Commitment timing in coalitional bargaining*

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Abstract

Most multilateral bargaining models predict bargaining power to emanate from pivotality—a party's ability to form different majority coalitions. However, this prediction contrasts with the empirical observation that negotiations in parliamentary democracies typically result in payoffs proportional to parties' vote shares. Proportionate profits suggest equality rather than pivotality drives results. We design an experiment to study when bargaining outcomes reflect pivotality versus proportionality. We find that commitment timing is a crucial institutional factor moderating bargaining power. Payoffs are close to proportional if bargainers can commit to majority coalitions before committing to how to share the pie, but pivotality dictates outcomes otherwise. Our results help explain Gamson's Law, a long-standing puzzle in the legislative bargaining literature.

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1 Introduction

An extensive literature documents that bargaining power in parliamentary democracies is proportional to parties' vote shares—an observation often referred to as Gamson's Law (e.g., Gamson, 1961; Warwick and Druckman, 2006). For instance, Browne and Franklin (1973) conclude, "the number of ministries received by partners in a governing coalition is indeed explained, almost on a one-to-one basis, by their contribution of parliamentary seats to that coalition."[1] This one-to-one proportionality between vote shares and pie shares has generated significant interest in the literature, not least because it contrasts with predictions from multilateral bargaining theory (e.g., von Neumann and Morgenstern, 1944; Baron and Ferejohn, 1989; Morelli, 1999; Ray and Vohra, 2015b). Most theories—but not all, as we will discuss below—predict that parties can leverage vote shares to achieve better negotiation outcomes only to the extent that they are *pivotal* for forming different majority coalitions. The predicted pie distributions differ markedly from the proportional shares. An important question is, thus, which institutional features of a negotiation can reconcile the theoretically expected influence of pivotality with the empirically observed pie distributions.

We design a lab experiment to help clarify when pivotality is the dominant source of bargaining power and when proportionality takes precedence. On the one hand, greater pivotality confers bargaining power due to better outside options: a negotiator can threaten to abandon negotiations with one party to seek agreement with another (e.g., Miller et al., 2018). On the other hand, proportionality is an attractive negotiation outcome because it implies equality within a winning coalition: it allocates an equal pie share to each vote supporting the coalition. Previous lab studies generally provide evidence in support of pivotality as the main determinant of outcomes (e.g., Fréchette et al., 2005a,b,c; Diermeier and Morton, 2005; Fréchette, 2009; Palfrey, 2013; Maaser et al., 2019; Baranski and Morton, 2021; Agranov, 2022). These experiments also document a slight bias toward proportionality, but it is insufficient to generate outcomes close to Gamson's Law. We make two crucial contributions. First, we implement a design that gives equality concerns a fair shot to impact negotiation outcomes. Second, we introduce different negotiation institutions that vary the timing of commitment.

A novelty of our design is that an actual person backs each vote. We group all individuals in a negotiation into different parties, and a party has as many votes as it has members. Each party has a representative (randomly selected) who negotiates on behalf of the other party members. The other party members can observe the negotiation between the representatives. Upon conclusion of the negotiation, representatives must share the negotiated pie shares with the other

[1] Further related studies are Browne and Frendreis (1980), Schofield and Laver (1985), Warwick and Druckman (2001), Ansolabehere et al. (2005), Bäck et al. (2009), and Cutler et al. (2016).

party members. This realistic feature of our experiment legitimizes attempts by a large party's representative to claim a large pie share on the grounds of equality. Equality may therefore be a strong attractor for negotiation outcomes. This feature sets us apart from previous experiments where there are no other party members with whom to divide the negotiated pie shares.[2]

Our second innovation is to distinguish between allocative commitment and coalitional commitment. An *allocative* commitment is an agreement on a specific pie distribution. The winning coalition is implicitly determined and consists of the proposer and the acceptor(s) of the implemented allocation. In contrast, a *coalitional* commitment pins down a majority coalition without yet specifying an allocation. Our negotiation institutions feature two stages to vary the timing of commitment. Bargaining is unstructured and happens in real-time. Stage 1 corresponds to the first minute of bargaining, and stage 2 to the remainder of the game. Treatment *Baseline* only allows for allocative commitment. The first stage is a cheap-talk stage where representatives can make but not yet accept allocative proposals (that is, the message space corresponds to non-binding allocative proposals). Representatives can commit to allocations in the second stage. Treatment *Stage2* additionally allows negotiators to engage in coalitional commitment in stage 2; the first stage is identical to the *Baseline*. After a coalitional commitment happens, only the representatives in the committed majority coalition continue to negotiate. Finally, treatment *Stages1&2* is identical to treatment *Stage2* except that it allows for coalitional commitment in both stages. Coalitional commitment is thus available (but voluntary) in stage 1 before representatives can engage in allocative commitment.

Our design is motivated by a theoretical literature arguing that coalition formation often precedes determining allocations. Diermeier and Feddersen (1998) offer a model of coalitional and allocative commitment to explain differences in voting cohesion across legislative systems. Baron and Diermeier (2001) offer a theory of parliamentary systems where parties are unable to commit to the pie shares they will support when becoming part of the governing coalition. In Diermeier et al. (2003) and Montero (2008), proto-coalitions form before bargaining over the pie shares is possible. Carroll and Cox (2007) develop a model in which parties can make binding pre-election pacts. Similarly, Bassi (2013) argues that parties often publicly commit to coalitions before beginning negotiations on the legislative pie, e.g., cabinet portfolios.[3] Predicted pie shares can be proportional to vote shares in

[2]Fréchette et al. (2005b) also study treatments where negotiated pie shares are divided by the vote share of a party. However, equality is inefficient in their design because part of the pie is lost when given to larger parties (specifically, it remains in the hands of the experiment). Weber (2020) designs an experiment with group representatives similar to our study to elicit people's preferences over voting systems.

[3]For instance, government formation in Italy between 1948 and 1992 started with coalition formation among the parties represented in parliament to designate a prime minister. Only then

these studies, suggesting the timing of commitment as an institutional feature that can explain Gamson's Law.[4]

What are our expectations for behavior in the experiment? The hypotheses follow from the experimental and theoretical literature outlined above. We also derive theoretical predictions based on the stable set (von Neumann and Morgenstern, 1944). We expect negotiation outcomes to mainly reflect a party's pivotality in the *Baseline* treatment—though equality concerns may play a bigger role than in previous studies because each vote is backed by a person in our experiment. We expect behavior in treatment *Stage2* to be similar to the *Baseline*. The availability of coalitional commitment in stage 2 does not alter the theoretical predictions because each outcome following a coalitional commitment can also be implemented directly via an allocative commitment. However, the availability of coalitional commitment could matter for behavioral reasons. Finally, we expect negotiation outcomes in treatment *Stages1&2* to be proportional to vote shares and thus in line with Gamson's Law. After a coalitional commitment occurs, the representatives can no longer credibly threaten to abandon the negotiations. They enter a pure bargaining game (e.g., Nash, 1950). Equality then becomes a stronger attractor. One question is why parties with better outside options (i.e., greater pivotality) agree to join coalitional commitments. Intuitively, a bird in the hand is worth two in the bush: coalitional commitment avoids the risk of exclusion from the winning coalition, which dominates the incentive to retain bargaining power derived from outside options.

Our experimental results confirm these expectations. First, in treatments *Baseline* and *Stage2*, parties' pivotality in forming majority coalitions is a significantly stronger source of bargaining power than proportionality and equality. There is a bias toward equality. But, like in the previous literature, it is not sufficient to bring outcomes close to Gamson's Law, even though each vote is backed by a participant in our experiment. Moreover, there are no significant differences in negotiation outcomes between *Baseline* and *Stage2*. The estimated bargaining power weights are 37% for proportionality and between 51% and 54% for pivotality in both treatments. The availability of coalitional commitment thus shows no impact when introduced simultaneously with allocative commitment. The results in treatment *Stages1&2* sharply contrast with the other treatments. Parties use coalitional commitment in stage 1 in 88% of instances. The percentage increases throughout the experiment, starting at 33% in round 1 and reaching 100% in rounds 7 to 10. Following a coalitional commitment, we observe negotiation outcomes proportional to vote shares. In line with our predictions, negotiators reward each vote supporting a winning coalition equally. To be more precise, 69% of a party's bargaining power

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did the nominated prime minister bargain with the coalition's parties to compile a list of ministers.

[4]Following a different approach, Snyder et al. (2005) and Montero (2017) extend Baron and Ferejohn (1989)'s model to show that for some coalitional games, predicted allocations are proportional when proposer power is proportional to vote shares.

is associated with proportionality in treatment *Stages1&2*, while only 19% comes from pivotality. The timing of commitment is thus a plausible institutional factor explaining Gamson's Law. Finally, we document a prevalence of minimum winning coalitions in all of our treatments: coalitions rarely include members that are not strictly needed for a majority.

Our study belongs to a well-established experimental literature on coalitional bargaining cited throughout the introduction.[5] It is worth mentioning a few secondary contributions we make to this literature. First, we consider negotiations with three and four parties, allowing us to establish the crucial role of commitment timing for different bargaining power constellations. Second, we show that many important results of the experimental coalitional bargaining literature—e.g., the prevalence of minimum winning coalitions and the dominance of pivotality (with some bias toward equality) in the standard environment—continue to hold in our unstructured bargaining setting. These results are interesting in the light of a recent trend toward unstructured bargaining (e.g., Montero et al., 2008; Guerci et al., 2014; Tremewan and Vanberg, 2016; Camerer et al., 2019; Karagözoğlu, 2019). Third, we document a moderate but significant advantage for proposers of winning coalitions despite the symmetric bargaining protocol (Fréchette et al., 2005b; Agranov and Tergiman, 2014; Baranski and Kagel, 2015; Baranski and Morton, 2021).

