron and Ferejohn, 1989; Chatterjee et al., 1993; Okada, 1996; Winter, 1996) when the bargaining friction is "negligible" or the environment is "competitive."

[5] To be specific, in a three-player veto game with a set of players $N = \{1,2,3\}$ and a set of winning coalitions $\mathbf{W} = \{\{1,2\},\{1,3\},N\}$, the unique core allocation is $(1,0,0)$; while the Shapley-Shubik index $(2/3,1/6,1/6)$, the Banzhaf index $(1/3,1/5,1/5)$, the Johnston index $(8/14,3/14,3/14)$, and the Deegan-Packel index $(1/2,1/4,1/4)$ assign a strictly positive value to non-veto players.

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 and Roth (1980) also point that the non-veto players have an option to "attempt to form a coalition with the veto players."[6]

In experiments, both Maschler (1965) and Murnighan and Roth (1977) find that the results are significantly different from the core allocation, observing the occasional occurrence of intermediate coalitions between non-veto players.[7] However, the role of intermediate coalition formation has not been rigorously tested in the literature.[8] 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 non-core allocations.

In Section 2, we provide theoretical predictions based on the model developed by Lee (2018).[9] The model is suitable to study the interactions among multiple players and the

[6]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 and 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.

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

[8]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 and Roth (1977) focused on the effects of communication and information availability, and Murnighan and Roth (1980) concerned the numbers of non-veto players, rather than the role of intermediate coalition formation.

[9]We follow non-cooperative legislative bargaining models in which a proposer is randomly selected in each period. In earlier models, such as Baron and 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 coalition 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 and Winter (1998); Okada (2000); Gomes (2005); Gomes and 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

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" offers) to the other non-veto player by offering upfront transfers, and a coalition is formed if the proposal is accepted. We derive two main theoretical predictions from this model. 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 essential item for hunting the deer whereas two non-veto players possess a non-essential 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 shows two main experimental findings. First, non-veto players did utilize the opportunity to form a coalition when they were allowed, but not as often as predicted by theory. Moreover, in contrast to the first hypothesis provided by theory, the frequencies of coalition formation were not correlated with players' negotiation power. Second, in contrast to the second 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

options, which provide theoretical prediction related to the role of intermediate coalition formation.

as an important factor behind the prevalence of non-core allocations in veto games.

As such, we provide an alternative explanation for our experimental findings in Section 5. In particular, we argue that inequity aversion has a potential to organize our data. Extending the standard model to incorporate inequity-averse players, we find that it is possible to sustain an equilibrium with no coalition. If an inequity-averse veto player is averse to advantageous inequality (i.e., utility loss from having more than others), he/she is willing to cede a considerable portion of the surplus to non-veto players. In turn, this generous offer renders the power to form a coalition less valuable for non-veto players. Therefore, it is possible in equilibrium for a non-veto player to negotiate directly with the veto player without exercising the option to form a coalition.

In the literature on veto game experiments, researchers have studied various factors influencing bargaining outcomes, including information availability (Murnighan and Roth, 1977), group size (Murnighan and Roth, 1980; Montero et al., 2008; Drouvelis et al., 2010), and voting rule (Bouton et al., 2017; Agranov and Tergiman, 2019).[10] But we are not aware of an experiment that explicitly tests the effect of the ability of non-veto players to form a coalition.[11]

Our paper is also related to the experimental works showing that non-core allocations, such as bargaining sets (Medlin, 1976; Rapoport and Kahan, 1976) and the Shapley value (Murnighan and 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 bargaining experiments based on Baron and Ferejohn (1989): open and closed amendment rules

[10] 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 and Tergiman (2019) considered committee decision making with unanimity rule to study the effects of communication.

[11] 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.

