Dynamic Coalitions and Communication: Public versus Private Negotiations*

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July 30, 2016

Abstract

We present a laboratory experiment to study the formation of dynamic coalitions in a bargaining setting where the current status quo policy is determined by the policy implemented in the previous period. Our main experimental treatment is the ability of subjects to negotiate with one another through unrestricted cheap-talk communication before a proposal comes to a vote. We compare committees with no communication, committees where communication is public and messages are observed by all committee members, and committees where communication is private and any committee member can send private messages to any other committee member. We find that the ability to communicate has a significant impact on outcomes and coalitions. When communication is public, committees more frequently agree on outcomes which give a significant fraction of the resources to every member. With private communication, we observe a significant increase in the share of allocations that give a positive amount only to a minimal winning coalition. When either type of communication is allowed, outcomes are more stable and coalitions last longer. The content of communication is correlated with outcomes and with the persistence of a dynamic coalition. These findings suggest a coordination role for communication that varies with the mode of communication.

* We are grateful to Marina Agranov, Alessandra Casella, Giovanni Andreottola, Guillaume Frechette, Drew Fudenberg, Dimitri Landa, Thomas Palfrey, Eduard Talamas, and seminar audiences at the 2014 Mini-Conference on Experimental Economics at Caltech, the 2014 Behavioral Models in Politics Conference at Duke, the 2016 Mini-Conference on Political Economy at Stanford University, the University of Warwick, the London School of Economics, the University of Padua, the 12th CSEF-IGIER Symposium on Economics and Institutions, and the 2nd EIEF Political Economy Workshop for helpful comments and interesting discussions. Elliott Ash and Anselm Rink provided excellent research assistance. Nunnari acknowledges financial support from the European Research Council (grant No. 648833).

1 Introduction

In this paper, we present a laboratory experiment to study the formation of durable coalitions in a dynamic legislative bargaining setting where the current status quo policy is determined by the policy implemented in the previous period. An *endogenous status quo* policy is a feature of many policy domains—for instance, tax rates, regulations, and entitlements—where policies can be changed by the legislature but continue in effect in the absence of a new agreement. This makes the policy-making process an intrinsically dynamic game that cannot be studied as a static competition among different constituencies, or even as a sequence of independent competitions as in a repeated game. In choosing a policy proposal and coalition partners, a policy-maker must not only consider the direct effect of the agreement but also the indirect effect of the agreement on future policy decisions. This creates incentives for a coalition to continue from one period to the next. We refer to this as a *dynamic coalition*.

Recent theoretical research on dynamic divide-the-dollar bargaining (Kalandrakis 2004, 2010, Diermeier and Fong 2011, Bowen and Zahran 2012, Battaglini and Palfrey 2012, Bowen and Zahran 2012, Richter 2014, Anesi and Seidmann 2015, Baron and Bowen 2015) has produced a rich assortment of predictions: almost any outcome can be supported in equilibrium, even when restricting to Markovian, stationary and weakly undominated strategies.

Reviewing this literature, Binmore and Eguia (2016) note that this "powerful result leaves us with shattered predictive power. [...] it is not the case that in real world applications anything happens in totally unpredictable fashion (budgets could be burned but are not; and in most assemblies some subsets of members are known to more frequently cooperate and coalesce with each other) and we still wish to explain and predict these coalitional patterns and bargaining outcomes in real world applications. One might conjecture that we need to include other elements [...] into the choice set in order to obtain more realistic predictions."

One aspect of bargaining processes that has received little attention in models of dynamic bargaining is that of communication, despite the fact that social interaction among individuals is an integral part of such processes. In fact, it is difficult to find examples in which democratic decisions are made without people engaging in negotiations beforehand: in the real world, committee members are allowed to—and do—engage in sometimes intense communication over both proposal-making and voting.[1] In the complete information, dynamic models studied to date there is no role for communication, and models with incomplete information are typically complex to study. Communication can play a role in complete

[1] The literature on sequential legislative bargaining where a committee is disbanded once it reaches a decision has considered communication. Austen-Smith (1990) and Chen and Eraslan (2014) study theoretically the effects of cheap-talk in the presence of asymmetric information between committee members in these *ad hoc* committees.

information models with multiple equilibria by coordinating the strategies of players.