The empirical literature on coalition governments uses different regression specifications when estimating bargaining power weights. The dependent variable is typically the number of ministries received by partners in a governing coalition, possibly adjusted for the salience of each ministry. The key independent variables are a formateur dummy, a party's voting weight (reflecting pivotality), and numerical vote shares (reflecting proportionality). Snyder et al. (2005) and Ansolabehere et al. (2005) do not include the numerical vote shares as an explanatory variable because their theory predicts they do not matter. In contrast, Warwick and Druckman (2006) and Carroll and Cox (2007) argue that one should not exclude an empirically highly significant variable such as the numerical vote shares.[6] Because we are interested in comparing the impact of vote shares and voting weights under varying institutional assumptions (something only an experiment allows us to do), our regressions include both variables. Remarkably, for coalition governments in 14 West European countries, Warwick and Druckman (2006) report coefficients of 0.626 to 0.705 for vote shares and 0.136 to 0.264 for voting weights in their preferred specifications (models 3 and 4 on page 654). These estimates closely correspond to

[5] Other related experiments on bargaining more broadly include studies on eleventh-hour agreements and strikes (e.g., Roth et al., 1988; Karagözoğlu and Kocher, 2019; Camerer et al., 2019), incomplete information (e.g., Embrey et al., 2015; Bochet and Siegenthaler, 2018, 2021), concerns for relative payoffs/fairness (e.g. Fehr and Schmidt, 1999; Bolton and Ockenfels, 2000), and multi-dimensional negotiations (e.g., Davis and Hyndman, 2019; Bochet et al., 2022).

[6] Moreover, as discussed, Carroll and Cox (2007) and Bassi (2013) have developed theoretical accounts where numerical vote shares do affect bargaining power.

those we find for our *Stages1&2* treatments and differ substantially from our results for the other treatments. This further suggests that commitment timing is a central institutional variable when studying bargaining power in coalitional negotiations. It should not be neglected when modeling legislative bargaining.

We organize the remainder of the paper as follows. In Section 2, we present the experimental design. In Section 3, we derive the behavioral hypotheses. In Section 4, we discuss the empirical results. Finally, Section 5 concludes.

2 Design of experiment

2.1 Setup

The experiment was conducted at the Laboratory for Research in Behavioural Experimental Economics (LINEEX) at the University of Valencia between May 2016 and May 2017. A total of 432 subjects participated in the study. All subjects were students at the University of Valencia from various fields. The mean age was 22 years, and 47% of the subjects were female. Each subject participated in one treatment only. The software was programmed in z-Tree (Fischbacher, 2007). At the start of a session, we distributed written instructions explaining the negotiation setting (available in the online appendix). All subjects completed a comprehension test before starting the experiment.

Subjects played 10 iterations or rounds of a coalitional negotiation game. In each round, subjects in a matching group were randomly matched into 3 negotiation groups with 5 individuals each (three-party setting) or 3 negotiation groups with 7 individuals each (four-party setting). Thus, the matching groups included 15 subjects (three-party setting) or 21 subjects (four-party setting). In each negotiation, subjects were randomly assigned to a party. A party consisted of 1, 2, or 3 members (details below). A party has as many votes as it has members. Votes are important because they allow parties to form majorities with other parties. Specifically, parties negotiated how to divide a pie of 100 experimental points, where an agreement requires a majority of the votes.

At the end of a round, subjects received feedback about the negotiation outcome. In the three-party treatments, the exchange rate was €7.50 per 100 experimental points. We increased the exchange rate to 7/5∗€7.50=€10.50 per 100 experimental points in the four-party treatments to keep the average gain per subject identical. All rounds were paid. We paid subjects in cash privately at the end of a session. Earnings averaged €13.13 per subject, ranging from €5 to €25.34. Sessions lasted between 60 and 70 minutes.

2.2 Coalitional game

A negotiation consists of a set of parties, $N = \{1, ..., n\}$, competing for a pie of 100. Each party i has v_i votes or members. Thus, each vote a party has corresponds to an individual in the game. Each party has a *representative*, a randomly selected party member, who negotiates on behalf of the other party members. Such representation is a novel feature of our experiment, as previous studies assigned vote shares in an ad-hoc manner.

Representatives can form coalitions. The sum of votes of a coalition $S \subseteq N$ is denoted by $v_S \equiv \sum_{i \in S} v_i$. A *winning coalition* $W \in \mathcal{W}$ controls a majority of the votes, where $\mathcal{W}$ is the set of all winning coalitions. A *minimum winning coalition* (MWC) $W \in \mathcal{W}^m$ is a winning coalition that ceases to be winning when removing from it any one of its members. A *least winning coalition* (LWC) $W \in \mathcal{W}^*$ has the smallest possible sum of vote shares that is still winning.[7]

A winning coalition can implement an *allocation* of the pie. An allocation is a vector $x = (x_1, x_2, \ldots, x_n)$ such that $\sum_{i=1}^n x_i \leq 100$ and $x_i \geq 0$, where x_i is party i's pie share. The set of all allocations is denoted by $X = \{x \in Z^n : \sum_{i=1}^n x_i \leq 100, x_i \geq 0 \text{ for } i = 1, ..., n\}$. Pie shares are divided equally among party members. Specifically, given a final allocation $x \in X$, the payoff per member of party i is $u_i(x) = x_i / v_i$. For example, the pie could represent a budget or the right to staff departments that needs to be allocated between divisions of a company or a political party. Dividing the benefit by the vote share is important as otherwise any claim of a larger party to receive a larger share would be offset by the fact that all of its members receive the full benefit (e.g., Fréchette et al., 2005b; Vidal-Puga, 2012).

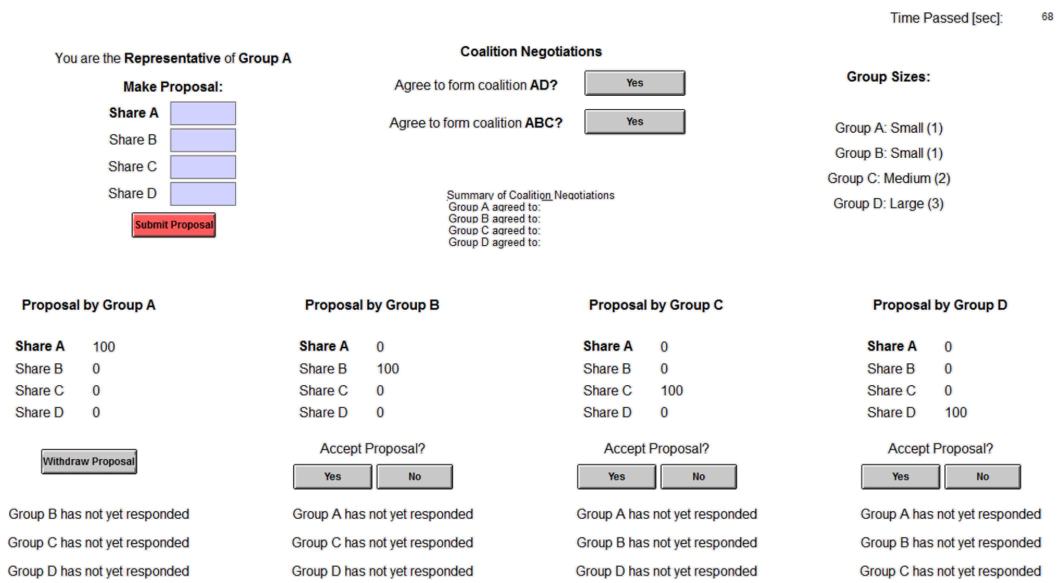
Negotiators can reach final allocations in two ways. An *allocative* commitment corresponds to an implementation of $x \in X$ by some $W \in \mathcal{W}$. In this case, forming a winning coalition requires an agreement on how to share the pie. In contrast, a *coalitional* commitment corresponds to an implementation of some $W \in \mathcal{W}$ without yet specifying an allocation. Allocations are then subsequently negotiated in a pure bargaining game where only parties in the committed winning coalition continue to negotiate.

2.3 Negotiation interface

At the beginning of each negotiation, the participants learn which party they belong to and whether they represent their party. Then, everyone moves to the negotiation interface, which is depicted in Figure 1. The screenshot shows the negotiation interface as observed by the representative of Group A (i.e., Party A). The interface looked similar for participants who were not in the role of a representative in a given

[7]The set $\mathcal{W}^m \subseteq \mathcal{W}$ consists of all $W \in \mathcal{W}$ for which $S \subset W$ implies $S \notin \mathcal{W}$. The set $\mathcal{W}^* \subseteq \mathcal{W}^m$ consists of all $W \in \mathcal{W}$ for which $v_W \leq v_{W'}$ for all $W' \in \mathcal{W}$.

Figure 1: Negotiation Interface



Notes: Decision screen in treatment *4P–Stages1&2*. Allocative proposals are made/revised in the top left panel. Active proposals appear on the bottom half of the screen. Representatives can accept/reject proposals after one minute of non-binding bargaining. A proposal is implemented when approved by enough representatives to have a majority of votes. In panel 'Coalition Negotiations', representatives indicate/revise their willingness to engage in coalitional commitments. Following a coalitional commitment, only parties in the committed winning coalition can continue to make/accept allocative proposals.

negotiation. They could observe the negotiation in real-time but could not make or accept proposals.

In the top-left panel of the interface, representatives can make proposals for allocative commitments on how to share the pie. In the top-middle panel, representatives can make proposals for coalitional commitments without specifying an allocation. The panel in the top-right corner reminds the participants of the number of votes/members each party has. The bottom half of the interface shows the active allocative proposals. In this hypothetical example, all four representatives propose to allocate the entire pie to their own party.