(Fréchette et al., 2003), public good provision (Fréchette et al., 2012), pre-play communication among players (Agranov and Tergiman, 2014), endogenous production of surplus (Baranski, 2016, 2019), proposer selection contest (Kim and Kim, 2017; Hahn et al., 2020), and legislative bargaining of cuts versus increases in government spending (Christiansen and 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 two main theoretical predictions. Section 3 explains our experimental setting and Section 4 shows our main experimental findings. Section 5 discusses a possible explanation for our experimental data based on an extension of the standard model by incorporating inequity-averse players. Section 6 concludes our paper. The experimental instruction can be found in Appendix A.1 and the extended model with inequity-averse players 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 $m \in [0, 1]$. Given $s_i = (j, m)$, denote $j(s_i) = j$ 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 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,

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

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

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

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

- $x = \left(\frac{(2-\delta)\delta p}{2-(2-p)\delta}, \frac{(1-p)(1-\delta)\delta p}{2-(2-p)\delta}, \frac{(1-p)(1-\delta)\delta p}{2-(2-p)\delta} \right)$; 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

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	0.559	0.798	0.556	0.833
	$x_2^B = x_3^B$	0.192	0.073	0.222	0.083
	q_{23}^B	0.358	1	0.500	1

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

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 *Stationarity* with buyout

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

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., $q_{23} > 0$. Table 1 summarizes the equilibrium 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 $\delta \to 1$.[12] 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:

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

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

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}), that is,

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

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

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

H3. Allowing buyout improves 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. 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 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

Table 3: Experimental Design

	Buyout Allowed	Buyout Not Allowed
$p = 1/3$	BL ($N = 36$)	NL ($N = 36$)
$p = 2/3$	BH ($N = 36$)	NH ($N = 36$)

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 deer hunting requires both types of items, this is a typical bargaining experiment between two individuals. 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 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, we wanted to minimize this possibility in our experiment to focus on other factors that could influence our subjects' behaviors.

Finally, Game III can be thought of as a continuation game after a buyout occurred in Game II. In Game III, we expect that subjects with a bow will obtain lower (higher) payoffs

Table 4: Frequency 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

than subjects with two arrows 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 percentages of buyout offers made by non-veto players in their first decisions. Pooling all three rounds in BL, 16.67% of non-veto players began their negotiations with buyout offers. The corresponding percentage in BH is about 18%. The last two columns in Table 4 show the corresponding numbers based on all offers made by non-veto players. The data clearly show that non-veto players utilize buyout opportunities, but they make buyout offers far less often than theoretical predictions. Moreover, there is no difference in the buyout rates between BL and BH, which contrasts 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.*

More formally, Table 5 shows regression results with BL as a base category. The dependent variable in columns (1)-(2) is the indicator variable with value 1 if non-veto players

Table 5: Regression Table for Buyout Offers

	(1)	(2)	(3)	(4)
Buyout	First offers		All offers	
BH	0.014	−0.010	−0.096	−0.086
	(0.072)	(0.071)	(0.084)	(0.082)
Round	−0.021	−0.017	−0.074**	−0.061*
	(0.034)	(0.034)	(0.036)	(0.035)
Delay			0.041***	0.038***
			(0.010)	(0.009)
Age		−0.028**		−0.024*
		(0.012)		(0.013)
Female		−0.154**		−0.112
		(0.070)		(0.076)
Economics		−0.117		−0.181**
		(0.081)		(0.075)
Atheist		−0.081		0.103
		(0.082)		(0.092)
Constant	0.271	1.071***	0.533**	1.057***
	(0.181)	(0.373)	(0.204)	(0.372)
R^2	0.002	0.088	0.140	0.183
N	144	144	313	313

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

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 in the first decision.

In columns (3)-(4), we use the entire decisions of non-veto subjects. In addition to variables *BH* and *Round*, we also include another indicator variable, *Delay*, capturing the number of negotiation failures: for example, Delay is 4 if the subject's offer is the fourth offer in a given round.

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

Table 6: Frequency of Immediate Minimum Winning Coalition

	BL	BH	NL	NH
Theory	0.642	0	1	1
Experiment	0.528	0.528	0.667	0.556

stable regardless of the inclusion of control variables, although the statistical significance slightly falls with controls. 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.

Columns (3)-(4) show that delay increases the buyout rates, and these effects are highly significant and robust to controls. Column (4) shows that a non-veto subject's age reduces the buyout rates; the Female dummy still has a negative coefficient but is not significant; and a non-veto subject whose major is Economics is less likely to make a buyout offer.