In this paper, we explore experimentally how free-form communication affects bargaining outcomes and the formation and durability of coalitions in dynamic environments. Laboratory experiments provide a direct and powerful tool for investigating the effect of communication on dynamic bargaining processes. In particular, we study the behavior of laboratory committees in a simple dynamic bargaining game with an endogenous status quo. In the game, one of three committee members is randomly selected to make a proposal for the allocation of a divisible resource in each period of an infinite horizon. The proposed allocation is implemented if it receives at least two affirmative votes (that is, a simple majority). Otherwise, the status quo policy prevails, and the resources are allocated according to that policy. The status quo policy, thus, evolves endogenously. Our main experimental manipulation is the ability of players to negotiate with one another through unrestricted cheap-talk communication before a proposal is brought to a vote. We compare committees with no communication, committees where communication is public and all messages are observed by all committee members, and committees where communication is private and any committee member can send private messages to any other committee member.

Our main goal is to answer the following questions: Does communication affect the distribution of resources? More interestingly, does allowing committee members to negotiate increase the formation and duration of dynamic coalitions? How are resources allocated among the members of a dynamic coalition? To what extent do these answers depend on whether the communication is public or private?

We find that the opportunity to communicate has a significant impact on outcomes and coalitions. In our experimental committees, the incidence of dictatorial outcomes–where one committee member gets the lion's share of resources—is negligible. In our no communication treatment, we find 27% of majoritarian outcomes—where two committee members share the resources—and 71% of universal outcomes—where everyone has receives a significant fraction of the pie. Private communication results in more majoritarian outcomes (51%) relative to no communication and fewer universal outcomes (45%). In contrast, public communication results in fewer majoritarian outcomes (4%) relative to no communication and more universal outcomes (95%), eliminating any proposer's advantage. Dynamic coalitions emerge more frequently and last longer when communication is allowed. We analyze the content of the messages sent to help understand the association of particular words, such as those related to fairness or to building a partnership, with coalition size, durability, and type. We find that messages associated with fairness are positively correlated with universal coalitions and negatively correlated with majoritarian coalitions; that the duration of universal coalitions is positively correlated with fairness terms, words related to coalition-building and history-

dependent strategies, attempts to lobby for oneself; and that the suggestion of an alternative allocation of resources is correlated with coalition dissolution.

This paper is related to two strands of literature. First, this paper contributes to the literature on laboratory experiments evaluating models of legislative bargaining (McKelvey 1991, Diermeier and Morton 2005, Diermeier and Gailmard 2006, Frechette, Kagel and Lehrer 2003, Frechette, Kagel and Morelli 2005*a*,*b*,*c*, 2012, Frechette 2009). In contrast with what we do, this work focuses on static environments where a given amount of resources is allocated only once. The only exceptions are Battaglini and Palfrey (2012) and Nunnari (2014) who investigate experimentally dynamic models of committee bargaining with an endogenous status quo in the absence of communication.[2] A subset of the experiments presented in Battaglini and Palfrey (2012) is analogous to our treatment without communication. They find a similar distribution of outcomes, but a lower incidence of universal allocations and a higher incidence of dictatorial and majoritarian outcomes with respect to our data.[3] More importantly, they uncover only modest support for the presence of dynamic coalitions and do not study the effect of communication. The experiments in Nunnari (2014) are less comparable to ours, as their bargaining protocol includes players who can veto a policy change.

This paper also contributes to a growing experimental literature on the impact of unrestricted communication (Charness and Dufwenberg 2006, 2011, Brandts and Cooper 2007, Goeree and Yariv 2011, Oprea, Charness and Friedman 2014). These studies show that communication facilitates greater coordination on Pareto superior outcomes. Three recent papers have allowed subjects to communicate in a multilateral bargaining setting (Agranov and Tergiman 2014*a*,*b* and Baranski and Kagel 2015).[4] These papers study sequential (one-period) games that end once the resources are allocated rather than dynamic games with an evolving status quo and cannot address the issue of coalition formation or durability. This research shows that, when communication is allowed, outcomes in these sequential bargaining games are closer to the unique stationary subgame perfect equilibrium in which the proposer captures a disproportionate share of the resources. In contrast to this finding for sequential legislative bargaining, in our experiment using a dynamic game, public communi-

[2]Roth (1995) surveys the earlier experimental literature in bargaining. These experiments are less related as they are predominantly bilateral, static, and do not allow communication.