Interactions occur in real-time. Representatives continuously make, withdraw, accept, and reject proposals. The negotiation ends when an allocative proposal receives the support of a majority of the individuals. More specifically, enough representatives have to accept the allocative proposal such that the represented parties control a majority of the votes. If a coalitional commitment receives majority support, this is announced to all participants in the negotiation. The representatives who are part of the committed coalition continue to negotiate how to allocate the pie using the same interface. The representatives excluded from the committed coali-

Table 1: Experimental Design

Treatment	Subjects	Sessions	Parties and Votes	Coalitional Commitment
3P–Baseline	60	4	Three: $(1, 2, 2)$	Not available
4P–Baseline	84	4	Four: $(1, 1, 2, 3)$	Not available
3P–Stage2	60	4	Three: $(1, 2, 2)$	Stage 2
4P–Stage2	84	4	Four: $(1, 1, 2, 3)$	Stage 2
3P–Stages1&2	60	4	Three: $(1, 2, 2)$	Stages 1 and 2
4P–Stages1&2	84	4	Four: $(1, 1, 2, 3)$	Stages 1 and 2

Sessions were run at the University of Valencia. The total number of participants is 432. Negotiations involve either five subjects divided into three parties or seven subjects divided into four parties. All negotiations consist of two phases: an initial minute during which allocations could be proposed but not yet accepted and the remainder of the game during which allocative commitment was possible. The treatments vary the availability and timing of coalitional commitment.

tion lose their ability to make, accept, or reject proposals. They become observers of the process.

A negotiation can also end exogenously to guarantee that the duration is well-defined. However, the breakdown probability is sufficiently small such that the pressure to reach a quick agreement is limited. In the absence of agreement, a negotiation lasts at least 3 minutes. Then, it breaks down with a small probability every few seconds: it lasts 4 minutes with a likelihood of 61%, 5 minutes with 38%, ..., 9 minutes with 5%, and ends with certainty at 10 minutes. More than 94% of the negotiations concluded within 3 minutes. Less than 2% of the negotiations ended in a breakdown.

The negotiation interface looks similar for all treatments. The interface differs depending on whether three or four parties negotiate, as explained in Section 2.4. The interface also varies depending on the availability of coalitional commitment, as explained in Section 2.5.

2.4 Three-party and four-party treatments

Table 1 summarizes the treatments. Our first treatment variable is the number of parties.

In the three-party treatments (*3P*), each negotiation includes 5 individuals. The 5 individuals are divided into three parties: a small party of size 1 and two large parties of size 2. All two-party coalitions and the grand coalition are winning (majority) coalitions.

In the four-party treatments (*4P*), each negotiation includes 7 individuals. The 7 individuals are divided into four parties: two small parties of size 1, a medium-sized party of size 2, and a large party of size 3. Here, the large party can form a winning coalition with any other party. The two small parties and the medium-sized party can also form a winning coalition.

These settings are generic in terms of bargaining power constellation. Specifically, independent of the specific vote shares, every two-party coalition must be a winning coalition in all three-party settings. Similarly, in all four-party settings, it always holds that one large party can form a winning two-party alliance with any of the other parties. At the same time, the smaller three parties, which may differ in size, can also form a winning coalition. These statements assume that no coalition has exactly 50% of the votes, and there are no "dummy" players that are not part of any minimum winning coalition.

2.5 Timing of commitment

Our second treatment dimension varies the availability and timing of coalitional commitment; see the last column in Table 1. All negotiations are separated into two stages. Stage 1 corresponds to the first minute of a negotiation. Stage 2 refers to the remainder of the game.

Representatives can make allocative proposals in stage 1, but they cannot yet accept such proposals. Allocative proposals in stage 1 are thus non-binding but may be used to signal expected stage-2 allocations.[8] Representatives can accept allocative proposals in stage 2. An allocative commitment occurs when a majority agrees with a proposal.

The representatives' ability to engage in coalitional commitment depends on the treatment.

- In treatments *3P–Baseline* and *4P–Baseline*, coalitional commitment is not available. All agreements must occur directly via allocative commitment. In the experiment, the top-middle panel in Figure 1 is not present in *Baseline*.
- In treatments *3P–Stage2* and *4P–Stage2*, coalitional commitment is available in stage 2. Hence, coalitional commitment becomes available simultaneously with allocative commitment. As with allocative commitment, representatives can make non-binding proposals for coalitional commitments in stage 1 of treatment *Stage2*.

[8]The phase with non-binding proposals is a realistic negotiation feature that allows us to implement different commitment timings. An alternative design would be to have three stages. The first stage would always allow for non-binding allocative proposals (but no other actions), and stages 2 and 3 would correspond to our current design. This approach would reduce the potentially limiting effect of early coalitional commitment on negotiators' ability to signal intended allocations. However, we view the latter effect as part of the impact of commitment timing we want to measure. Moreover, the two-stage setting is simpler and feels more natural to us.

- In treatments *3P–Stages1&2* and *4P–Stages1&2*, coalitional commitment is available in stage 1 and stage 2. Hence, coalitional commitment can occur before allocative commitment is available.

3 Theoretical background

3.1 Proportionality versus pivotality

We highlight two salient negotiation outcomes. The *proportional* allocation for coalition W is given by $x^p(W)$, where $x_i^p(W) = 100 * v_i/v_W$ for all $i \in W$ and $x_i^p(W) = 0$ for all $i \notin W$. Each party in the winning coalition obtains a proportion equal to its number of votes divided by the total votes controlled by the winning coalition (Gamson's Law). The allocation $x^p(W)$ is also *equal* in the sense that each individual in the winning coalition receives a payoff of $x_i^p(W)/v_i = 100/v_W$. The set of all proportional allocations is $X^p \equiv \{x^p(W) : W \in \mathcal{W}\}$.

Most multilateral bargaining models predict *pivotality* to influence negotiation outcomes (e.g. Morelli, 1999; Ray and Vohra, 2015b). We rely on the stable set (e.g., von Neumann and Morgenstern, 1944; Morelli and Montero, 2003), which is suitable for our unstructured bargaining environment. The stable set is defined as follows. An allocation x is said to dominate another allocation x' if $u_i(x) > u_i(x')$ for all $i \in W$ for some $W \in \mathcal{W}$. A set of allocations Z is a stable set if two conditions are satisfied: *internal stability* requires that no allocation $x \in Z$ is dominated by another allocation $x' \in Z$, and *external stability* requires that all allocations $y \notin Z$ are dominated by some allocation $x \in Z$.

Consider the vector $a = (a_1, ..., a_n)$ with $a_i \geq 0$ such that $\sum_{i \in W} a_i = 1$ for all minimum winning coalitions $W \in \mathcal{W}^m$. Let allocation $x^a(W)$ be such that $x_i^a(W) = a_i$ if $i \in W$ and $x_i^a(W) = 0$ if $i \notin W$. Then, the set of allocations $X^a \equiv \{x^a(W) : W \in \mathcal{W}^m\}$ is a stable set and is called the *main simple solution*. In this construction, a party's reward when part of a winning coalition increases with the total number of minimum winning coalitions for whose formation the party is pivotal. Parties can thus leverage their outside options. The main simple solution nicely captures pivotality.

Let us illustrate the difference between proportionality and pivotality in our experimental games.

Three Parties (3P). In the three-party treatments, one party has one vote, $v_1 = 1$, and two parties have two votes, $v_2 = 2$ and $v_3 = 2$. The proportional (integer) allocations are $x^p(\{1, 2\}) = (33, 67, 0)$, $x^p(\{1, 3\}) = (33, 0, 67)$ and $x^p(\{2, 3\}) = (0, 50, 50)$. The main simple solution consists of the three allocations $(50, 50, 0)$, $(50, 0, 50)$ and $(0, 50, 50)$. As can be seen, the main simple solution does not share benefits proportionally to votes. Instead, it rewards pivotality in forming MWCs, which is the same for all parties.

Four Parties (4P). In the four-party treatments, the vote distribution is $v_1 = 1$, $v_2 = 1$, $v_3 = 2$ and $v_4 = 3$. The set of MWCs consists of coalitions $\{1,4\}$, $\{2,4\}$, $\{1,2,3\}$, and $\{3,4\}$. The proportional allocations are $x^p(\{1,4\}) = (25,0,0,75)$, $x^p(\{2,4\}) = (0,25,0,75)$, $x^p(\{1,2,3\}) = (25,25,50,0)$ and $x^p(\{3,4\}) = (0,0,40,60)$. The main simple solution, rounded to the next integer, consist of allocations $(33,0,0,67)$, $(0,33,0,67)$, $(0,0,33,67)$, $(33,33,33,0)$.[9] The main simple solution rewards the large party for its greater pivotality, but less than the proportional pie shares would prescribe. Moreover, the medium-sized party gets the same pie share as the small parties despite its larger vote share. The main simple solution again differs from proportionality.

3.2 Behavioral hypotheses

Table 2 summarizes the predictions for the different treatments. The first column lists the possible winning coalitions for the three-party and four-party environments. To save on notation, we subsequently identify a party directly by its size. We denote a coalition by $\{x, y, z\}$ where x, y and z correspond to the sizes of the parties in the coalition. The second and third columns show whether a winning coalition is an MWC and LWC, respectively. The fourth and fifth columns show the predicted allocations. If no allocation is given in these columns, we predict that this winning coalition should not occur.

We summarize the predictions in two main hypotheses.

Hypothesis 1. *In the Baseline and Stage2 treatments, most winning coalitions are MWCs and form via an allocative commitment. In the Stages1&2 treatments, most winning coalitions are LWCs and form via a coalitional commitment.*

Hypothesis 2. *The main simple solution is a better predictor of pie allocations in the Baseline and Stage2 treatments than in the Stages1&2 treatments. The proportional solution is a better predictor of pie allocations in the Stages1&2 treatments than in the Baseline and Stage2 treatments.*

Note that we focus on how well the main simple solution or the proportional solution fare as predictors across commitment settings. Alternatively, we could focus on whether the main simple solution or the proportional solution explains behavior better within each commitment setting. However, formulating hypotheses within a commitment setting is trickier. We anticipated that our design may lead

[9] The provided numbers are rounded from the main simple solution with continuous allocations, which would consist of $(33^1/_3, 0, 0, 66^2/_3)$, $(0, 33^1/_3, 0, 66^2/_3)$, $(0, 0, 33^1/_3, 66^2/_3)$, and $(33^1/_3, 33^1/_3, 33^1/_3, 0)$. Note that the rounded main simple solution does not dominate the allocations $(33,33,34,0)$, $(33,34,33,0)$, and $(34,33,33,0)$. However, the latter allocations are best viewed as different versions of $(33^1/_3, 33^1/_3, 33^1/_3, 0)$ arising from the discreteness of allocations. They should not be seen as interfering with the logic of the stable set.