Table 6 shows the frequency of immediate agreement between the veto player and one of the non-veto players. In the B-treatment, the theoretical frequency equals the rate of non-buyout offers from non-veto players: 0.642 in BL and 0 in BH. As buyout offers are not possible in the N-treatment, the theoretical frequency is equal to 1. In contrast to the theoretical predictions, the data show that (i) there was no difference in the frequency between BL and BH, (ii) an immediate minimum winning coalition (MWC) was formed less often than predicted by theory in the N-treatment, and (iii) an immediate MWC was more likely to arise in the N-treatment than in the B-treatment, where the average frequencies were 0.611 and 0.528, respectively, and this difference was statistically significant (t-test p-value 0.08).

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 7 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 the case of N-treatments, the average surplus is only

Table 7: 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

52% in NL and 61% in NH, whereas theory predicts 80% and 90%, respectively, for $\delta = 0.95$. In B-treatments, the average surplus is only 51% in BL 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 in t-tests: p-value is 0.008 for BL and BH and 0.0117 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 improves inequality.*

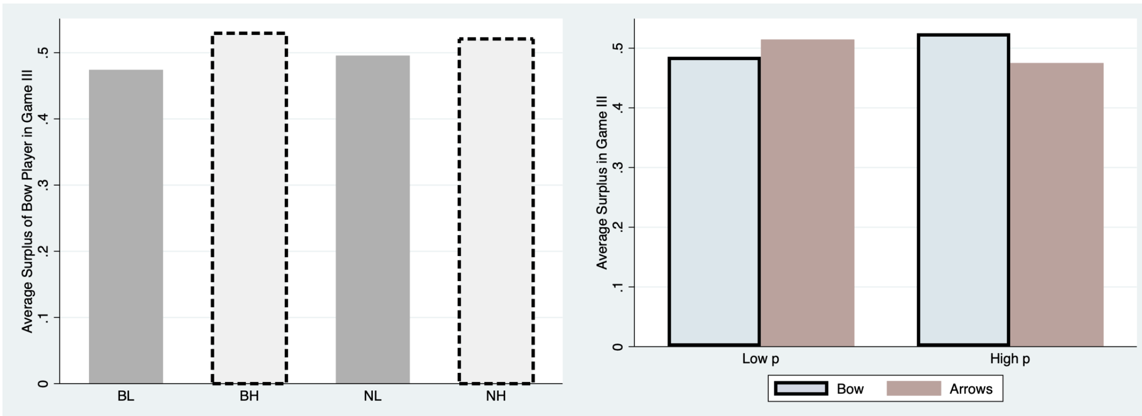
However, in contrast to our third hypothesis, the veto player's share is remarkably similar and does not vary with respect to the buyout dimension: p-value is 0.7731 for BL and NL and 0.8138 for BH and NH. Thus, our experimental data suggest that an important factor behind inequality between veto and non-veto players is not the ability to make buyout offers but the recognition probability.

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

We now turn to Game III (i.e., Rounds 7-9) to see how subjects played bilateral bargaining games after their experiences with multilateral bargaining situations. Figure 1(a) shows the average surplus of bow players, who were considered as veto players in previous rounds. As there is no difference between B-treatment and N-treatment in Game III, we expect bow players obtain the same amount of surplus in BL and NL, and in BH and NH, respectively, which can be confirmed in the figure (p-values are 0.299 for BL vs. NL, and 0.723 for BH vs. NH). The figure also shows that bow players obtain a higher surplus when their recognition probability is high, which is also intuitive (p-values are 0.003 for BL vs. BH, and 0.333 for NL vs. NH).

Figure 1: Average Surplus in Game III

(a) Average Surplus of Bow Player (b) Average Surplus of Bow/Arrow Player



We also expect that subjects with a bow will obtain lower (higher) payoffs than subjects with two arrows in BL and NL (in BH and NH) because the former subjects have a lower (higher) recognition probability. In Figure 1(b), the bars on the left (those with "Low p") represent the average surplus of subjects with one bow and two arrows, respectively, when $p = 1/3$. As expected, the subjects endowed with a bow obtained a lower surplus on average as their recognition probability is lower than their counterparts (p-value is 0.0513). Likewise, the bars on the right (those with "High p") show that a higher average surplus accrues to the subjects with a bow (p-value is 0.004) when $p = 2/3$.