Table 2: Theoretical Predictions

Winning coalitions[a]	**MWC**	**LWC**	**Main simple solution** (*Baseline & Stage2*)	**Proportional solution** (*Stages1&2*)
Three-Party Setting				
$\{1,2\}$	✓	✓	$(50,50,0)$	$(33,67,0)$
$\{2,2\}$	✓	No	$(50,50,0)$	–
$\{1,2,2\}$	No	No	–	–
Four-Party Setting				
$\{1,3\}$	✓	✓	$(33,67,0,0)$	$(25,75,0,0)$
$\{1,1,2\}$	✓	✓	$(33,33,33,0)$	$(25,25,50,0)$
$\{2,3\}$	✓	No	$(33,67,0,0)$	–
$\{1,1,3\}$	No	No	–	–
$\{1,2,3\}$	No	No	–	–
$\{1,1,2,3\}$	No	No	–	–

Notes: (a) The notation $\{x, y\}$ means that the winning coalition consists of two parties, one party with x votes and another party with y votes. A MWC is a coalition the ceases to control more than 50% of the votes when removing any one of its members. A LWC is a MWC with the smallest number of votes.

to outcomes closer to proportionality/equality even in *Baseline* because each vote is backed by a person.

Our hypotheses align with the previous theoretical literature. Particularly, Carroll and Cox (2007) and Bassi (2013) offer theories of legislative bargaining predicting proportionality when coalitional commitment precedes allocative commitment. We do not directly implement or test these models, but the *Stages1&2* treatments reflect the same commitment timing. On the other hand, theoretical accounts like Morelli (1999) or Ray and Vohra (2015b) predict the main simple solution in standard coalitional bargaining settings such as our *Baseline*: votes produce bargaining power only to the extent that they increase a party's pivotality. Our *Stage2* treatments are theoretically equivalent to the *Baseline* because, in stage 2, negotiators can achieve any expected outcome from a coalitional commitment also directly via an allocative proposal.

Why do we predict coalitional commitments followed by proportional pie shares in the *Stages1&2* treatments? Note first that for every winning coalition, at least one party is better off under the main simple solution than the proportional solution. This party may thus want to forgo coalitional commitment in stage 1 because a committed coalition is predicted to share the pie proportionately. However, entering stage 2 involves risking exclusion from the winning coalition. Based on Carroll and Cox (2007) and Bassi (2013) and theoretical predictions we present in online Appendix A, we expect that the perceived gains from avoiding the exclusion risk outweigh the potentially higher payoff from trying to leverage pivotality in stage 2.

Table 3: Summary Table

	MWCs	LWCs	Coalitional Commitments Total	Stage 1	Stage 2	Agreement Time	Difference to MSS	PS
3P–Baseline	72%	63%	–	–	–	97 sec	10	12
3P–Stage2	71%	52%	20%	–	20%	103 sec	5	10
3P–Stages1&2	93%	79%	90%	88%	2%	117 sec	13	3
4P–Baseline	74%	70%	–	–	–	83 sec	7	5
4P–Stage2	82%	76%	27%	–	27%	106 sec	8	5
4P–Stages1&2	89%	81%	86%	69%	17%	119 sec	8	1

Notes: MWC (LWC): percentage of negotiations where the proposer and the acceptors of the winning coalition correspond to an MWC (LWC) and the excluded parties receive zero. Coalitional Commitments: percentage of negotiations involving a coalitional commitment, and whether it occurred in stage 1 or 2. Agreement Time: average time an allocation was agreed on. Difference to MSS (PS): median distance of the empirical pie shares to MSS (PS).

Specifically, we show in the appendix that the *proportional solution* $X^* \equiv \{x^p(W) : W \in \mathcal{W}^*\}$ is the unique stable set in stage 1 of the *Stages1&2* treatments. An interesting detail is that only least winning coalitions (LWCs), a subset of the MWCs, are predicted to occur in *Stages1&2*.

4 Results

We first examine the formation of minimum winning coalitions (MWCs) and least winning coalitions (LWCs) to test Hypothesis 1. We then analyze pie allocations to test Hypothesis 2. Finally, we explore the negotiation process and discuss two robustness checks.

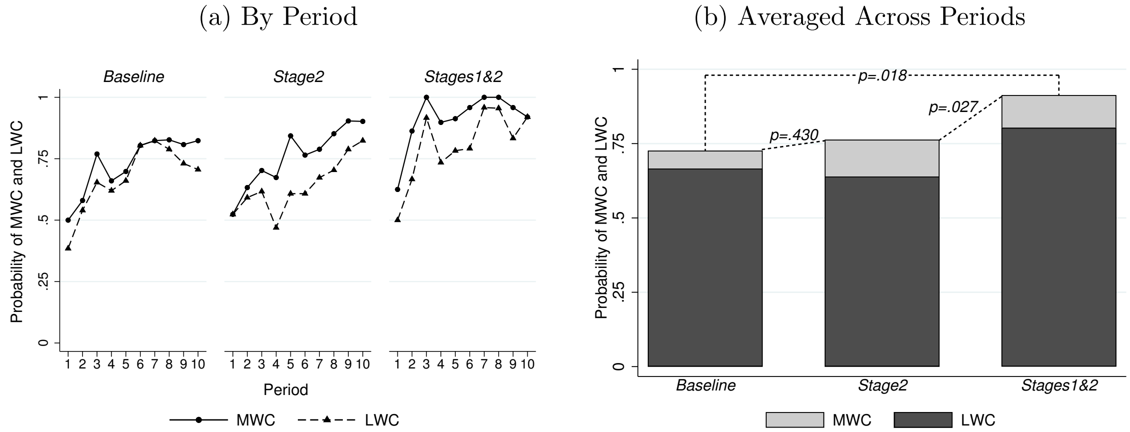
The data comprises of 432 participants organized into 24 independent matching groups, 8 matching groups per commitment setting *Baseline*, *Stage2* and *Stages1&2*. The unit of observation is the mean outcome for an independent matching group. All non-parametric tests are two-sided. We pool the three-party and four-party settings unless indicated otherwise because Hypotheses 1 and 2 equally apply to both. We will confirm that the results hold separately for the three-party and four-party settings.

Table 3 provides an overview of the key descriptive statistics. We will provide more detailed information throughout the results section.

4.1 Minimum and least winning coalitions

To test Hypothesis 1, we need to identify MWCs and LWCs in the experiment. Two dimensions matter: the set of proposers and acceptors of a winning coalition

Figure 2: Minimum and Least Winning Coalitions



Notes: A coalition must allocate the entire pie (100 points) to the coalition members to qualify as an MWC. The set of LWCs is the subset of MWCs with the smallest number of votes. ***Figure (a)*** shows that the probability of observing MWCs and LWCs increases over the iterations of the negotiations in the experiment. In addition, most MWCs are also LWCs. ***Figure (b)*** averages the probabilities across all periods. P-values are from Wilcoxon rank-sum tests.

and the set of parties that receive a positive pie share. While these sets coincide in theory, the representatives who agree to form a winning coalition may choose to allocate some of the pie to excluded parties. We classify a winning coalition as an MWC only if the proposer and the acceptors of the coalition correspond to an MWC *and* the excluded parties receive zero. We use an analogous definition for LWCs.

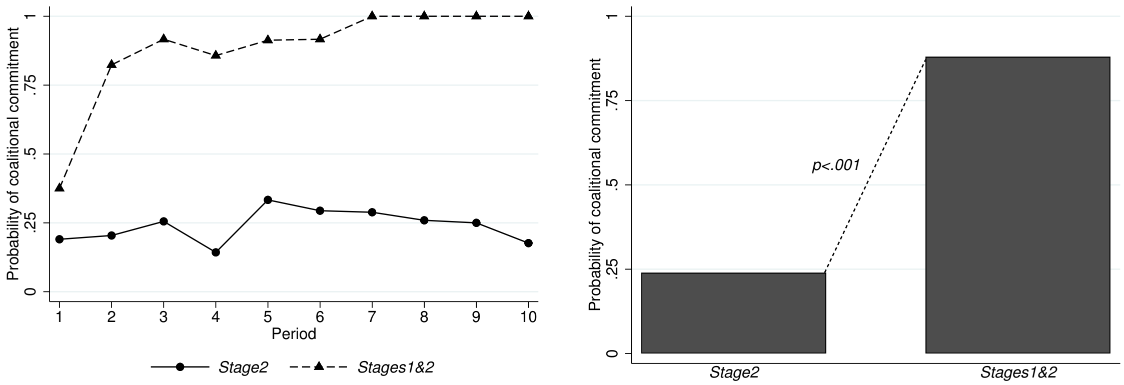
We find that MWCs are common in all treatments. Figure 2a shows that the probability of observing an MWC increases over the iterations of the bargaining game, from 50% to 80% in *Baseline* and *Stage2* and to over 90% in *Stages1&2*. Most MWCs are also LWCs. This is predicted by the proportional solution. The main simple solution would allow for the formation of MWCs that are not LWCs, but these rarely occur in the data. Figure 2b averages the probabilities over the 10 periods. The probability of MWCs is significantly higher in *Stages1&2* than in *Baseline* (Wilcoxon rank-sum test, $p = .018$) and *Stage2* ($p = .027$), while the difference between the latter two treatments is insignificant ($p = .430$).[10]

[10]Random effects logit regressions confirm these results ($N = 1,493$, standard errors clustered on the 24 matching groups). There are significant differences in the probability of observing an MWC between *Stages1&2* and *Baseline* ($p < .001$) as well as *Stages1&2* and *Stage2* ($p < .001$), and no significant difference between *Baseline* and *Stage2* ($p = .545$). The same pattern holds for LWCs, with a significant difference between *Stages1&2* and *Baseline* ($p = .013$), *Stages1&2* and *Stage2* ($p = .017$), and no significant difference between *Baseline* and *Stage2* ($p = .879$).