5 Explanation with Inequity Aversion

We found that our experimental results diverged significantly from the theoretical predictions in two ways. First, non-veto player subjects made a buyout offer much less frequently than the theoretical benchmark. Second, the surplus was shared more equally among the players than predicted by theory. In this section, we discuss these observations by focusing on an individual's tendency to avoid payoff inequalities (Bolton and Ockenfels, 2000; Fehr and Schmidt, 1999).

Suppose that it is common knowledge that individuals are inequity-averse, which means that the subjects expect the surplus (i.e., the additional 600 coins) to be shared more or less equally in the subgame after coalition formation, which corresponds to the bilateral bargaining game like Game I or Game III. For an illustration, let us assume that the expected payoff in bilateral bargaining is 300 coins. Then this is the surplus to be shared by the non-veto players who are about to form a coalition. If the non-veto players are egalitarian within the coalition, each will get 150 coins. If, however, the inequity-averse veto player is willing to give more than 150 coins to his/her bargaining partner, the ability to form a coalition will be less valuable. In other words, the agreement between non-veto players to avoid the race to the bottom is worth being considered only if the competition drives their payoffs down sufficiently low.

Indeed, our experimental data show that veto players are willing to give more than 150 coins. Veto player subjects offered quite generous amounts of coins and accepted shares much smaller than the theoretical prediction. Moreover, it is worth emphasizing that this was also the case in NL and NH, i.e., the treatments without buyout options. This observation suggests that the main driving factors behind our data are social preferences such as inequity aversion, not the ability to form a coalition among non-veto players. This observation also explains why we do not find significant differences between B-treatment and N-treatment: Because forming a coalition is not very profitable given the veto players' generosity, the availability of it does not make much difference. In Appendix A.2, extending our basic model to incorporate the inequity aversion, we show that it is possible to sustain an equilibrium in which a veto player and a non-veto player agree to split the surplus without exercising the non-veto player's buyout option.

It is worth mentioning that the inequity aversion of players could *increase* inequality *among* non-veto players. In other words, 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 the strategic alliance of non-veto players is never formed because of inequity aversion, the non-veto player excluded from MWC obtains zero surplus, which exacerbates inequality between the non-veto players when considering a substantial amount of surplus going to the other non-veto player due to generosity of the veto player. Analyzing a model without buyout option, Montero (2007) also shows that inequity aversion may increase inequity, but the intuition is different from ours. In her model, inequity aversion may make responders willing to accept a lower share rather than the exclusion from the winning coalition. If the coalition of non-veto players can be formed as in our experiment, on the other hand, inequity aversion may increase inequity by lowering the profitability of the strategic alliance.

6 Concluding Remarks

We implemented a veto game experiment in which we tested whether allowing non-veto players to form an intermediate coalition has an effect on surplus distribution between veto and non-veto players. From the standard model in the literature based on the alternating-offer bargaining by Baron and Ferejohn (1989), we derived two main theoretical predictions. First, the frequency 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. The model also 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. First, although the frequency of coalition formation among non-veto players is positive throughout sessions, the frequency is much lower than predicted by theory. Moreover, the frequency is not correlated with power distribution between the veto and non-veto players. Second, and more importantly, allowing non-veto players to form a coalition has no effect on their shares of surplus. We provided an argument for inequity aversion in organizing our experimental data, thereby suggesting that incorporating behavioral elements in the bargaining models could enhance their predictive power.

We conclude with a discussion about several limitations in our experiment and extensions for further research. First, 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 communication device (Murnighan and Roth, 1977; Agranov and 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 frequency of coalition formation among non-veto players.

Following Baron and 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.