Figure 3: Coalitional Commitments

(a) By Period

(b) Averaged Across Periods



Notes: ***Figure (a)*** shows that the probability of observing coalitional commitments increases over the iterations of the negotiations in the experiment in *Stages1&2*, while it is stable and substantially lower in *Stage2*. ***Figure (b)*** shows the average probabilities over all periods. P-values are from Wilcoxon rank-sum tests.

Result 1. *The probability of observing MWCs is high in all treatments and significantly higher in Stages1&2 (91%) than in Baseline (73%) or Stage2 (77%). Furthermore, across all treatments, 88% of the MWCs are also LWCs.*

Are coalitions formed via allocative or coalitional commitments? Figure 3a shows the probability of observing a coalitional commitment in *Stage2* and *Stages1&2* over the 10 periods; coalitional commitments are not available in *Baseline* by design. Engaging in a coalitional commitment in *Stages1&2* is not the default behavior: in the first period, two thirds of the negotiations do *not* feature a coalitional commitment. However, the percentage of coalitional commitments increases over time, reaching 100% in period 7 (almost 90% of them happen in stage 1). Figure 3b shows the probabilities averaged over all periods. Coalitional commitments make up 88% of the agreements in *Stages1&2* and 24% of the agreements in *Stage2* (Wilcoxon rank-sum test, $p < .001$).

Result 2. *Coalitional commitments occur significantly more often in Stages1&2 (88%) than in Stage2 (24%).*

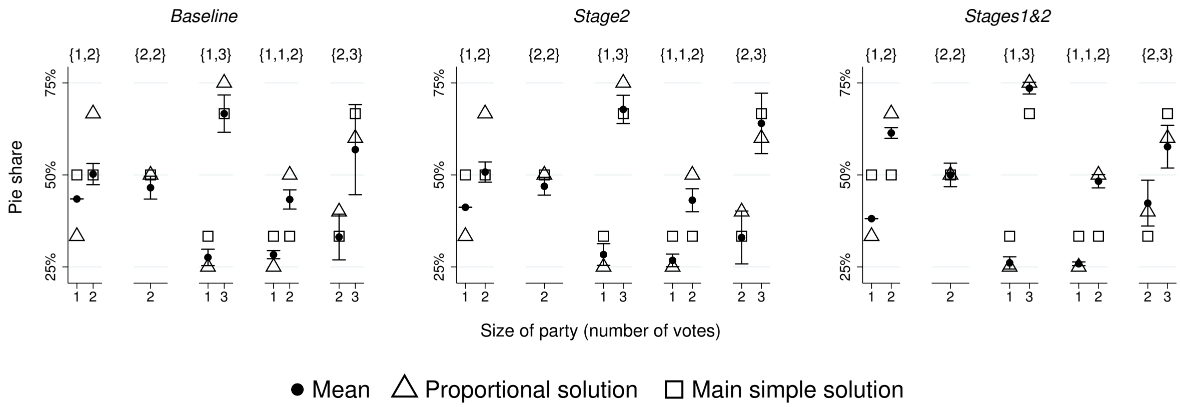
Results 1 and 2 confirm Hypothesis 1.

4.2 Pie allocations: pivotality versus proportionality

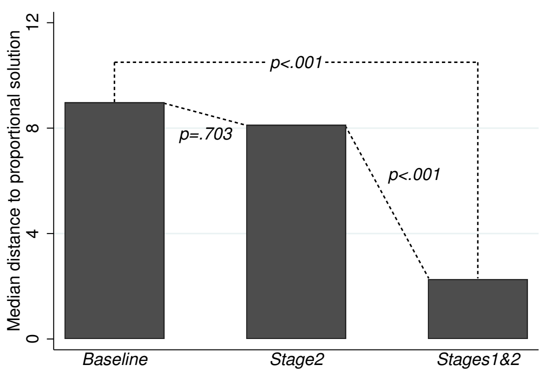
Figure 4a displays the mean empirical pie shares for coalitions {1,2}, {2,2} in the three-party setting and coalitions {1,3}, {1,1,2}, {2,3} in the four-party setting.

Figure 4: Allocations

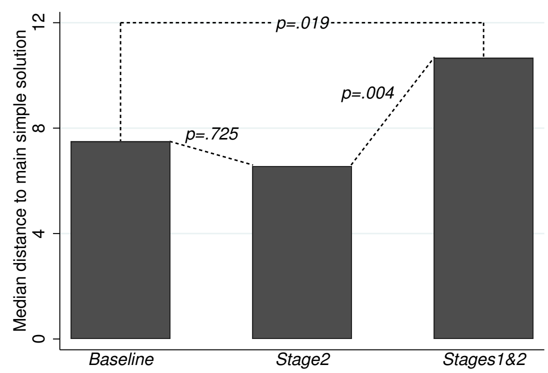
(a) Allocations in Different Winning Coalitions



(b) Distance to Proportional Solution



(c) Distance to Main Simple Solution



Notes: ***Figure (a)*** shows the pie shares for different winning coalitions with 95% confidence intervals (OLS, bootstrapped s.e.) and the predictions of the proportional and main simple solution. ***Figures (b)*** and ***(c)*** show the median distances of the empirical pie shares to the proportional and main simple solution.

These are unconditional pie shares, i.e., we do not restrict attention to negotiations where only the proposers and acceptors of a coalition receive a positive share. The figures cover 98.5% of the realized winning coalitions. The figures also show the proportional solution (triangle markers) and the main simple solution (square markers). Two patterns stand out. First, pie shares in *Stages1&2* are *strikingly* close to the proportional solution for all winning coalitions—the mean pie shares (circles) almost completely overlap with the triangles. Second, in *Baseline* and *Stage2*, it is not immediately clear whether pie shares are closer to the proportional or the main simple solution.

Figures 4b and 4c aggregate the data over the different winning coalitions. In Figure 4b, we calculate for each negotiation the distance of the realized pie shares to the proportional solution and then report the treatment median. In *Stages1&2*, the distance to the proportional solution is 2.3% points. The distances to the proportional solution are larger in *Baseline* and *Stage2*, respectively 9.0% points and 8.1% points. Pie shares are thus significantly closer to the proportional solution in *Stages1&2* than in *Baseline* (Wilcoxon rank-sum test, $p < .001$) and *Stage2* ($p < .001$). The difference between the latter two settings is insignificant ($p = .703$).

Figure 4c shows the median distance between the realized pie shares and the main simple solution. It is 7.5% points in *Baseline*, 6.6% points in *Stage2*, and 10.7% points in *Stages1&2*. The median pie shares are significantly closer to the main simple solution in *Baseline* ($p = .019$) and *Stage2* ($p = .004$) than in *Stages1&2*. The difference between *Baseline* and *Stage2* is insignificant ($p = .725$).[11]

Identical results hold when considering the mean instead of the median distances between the empirical pie shares and the proportional or main simple solution. The only exception is that the mean distances to the main simple solution in *Baseline* (9.2% points) and *Stage2* (9.1% points) are larger than the median distance. The reason is that about 20% of the negotiations in *Baseline* and *Stage2* conclude in all-way splits of the pie. Such negotiations cause an increase in the mean deviation from the predictions.

We can also compare distances of the pie shares to the proportional and main simple solution within a commitment setting. For example, we can compare the third bars in Figures 4b and 4c. We find that pie shares are significantly farther away from the main simple solution than the proportional solution in *Stages1&2* (Wilcoxon signed-rank test, $p = .007$). However, pie shares are statistically equally close to the main simple solution and the proportional solution in *Baseline* ($p =$

[11] How do pie shares depend on coalitional commitment rather than treatment? Combining *Stage2* and *Stages1&2*, the median distance of the empirical pie shares to the proportional solution is 2.7% after a coalitional commitment and 7% otherwise ($p = 0.006$). This difference shows how coalitional commitment brings behavior closer to the proportional solution. Pie shares are also closer to the main simple solution after a coalitional commitment—7.8% versus 10% ($p = .012$)—because the frequency of MWCs increases from 57% for allocative commitments to 100% ($p < .001$). Similar results hold for *Stage2* and *Stages1&2* separately.

.845) and *Stage2* ($p = .945$).

In Table 4, we report random effects regressions to assess further the predictive ability of the proportional and the main simple solution. The specifications align with the empirical literature on coalition formation. Ansolabehere et al. (2005), Warwick and Druckman (2006), and Carroll and Cox (2007) argue that empirical studies often focus on vote shares but lack a measure of a party's pivotality. Our regression models include the predicted pie shares associated with pivotality (main simple solution) and numerical vote shares (proportional solution). This approach allows us to quantify the relative importance of each factor. Moreover, in line with the literature, models 1 and 3 use unconditional pie shares; they consider all negotiations, not just the ones where the entire pie goes to the members of the winning coalition. For comparison, models 2 and 4 show the results conditional on MWCs. Finally, models 1 and 2 include only proposers, and models 3 and 4 only acceptors of a winning coalition. This setup avoids over-specification, as proposer pie shares typically correspond to 100 minus the acceptors' pie shares.

Pie shares almost always lie between the proportional solution (PS) and the main simple solution (MSS). We can express the realized pie shares as a linear combination of PS and MSS. Accordingly, we can interpret the coefficients of the interaction terms between the treatment dummies and PS or MSS as the latter's weight in explaining the empirical pie shares. Model 1 in Table 4 shows that proposer pie shares in *Baseline* are best explained by the linear combination $0.377 * PS + 0.541 * MSS$ (and a constant). In *Stage2*, we obtain a similar result, $0.375 * PS + 0.513 * MSS$. The main simple solution receives the larger weight, but the proportional solution is also significant. In contrast, in *Stages1&2* we obtain $0.688 * PS + 0.187 * MSS$ such that the proportional solution is the main determinant of the pie shares.

Model 2 only includes negotiations that conclude in the formation of an MWC. It produces slightly more pronounced results that are in line with model 1. The results for acceptor pie shares in models 3 and 4 also confirm the ones for model 1. One notable difference is that the effect of MSS tends to be larger for acceptors. This suggests that acceptors are more likely than proposers of an eventual agreement to agree to pie shares that reflect pivotality.

The Wald tests in Table 4 are helpful to see whether the coefficient differences are statistically significant. The regressions fully confirm the results of the non-parametric analyses: (i) the weight of PS for determining bargaining power is significantly larger in *Stages1&2* than in *Baseline* and *Stage2*; (ii) the weight of MSS is significantly larger in *Baseline* and *Stage2* than in *Stages1&2*; *(iii)* Within a commitment setting, we find that the weight of PS is significantly larger than that of MSS in *Stages1&2*, while in *Baseline* and *Stage2*, the weight of MSS is larger than that of PS though this difference is not always significant.

Table 4: Predictive Ability of Proportional and Main Simple Solution

	(1) Proposer share (uncond.)	(2) Proposer share (cond. on MWC)	(3) Acceptor share (uncond.)	(4) Acceptor share (cond. on MWC)
Stage2	1.218	8.195	-5.508	1.328
	(6.239)	(5.801)	(5.657)	(4.070)
Stages1&2	4.720	11.72**	0.424	5.215
	(4.551)	(5.500)	(4.171)	(3.508)
Baseline × PS	0.377***	0.377***	0.277**	0.409***
	(0.0979)	(0.120)	(0.125)	(0.109)
Stage2 × PS	0.375***	0.371***	0.248***	0.297***
	(0.0684)	(0.121)	(0.0905)	(0.107)
Stages1&2 × PS	0.688***	0.724***	0.690***	0.711***
	(0.0563)	(0.0567)	(0.0319)	(0.0281)
Baseline × MSS	0.541***	0.718***	0.673***	0.721***
	(0.168)	(0.193)	(0.146)	(0.144)
Stage2 × MSS	0.513***	0.585***	0.839***	0.778***
	(0.144)	(0.169)	(0.156)	(0.146)
Stages1&2 × MSS	0.187**	0.156**	0.310***	0.281***
	(0.0727)	(0.0728)	(0.0979)	(0.0785)
Constant	3.506	-4.427	-3.808*	-6.573***
	(3.711)	(4.544)	(2.162)	(2.236)
Wald tests comparing effect of PS/MSS across commitment setting				
Stages1&2 × PS = Baseline × PS	$p = 0.006$	$p = 0.009$	$p = 0.001$	$p = 0.007$
Stages1&2 × PS = Stage2 × PS	$p = 0.000$	$p = 0.008$	$p < 0.001$	$p < 0.001$
Baseline × PS = Stage2 × PS	$p = 0.990$	$p = 0.974$	$p = 0.850$	$p = 0.469$
Stages1&2 × MSS = Baseline × MSS	$p = 0.052$	$p = 0.006$	$p = 0.036$	$p = 0.006$
Stages1&2 × MSS = Stage2 × MSS	$p = 0.044$	$p = 0.017$	$p = 0.004$	$p = 0.002$
Baseline × MSS = Stage2 × MSS	$p = 0.901$	$p = 0.605$	$p = 0.436$	$p = 0.781$
Wald tests comparing effect of PS/MSS within commitment setting				
Baseline × PS = Baseline × MSS	$p = 0.527$	$p = 0.266$	$p = 0.139$	$p = 0.213$
Stage2 × PS = Stage2 × MSS	$p = 0.487$	$p = 0.451$	$p = 0.009$	$p = 0.049$
Stages1&2 × PS = Stages1&2 × MSS	$p < 0.001$	$p < 0.001$	$p = 0.001$	$p < 0.001$
Period dummies	✓	✓	✓	✓
Negotiations (N)	702	576	767	628
Unique representatives (subjects)	326	270	334	300
Matching groups (clusters)	24	24	24	24

Notes: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Random effects regressions with individual and matching group random effects. Standard errors in parentheses are clustered on matching groups. Reference group: proposers (models 1 and 2) or acceptors (models 3 and 4) of a winning coalition in *3P-Baseline* and *4P-Baseline*. Models 1 and 3 include all negotiations. Models 2 and 4 restrict data to negotiations where the entire pie is allocated to the parties proposing or accepting the winning coalition. PS and MSS abbreviate the proportional and main simple solution, respectively. Dependent variables (shares) and PS/MSS are numbers between 0 and 100.

Result 3. *The proportional solution is the better predictor of pie shares in Stages1&2 than in Baseline and Stage2. The main simple solution is the better predictor of pie shares in Baseline and Stage2 than in Stages1&2.*

The results on pie allocations largely confirm Hypothesis 2. The only deviation is that bargaining power in *Baseline* and *Stage2* also significantly depends on proportionality, which should not matter in theory. This departure from theory is consistent with the previous experimental literature (e.g., Baranski and Morton, 2021). We attribute it to concerns for equality. Such concerns are particularly credible in our experiment because each vote is represented by a person. However, the results also show that equality concerns are far from enough to generate proportional pie shares.

4.3 Bargaining process

4.3.1 Proposer advantage and timing of offers

Is there a proposer advantage? Many previous studies (e.g., Fréchette et al., 2005a,b,c; Ansolabehere et al., 2005; Warwick and Druckman, 2006; Baranski and Kagel, 2015) examine proposer advantages because it is a central prediction of Baron and Ferejohn (1989)'s model. Regression (1) in Table 5 shows that in our experiment, proposers of an accepted allocative proposal earn 5.65% points more than acceptors (the regression excludes individuals that are not part of the winning coalition). We control for the predicted pie shares (scale 0-100), which correspond to the proportional solution in *Stages1&2* and the main simple solution in *Baseline* and *Stage2*. The coefficient is close to 1 and highly significant, again demonstrating the theory's accuracy in predicting empirical pie shares. In line with the previous literature (e.g., Baranski and Morton, 2021), we find a moderate but significant proposer advantage. Even though our experiment implements unstructured bargaining without an explicit proposer advantage, proposers extract larger pie shares.

How long does bargaining typically last? The average acceptance time of an allocative commitment is 85.36 seconds, 25.36 seconds into stage 2; see regression (2) in Table 5. When a coalitional commitment occurs, the average duration until the members of the winning coalition agree on a pie distribution increases by 42.13 seconds to 125.49 seconds. Representatives in a committed coalition can delay agreement without running the risk of exclusion from the winning coalition. This delay allows larger parties to leverage their vote shares to achieve proportional outcomes. Though not visible in Table 5, we also note that when a coalitional commitment occurs in *Stages1&2*, it happens on average after 33.35 seconds. Only 12% of the coalitional commitments in *Stages1&2* occur after one minute.

How many proposals do the representatives make in a typical negotiation? Regression (3) in Table 5 shows that the average number of proposals is 4.55, with

Table 5: Bargaining Process

	(1) Pie share	(2) Acceptance time	(3) No. of proposals	(4) Demanded pie shares
Proposer	5.650***			
	(1.287)			
Coalitional commitment (CC)	1.356	42.13***	2.446***	0.0584***
	(0.843)	(4.568)	(0.553)	(0.0172)
Proposer × CC	-3.976**			
	(1.789)			
Proposal number				-0.0302**
				(0.0118)
Proposal number × CC				-0.0467***
				(0.0154)
Predicted pie share	0.937***			0.768***
	(0.0390)			(0.0374)
Constant	1.128	85.36***	4.556***	0.171***
	(1.923)	(3.500)	(0.356)	(0.0277)
Period dummies	✓	✓	✓	✓
N	710	710	720	3,965
Matching groups/Clusters	24	24	24	24

Notes: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Random effects regressions with matching group and individual (models 1 and 2) or proposal-level (models 3 and 4) random effects. The reference groups are acceptors (model 1) or proposers (model 4), and negotiations that conclude in allocative commitments in models 2 and 3. Predicted pie share correspond to MSS (*Baseline* and *Stage2*) or PS (*Stages1&2*) and lie between 0 and 100.

an additional 2.44 proposals when the negotiation involves a coalitional commitment. The median number of proposals is 5, the 25th percentile is 1 proposal, and the 75th percentile is 26 proposals. These statistics show that negotiations are heterogeneous, and many involve extensive bargaining.

Do representatives reduce demanded pie shares over time? Regression (4) in Table 5 examines the relationship between the pie shares demanded in an allocative proposal and the normalized number of a proposal in a negotiation. The latter is calculated by dividing the specific proposal number by the total number of proposals for that negotiation. One can see that the demanded pie shares significantly decrease for proposals that occur later in a negotiation. In addition, demanded pie shares are higher after a coalitional commitment, but this tends to be offset by faster compromise.

4.3.2 Why do negotiators engage in coalitional commitment?

Small parties face a trade-off in stage 1 of the *Stages1&2* treatments. They can refuse coalitional commitment to try to leverage pivotality in stage 2. Alternatively, they can accept a coalitional commitment in stage 1 to avoid the risk of exclusion from the winning coalition in stage 2. Theory predicts that a small party engages in a coalitional commitment in stage 1 when the *expected* allocation in stage 2 does not justify the exclusion risk. However, if the small party, say i, could guarantee participation in the winning coalition in stage 2, she would reject coalitional commitment in stage 1. That is, we should have $x_i^e < x_i^p(W) < a_i$ for any LWC, where $x_i^e = \mu_i a_i$ is the expected allocation in the main simple solution, $x_i^p(W)$ is the proportional benefit pie share, and a_i is the pie share in the main simple solution conditional on winning.