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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 A Simple Model with Inequity Averse Players

This section finds that each of the non-veto players obtains substantial shares without offering a buyout to the other non-veto player when inequity aversion is introduced. Kohler and Schlag (2019) show that in infinite horizon bargaining games, strong *guilt* makes players split the pie equally, regardless of the strength of *envy*. Following this, and for simplicity, we assume that guilt is strong, but envy is negligible. With a guilt parameter $\beta \geq 0$, which captures the distaste for advantageous inequality, player i's adjusted payoff from an allocation $x \in \Delta(N)$ is

$$x_i - \beta \frac{1}{|N|-1} \sum_{j \neq i} \max\{x_i - x_j, 0\},$$

as in Fehr and Schmidt (1999).

Two-Player Subgames

First, we find an equilibrium in a two-player subgame, with a recognition probability $(p, 1-p)$. Assume that $p \geq 1/2$, that is, player 1 has a higher recognition probability. Consider a cutoff strategy profile x: 1) player i makes an offer x_j to the other player retaining $1 - x_j$ for herself; and 2) player i accepts an offer m if and only if $m \geq x_i$. Note that $x_1 \geq x_2$ in equilibrium, as $p \geq 1/2$. Given such x, the players' continuation payoff is as follows:

$$\begin{aligned} u_1 &= p(1 - x_2 - \beta \max\{(1-x_2) - x_2, 0\}) + (1-p)(x_1 - \beta \max\{x_1 - (1-x_1), 0\}) \\ &= p(1 - x_2 - \beta(1 - 2x_2)) + (1-p)(x_1 - \beta(2x_1 - 1)) \end{aligned} \tag{3}$$

and

$$\begin{aligned} u_2 &= p(x_2 - \beta \max\{x_2 - (1-x_2), 0\}) + (1-p)(1 - x_1 - \beta \max\{(1-x_1) - x_1, 0\}) \\ &= p x_2 + (1-p)(1-x_1), \end{aligned} \tag{4}$$

where the inequity aversion term does not appear in u_2.

In equilibrium, any offer must make the respondent indifferent between accepting and rejecting, that is, $x_1 = \delta u_1$ and $x_2 = \delta u_2$. Solving the system of equations, the equilibrium consists of

$$
\begin{aligned}
x_1 &= \frac{\delta(p-\delta p+\beta(1-(2-\delta)p))}{1-\delta(1-2\beta(1-p))} && (5)\\
x_2 &= \frac{\delta(1-(1-\beta)\delta)(1-p)}{1-\delta(1-2\beta(1-p))}. && (6)
\end{aligned}
$$

In particular, for $p = 2/3$ and $\delta = 0.9$, we have

$$
x_1 = \frac{12\beta+3}{30\beta+5} \quad \text{and} \quad x_2 = \frac{27\beta+3}{60\beta+10}. \tag{7}
$$

Note that, as $\delta \to 1$, the equilibrium converges to $x_1 = x_2 = 1/2$ for any p and any β.

Three-Player Bargaining Game

We are interested in constructing an equilibrium in which no buyout occurs, which requires $e_2(\{1,2\}) \geq e_2(\{2,3\})$, $e_3(\{1,3\}) \geq e_3(\{2,3\})$. Furthermore, as shown in Lee (2018), non-veto players' payoff should be the same in equilibrium. Hence, we consider a cutoff strategy profile with $x = (x_1, x_2, x_2)$, $q_1(\{1,2\}) = q_1(\{1,3\}) = 1/2$, and $q_2(\{1,2\}) = q_3(\{1,3\}) = 1$. Given such a strategy profile, the players' continuation payoff is

$$
\begin{aligned}
u_1 &= p\Big(1-x_2-\frac{\beta}{2}\big(\max\{(1-x_2)-x_2,0\}+\max\{(1-x_2)-0,0\}\big)\Big)\\
&\quad +(1-p)\Big(x_1-\frac{\beta}{2}\big(\max\{x_1-(1-x_1),0\}+\max\{x_1-0,0\}\big)\Big)\\
&= p\Big(1-x_2-\frac{\beta}{2}(2-3x_2)\Big)+(1-p)\Big(x_1-\frac{\beta}{2}(3x_2-1)\Big) && (8)
\end{aligned}
$$