We find that the inequalities $x_i^e < x_i^p(W) < a_i$ are satisfied in the data. Specifically, a small party's empirical expected pie share in stage 2 of *Stage2* equals the theoretically expected allocation x_i^e: one-third of the pie in the three-party setting and one-sixth in the four-party setting. The realized benefit of a small party that chooses to commit in stage 1 of *Stages1&2* exceeds x_i^e by, on average, 7.61 percentage points (Wilcoxon rank-sum test, $p = .035$). This establishes $x_i^e < p_i(W)$ in the data. In contrast, a small party's pie share in stage 2 of *Stage2* conditional on participation in the winning coalition exceeds x_i^e by, on average, 12.47 points, a significantly higher pie share than when committing in stage 1 of *Stages1&2* ($p = .027$). This finding establishes the second inequality.

Coalitional commitment is rare in stage 2 of *Stage2* even though we showed that the proportional pie shares after a coalitional commitment exceed the expected benefit from allocative commitment. The reason is that proposals for coalitional commitments in stage 2 can be blocked by allocative offers, adjusted throughout a negotiation. The same is not possible in stage 1 of *Stages1&2*, as representatives cannot yet implement allocations; hence proposals are less credible and less effective at blocking proposals for coalitional commitments. The timing of commitment matters.

4.4 Robustness checks

Our first robustness check concerns the three-party and four-party treatments. We have so far pooled the data from the two settings because our hypotheses equally apply to both environments. In online Appendix B.1, we show that Results 1 to 3 also hold for the two settings separately.

Our second robustness check concerns a joint test of Hypotheses 1 and 2. We have confirmed Hypothesis 1 through results 1 and 2. Result 3 provided evidence in support of Hypothesis 2. Fréchette et al. (2005b) emphasize that testing the joint hypothesis is of interest because multilateral bargaining theory explains winning coalitions and pie shares simultaneously. We test the joint hypothesis in online Appendix B.2. We confirm that the proportional solution performs better at explaining joint outcomes in *Stages1&2*, while the main simple solution performs better at explaining joint outcomes in *Baseline* and *Stage2*.

5 Concluding remarks

We distinguish between coalitional commitment (with whom to coalesce) and allocative commitment (how to share resources) in multilateral bargaining. Our main contribution is a classification of negotiation institutions based on the timing of coalitional commitment. We demonstrate in lab experiments that commitment timing determines when bargaining power stems from an agent's pivotality in forming majority coalitions and when it stems from a claim to equality.

Previous work highlights the importance of learning in coalitional bargaining environments (e.g., Baranski and Morton, 2021). Learning can bring behavior closer to equilibrium predictions (Fréchette, 2009) and reduce behavioral effects such as the impact of purely nominal vote shares that should not alter real bargaining power (Maaser et al., 2019). In line with this, we also observe a significant increase in the percentage of minimum winning coalitions over time. A natural question is if the impact of equality concerns in determining bargaining outcomes weakens over time. We do not find evidence for such an effect. In fact, the impact of equality concerns accentuates over time as the probability of observing coalitional commitments increases in the relevant treatment.

As an application, we discuss Gamson's Law, the empirical observation that legislative bargaining often allocates government portfolios proportionally to parties' vote shares. The most prominent models of coalitional bargaining are inconsistent with Gamson's Law. Our experiments show that when coalitional commitment is available before allocative commitment, Gamson's Law emerges. International negotiations provide another area where our results are potentially relevant. For instance, Nordhaus (2015) argues that in the context of climate negotiations, countries may form a tariff club (a coalitional commitment) before determining precisely the degree to which emissions need to be curbed by each member.

A central feature of proportionality is that it leads to equal payoffs for all members of a winning coalition. But proportionality and equality can also diverge. One example is when negotiators do not divide a fixed pie such as when negotiating policies (e.g., Baranski et al., 2022). Two other assumptions of our experiment warrant a brief discussion. First, negotiators only differ by their vote shares. In reality, actors differ on several dimensions: they value benefits differently (Warwick and Druckman, 2001, 2006), have different incentives to meet supporters' expectations (Martin and Vanberg, 2020), and may contribute differently to generating the pie (Baranski, 2016; Baranski and Cox, 2019; Baranski, 2019). Second, we assume that coalitional commitments are fully binding. Carroll and Cox (2007) state that "parties will not renege on [their] promises because they would thereby disrupt an entire trading relationship and sacrifice future gains from trade." This reasoning suggests that irreversible commitment is a useful approximation for many bargaining situations in daily life. Exploring the interaction of commitment timing and reversibility would be important nonetheless (e.g., Hyndman and Ray, 2007; Nunnari, 2021; Agranov, 2022).

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Declarations

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Online Appendices

A Derivation of behavioral hypotheses

Expected allocation after coalitional commitment

We use a backward induction argument, starting with the game after a coalitional commitment has occurred. Following a coalitional commitment to $W \in \mathcal{W}$, the predicted outcome is the proportional allocation $x^p(W)$.

The Nash bargaining solution (NBS) is the natural cooperative game-theoretic counterpart of the stable set when considering pure (within-coalition) bargaining rather than coalitional (between-coalition) bargaining. The NBS predicts proportionality/equality in our setting without outside options. The NBS for n players is characterized by the maximization problem $\max_x \prod_{i \in W} u_i(x)$ subject to $\sum_{i \in N} x_i \leq 100$ (Nash, 1950; Harsanyi and Selten, 1972; Okada, 2010). Suppose by contradiction that $u_i(x) \neq u_j(x)$ for some representatives $i, j \in W$ and let $\bar{u}$ be the mean of $u_i(x)$ and $u_j(x)$. Thus, $u_i(x) = \bar{u} + d$ and $u_j(x) = \bar{u} - d$ for some $d \neq 0$. In addition, $u_i(x) + u_j(x) = 2\bar{u}$ and $u_i(x)u_j(x) = \bar{u}^2 - 2d < \bar{u}^2$. Replacing both $u_i(x)$ and $u_j(x)$ by $\bar{u}$ increases the product of payoffs while keeping the sum of payoffs fixed. The NBS is therefore achieved when $d = 0$ and $u_i(x) = u_j(x)$ for all $i, j \in W$ and $u_i(x) = 0$ for all $i \notin W$—the proportional solution.

Expected allocations in stage 2

We next consider stage 2 of the coalitional bargaining game. All allocations can be reached via an allocative commitment. Coalitional commitment thus plays no role in stage 2 from a theoretical perspective.

The unique stable set in the coalitional weighted majority game is the main simple solution, X^a (e.g., von Neumann and Morgenstern, 1944; Ray and Vohra, 2015a). One can verify internal and external stability of $\{(50, 50, 0), (50, 0, 50), (0, 50, 50)\}$ in the three-party setting and of $\{(33\tfrac{1}{3}, 0, 0, 66\tfrac{2}{3}), (0, 33\tfrac{1}{3}, 0, 66\tfrac{2}{3}), (0, 0, 33\tfrac{1}{3}, 66\tfrac{2}{3}), (33\tfrac{1}{3}, 33\tfrac{1}{3}, 33\tfrac{1}{3}, 0)\}$ in the four-party setting. There are typically also discriminatory stable sets in addition to the main simple solution in weighted majority games (e.g., Ray and Vohra, 2015b). However, discriminatory stable sets disappear with discrete allocations. We avoid a proof for brevity.

We thus predict an allocation belonging to the main simple solution, $x \in X^a$, when representatives negotiate in stage 2. Pivotality takes precedence. Proportional allocations, $x \in X^*$, could still be expected in stage 2 if $X^a = X^*$. However, $X^a = X^*$ occurs only for the particular case when vote shares exactly correspond to the so-called homogenous representation of the game: when all MWCs have the same sum of vote shares or, equivalently, when all MWCs are also LWCs (e.g., Morelli and Montero, 2003; Montero, 2017; Eraslan and Evdokimov, 2019).

Prediction 1: The main simple solution determines allocations in stage 2 of all treatments.

Expected allocations in stage 1

In stage 1 of the *Stages1&2* treatments, representatives can commit to coalitions. We showed that a coalitional commitment to winning alliance W leads to the proportional allocation $x^p(W)$. In addition, representatives may choose to forgo coalitional commitment in stage 1 to enter stage 2. In stage 1, they thus consider the *expected* stage-2 allocation. Following Prediction 1, expected stage-2 allocations correspond to the expected main simple solution. Therefore, recalling that a_i is constant across MWCs, we can denote the expected stage-2 allocation by $x^e \equiv (\mu_1 a_1, ..., \mu_n a_n) \in X$, where $\mu_i \in (0, 1)$ is party i's belief that she will be part of the winning coalition in stage 2. The set of relevant allocations in stage 1 is thus $X^p \cup x^e$.

Is there a stable set in stage 1? We show that X^* is the unique candidate for a stable set $Z \subseteq X^p$. That is, only LWCs can be part of a proportional stable set. To see this, note that $x_i^p(W) = v_i/v_W$ for all $i \in W$ implies $x_i^p(W) > x_i^p(W')$ for all $i \in W$ and $W \in \mathcal{W}^*$, $W' \notin \mathcal{W}^*$ (because v_W is the smallest for LWCs). Thus, $x^p(W)$ for $W \in \mathcal{W}^*$ cannot be dominated by any allocation in X^p. By external stability, $x^p(W)$ for $W \in \mathcal{W}^*$ must be part of any stable set $Z \subseteq X^p$. In addition, $x^p(W')$ for $W' \notin \mathcal{W}^*$ is dominated by any $x^p(W)$ with $W \in \mathcal{W}^*$. By internal stability, $x^p(W')$ for $W' \notin \mathcal{W}^*$ cannot be in a stable set that includes some $x^p(W)$, $W \in \mathcal{W}^*$. It follows that X^* is the unique candidate for a stable set $Z \subseteq X^p$.

To constitute a stable set in stage 1, X^* also needs to be externally stable, which means it must dominate allocation x^e (the expected stage-2 outcome that can be used to block allocations in stage 1). By definition, $x^p(W)$ dominates x^e if $x_i^p(W) > x_i^e \Leftrightarrow v_i/v_W > a_i\mu_i$ for all $i \in W$ for some $W \in \mathcal{W}^*$. We verify this requirement for our experimental games. To do so, we must consider specific beliefs μ. The most natural beliefs are $\mu_i = m_i/m$, where m is the total number of MWCs and m_i is the number of MWCs that include party i, reflecting that the main simple solution does not discriminate between different MWCs; each one is equally likely to occur.