and

$$
\begin{aligned}
u_2 &= \frac{1-p}{2}\Big(1-x_1-\frac{\beta}{2}\big(\max\{(1-x_1)-x_1,0\}+\max\{(1-x_1)-0,0\}\big)\Big)\\
&\quad +\frac{p}{2}\Big(x_2-\frac{\beta}{2}\big(\max\{x_2-(1-x_2),0\}+\max\{x_2-0,0\}\big)\Big)\\
&= \frac{1-p}{2}\Big(1-x_1-\frac{\beta}{2}(1-x_1)\Big)+\frac{p}{2}\Big(x_2-\frac{\beta}{2}x_2\Big). && (9)
\end{aligned}
$$

For $p = 1/3$ and $\delta = 0.9$, solving the equilibrium condition, $x_1 = \delta u_1$ and $x_2 = \delta u_2$, it follows

$$x_1 = \frac{-27\beta^2 + 81\beta + 66}{390\beta + 100} \quad \text{and} \quad x_2 = \frac{-27\beta^2 + 51\beta + 6}{195\beta + 50}. \tag{10}$$

Furthermore, no buyout condition requires $e_2(\{1,2\}) \geq e_2(\{2,3\})$, or equivalently,

$$\begin{aligned} 1 - x_1 - x_2 &\geq \delta x_2^{\{2,3\}} - 2x_2 \\ 1 - x_1 - x_2 &\geq 0.9\frac{12\beta + 3}{30\beta + 5} - 2x_2, \end{aligned} \tag{11}$$

by replacing $x_2^{\{2,3\}}$ with x_1 in (7). Combining (10) and (11), we conclude that the strategy profile supports an equilibrium for any $\beta \gtrsim 0.0264$. For instance, when $\beta = 0.203$, the equilibrium outcome coincides with the experiment result, as $x_1 = 272/600 \approx 0.453$.

For $p = 2/3$ and $\delta = 0.9$, on the other hand, the equilibrium condition, $x_1 = \delta u_1$ and $x_2 = \delta u_2$, requires

$$x_1 = \frac{-27\beta^2 - 9\beta + 66}{120\beta + 80} \quad \text{and} \quad x_2 = \frac{-27\beta^2 + 51\beta + 6}{240\beta + 160}. \tag{12}$$

Again, from no buyout condition, it follows

$$\begin{aligned} 1 - x_1 - x_2 &\geq \delta x_2^{\{2,3\}} - 2x_2 \\ 1 - x_1 - x_2 &\geq 0.9\frac{27\beta + 3}{60\beta + 10} - 2x_2, \end{aligned} \tag{13}$$

by replacing $x_2^{\{2,3\}}$ with x_2 in (7). Using (12) and (13), we confirm that the strategy profile supports an equilibrium for any $\beta \gtrsim 0.0642$. In particular, for $\beta = 0.229$, the equilibrium outcome coincides with the experiment result, $x_1 = 349/600 \approx 0.582$.

In addition, we also provide the equilibrium outcome with $\delta \to 1$. If $p = 1/3$, no buyout equilibrium requires

$$x_1 = \frac{-\beta^2 + 3\beta + 2}{13\beta + 2} \quad \text{and} \quad x_2 = \frac{-2\beta^2 + 4\beta}{13\beta + 2}$$

and

$$1 - x_1 - x_2 \geq 1/2 - 2x_2.$$

Hence, for any $\beta \gtrsim 0.08002$, no buyout equilibrium exists; and for $\beta = 0.33832$, the equilibrium outcome coincides with the experiment result, $x_1 = 272/600 \approx 0.453$.

As $\delta \to 1$, If $p = 2/3$, no buyout equilibrium requires

$$x_1 = \frac{-\beta^2 + 2}{4\beta + 2} \quad \text{and} \quad x_2 = \frac{-\beta^2 + 2\beta}{8\beta + 4}$$

and

$$1 - x_1 - x_2 \geq 1/2 - 2x_2.$$

Thus, for any $\beta \gtrsim 0.316625$, no buyout equilibrium exists; and for $\beta = 0.316625$, the equilibrium outcome is close to the experiment result $x_1 = 349/600 \approx 0.5817$.