Consider the three-party negotiation environment. The set of MWCs consists of coalitions $\{1, 2\}$, $\{1, 3\}$ and $\{2, 3\}$. Only the first two MWCs are LWCs. The proportional allocations are $x^p(\{1, 2\}) = (33, 67, 0)$, $x^p(\{1, 3\}) = (33, 0, 67)$ and $x^p(\{2, 3\}) = (0, 50, 50)$. The main simple solution allocates 50 to each party in a MWC. The expected stage-2 allocation is $x^e = (33^1\!/\!_3, 33^1\!/\!_3, 33^1\!/\!_3)$ because $m = 3$ and $m_i = 2$ such that $\mu_i a_i = 2/3 * 50 = 1/3$ for all i. The MWC-allocation $x^p(\{2, 3\})$ would dominate x^e but is excluded by internal stability. Strictly speaking, neither $x^p(\{1, 2\})$ nor $x^p(\{1, 3\})$ dominate x^e because the lowest proportional payoff is exactly the same as the expected stage-2 payoff. So, this is a knife-edge case. However, a small degree of risk aversion would imply an expected stage-2 utility of less than 1/3 such that x^e would be dominated by both $x^p(\{1,2\})$ and $x^p(\{1,3\})$. The set of LWC allocations is then externally stable in stage 1 and coalitional commitment is expected to occur.

Consider now the four-party negotiation environment. The set of MWCs consists of coalitions $\{1,4\}$, $\{2,4\}$, $\{1,2,3\}$ and $\{3,4\}$. The first three MWCs are LWCs. The proportional allocations are $x^p(\{1,4\}) = (25,0,0,75)$, $x^p(\{2,4\}) = (0,25,0,75)$, $x^p(\{1,2,3\}) = (25,25,50,0)$ and $x^p(\{3,4\}) = (0,0,40,60)$. The expected main simple solution allocates $66^2/_3$ to the large party and $33^1/_3$ to the other parties in an MWC. The expected stage-2 allocation is $x^e = (16^2/_3, 16^2/_3, 16^2/_3, 50)$, because $m = 4$, $m_i = 2$ for $i = 1,2,3$, and $m_4 = 3$ such that $\mu_i a_i = 1/2 * 33^1/_3 = 16^1/_3$ for $i = 1,2,3$ and $\mu_4 a_4 = 3/4 * 66^2/_3 = 50$. One can see that $x^p(\{1,4\})$ and $x^p(\{2,4\})$ dominate x^e. Together with the third LWC-allocation $x^p(\{1,2,3\})$, they constitute a stable set in stage 1. We thus expect coalitional commitment in stage 1 to occur because it is part of a stable outcome.

In fact, this analysis also implies that there cannot be a stable set in stage 1 that includes x^e. The set X^* is thus the unique stable set in stage 1.

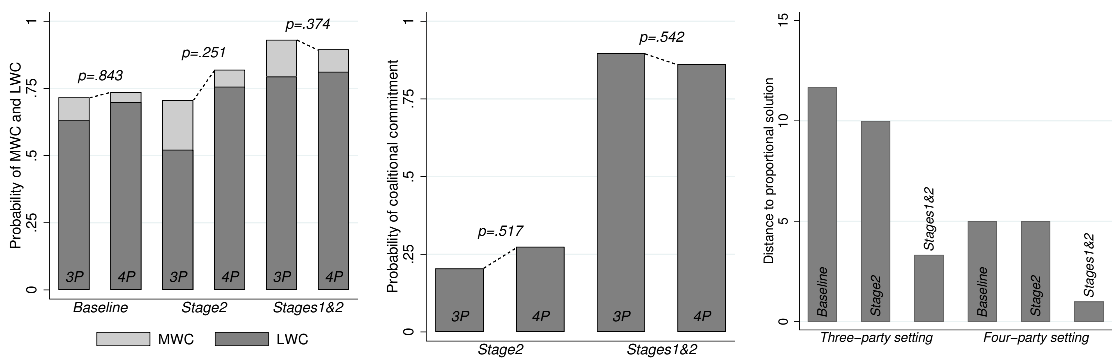
Prediction 2: Coalitional commitment occurs in stage 1 of the *Stage1&2* treatments. The winning coalition is predicted to be an LWC, and its members share the pie proportionally.

B Robustness checks

B.1 Three-Party and Four-Party Setting

Figure 5: Three-party and four-party setting

(a) MWC and LWC (b) Coalitional Commitments (c) Pie Allocations



Notes: ***Figure (a)*** shows the probability of observing a MWC/LWC. ***Figure (b)*** shows the probability of observing coalitional commitments. ***Figure (c)*** shows the median difference between the empirical pie shares and the proportional solution. All P-values are from logit random effects regressions with standard errors clustered on matching groups.

In the main analysis, we pool the data from the three-party and four-party treatments. This approach is justified because our hypotheses equally apply to both settings. Examining if Results 1 to 3 hold independently of the number of parties serves as a helpful robustness check.

Figure 5a shows the probability of observing MWCs and LWCs. As can be seen, there are no significant differences depending on the number of parties. Treatments *3P–Stages1&2* and *4P–Stages1&2* have the highest rates of MWCs and LWCs, but negotiations tend to lead to MWCs and LWCs in all treatments.

Figure 5b shows the probability of observing coalitional commitments. As can be seen, coalitional commitments are common in *3P–Stages1&2* and *4P–Stages1&2* and infrequent in *3P-Stage2* and *4P-Stage2*. Again, there are no significant differences between the three-party and four-party treatments.

Finally, Figure 5c shows the median distance between the empirical pie shares and the proportional solution. The three-party and four-party settings are not directly comparable due to the different predicted pie shares. However, the critical point is that in both settings, *Stages1&2* leads to pie shares that are much closer to proportionality than those in *Baseline* or *Stage2*. A random-effects logistic regression (s.e. clustered on matching groups) with dependent variable "distance to proportionality" and the six treatments as independent variables confirms that the differences between *Stage2* and the other two treatments are highly significant for the three-party and the four-party setting (for all four comparisons, $p < .001$).

B.2 Joint test of hypotheses

Results 1 and 2 confirm Hypothesis 1. Result 3 confirms Hypothesis 2. Here, we evaluate the *joint hypothesis* requiring theory to simultaneously explain winning coalitions (Hypothesis 1) and pie shares (Hypothesis 2).

We create the variables Joint Proportional Solution (JPS) and Joint Main Simple Solution (JMSS). JPS is equal to the pie shares predicted by the proportional solution only if an LWC forms. It is equal to 0 otherwise. Likewise, JMSS is equal to the pie shares predicted by the main simple solution only if an MWC forms and is equal to 0 otherwise. These variables can thus explain an empirical outcome only if they are accurate for the winning coalition *and* the pie shares simultaneously.

We run analogous regressions to Table 4, except that we use JPS and JMSS instead of PS and MSS. We present the results in Table 6. The random-effects regressions examine how proposers' (model 1) and acceptors' (model 2) pie shares depend on JPS and JMSS for the different negotiation environments. Consistent with our main findings, JPS performs best at explaining outcomes in *Stages1&2* while JMSS performs best in *Baseline* and *Stage2*. The coefficients in Table 6 are smaller than the ones reported in Table 4 because, by definition, fewer negotiation outcomes are consistent with JPS/JMSS than PS/MSS.

Table 6: Proportional and Main Simple Solution—Joint Test

	(1) Proposer pie share		(2) Acceptor pie share	
Stage2	-4.326*	(2.553)	3.897*	(2.346)
Stages1&2	5.000*	(2.625)	2.089	(2.845)
Baseline × JPS	0.0579	(0.0452)	0.137**	(0.0618)
Stage2 × JPS	0.0743**	(0.0300)	0.0633*	(0.0385)
Stages1&2 × JPS	0.193***	(0.0327)	0.202***	(0.0187)
Baseline × JMSS	0.117**	(0.0551)	0.283***	(0.0829)
Stage2 × JMSS	0.204***	(0.0625)	0.241***	(0.0389)
Stages1&2 × JMSS	-0.0685	(0.0608)	0.148**	(0.0607)
Constant	25.45***	(1.750)	14.04***	(1.753)
Wald tests comparing effect of JPS/JMSS across commitment setting				
Stages1&2 × JPS = Baseline × JPS	$p = 0.016$		$p = 0.303$	
Stages1&2 × JPS = Stage2 × JPS	$p = 0.008$		$p = 0.002$	
Baseline × JPS = Stage2 × JPS	$p = 0.768$		$p = 0.283$	
Stages1&2 × JMSS = Baseline × JMSS	$p = 0.020$		$p = 0.174$	
Stages1&2 × JMSS = Stage2 × JMSS	$p = 0.001$		$p = 0.125$	
Baseline × JMSS = Stage2 × JMSS	$p = 0.294$		$p = 0.630$	
Wald tests comparing effect of JPS/JMSS within commitment setting				
Baseline × JPS = Baseline × JMSS	$p = 0.537$		$p = 0.306$	
Stage2 × JPS = Stage2 × JMSS	$p = 0.120$		$p = 0.004$	
Stages1&2 × JPS = Stages1&2 × JMSS	$p = 0.001$		$p = 0.392$	
Period dummies	✓		✓	
Party size dummies	✓		✓	
Three-party/four-party dummies	✓		✓	
Negotiations (N)	710		783	
Unique representatives (subjects)	327		334	
Matching groups (clusters)	24		24	

Notes: * significant at 10%, ** significant at 5%, *** significant at 1%. Random effects regressions (individual and matching group random effects) with standard errors in parentheses are clustered on matching groups. All regressions include dummies for the size of a party and whether the observation stems from a three-party or four-party treatment to improve the fit for non-MWC winning coalitions for which JPS and JMSS are equal to 0. Reference group: proposers (model 1) or acceptors (model 2) in *Baseline*.