[3]There are many small differences between the two experimental designs (in the discount factor, the bargaining protocol, the sample size, and the subject pool) which can account for these differences in outcomes.

[4]The experiments in Murnighan and Roth (1977), Roth and Murnighan (1982), Rapoport and Kahan (1984), Rapoport, Erev and Zwick (1995), Valley et al. (2002), Croson, Boles and Murnighan (2003), Andreoni and Rao (2011) also explore the effect of communication on bargaining outcomes but are less related to ours, as they are bilateral and static.

cation strongly reduces the advantage for the proposer compared to no communication, whit private communication not affecting it.

The reminder of the paper is organized as follows. In Section 2, we describe the dynamic divide-the-dollar gam subjects play in the laboratory. In Section 3, we identify the equilibria in the existing theoretical literature for the game with no communication, and state the testable hypotheses regarding the introduction of communication. In Section 4, we present the experimental design. Section 5 discusses the results of the experiment, and Section 6 concludes.

2 Our Dynamic Divide-The-Dollar Game

We consider a committee of 3 players who repeatedly bargain over how to divide 60 tokens, in integer amounts, among its members. In each period of an infinite horizon,[5] the committee chooses an allocation $x^t = (x_1^t, x_2^t, x_3^t)$, where $x_i^t \in \mathbb{N}^+$ for any $i = \{1, 2, 3\}$, and $\sum_{i=1}^{3} x_i^t =$ 60—that is, only efficient allocations that do not waste the available resources are allowed. Player i derives utility $u(x_i^t)$ from the allocation he receives in period t, where u is increasing. Players are assumed to maximize the expectation of their discounted, infinite stream of utilities, where $\delta \in [0, 1)$ is the common discount factor.

The bargaining protocol with which allocation x^t is chosen is as follows. At the beginning of each period, a player is chosen at random to be the proposer and proposes an allocation y^t. The committee then votes between this allocation and the status quo. If a simple majority votes in favor of the proposal, it is accepted and $x^t = y^t$ is the implemented allocation in period t and the status quo for period $t + 1$. If the proposal is supported by less than a simple majority, it is rejected and the status quo allocation $x^t = x^{t-1}$ is implemented and remains the status quo in the following period. The initial status quo, x^0, is exogenously selected at random.

3 Theoretical Predictions

The theories developed for dynamic divide-the-dollar games characterize different classes of Markov Perfect Equilibria (MPE) with various assumptions about committee size, payoffs, discount factors, selection probabilities, rules for breaking indifference, and the space of possible agreements. An MPE is a subgame perfect equilibrium in which strategies depend only on the payoff-relevant history (Maskin and Tirole 2001), which in this game is the

[5] We describe how we implement an infinite horizon game in the laboratory in Section 4.

status quo policy. In our experiment, we have committees composed of three players with equal agenda setting powers, and do not allow for waste—that is, the sum of allocations to the three players exhausts the dollar. Given these parameters, the papers which can inform behavior in our experiment are Kalandrakis (2014), Battaglini and Palfrey (2012), Anesi and Seidmann (2015), and Baron and Bowen (2015).[6]

In the MPE characterized by Kalandrakis (2004), outcomes quickly converge to a rotating dictatorship with an ergodic distribution where in each period the randomly selected proposer extracts all the resources. Along the convergence path to this distribution, coalitions are majoritarian and unstable, with the proposer giving a positive allocation only to one other player, either to the cheaper or to a randomly chosen one. This MPE exists for any degree of players' patience and initial status quo.

In the Markov Logit Quantal Response Equilibria (MLE) numerically computed by Battaglini and Palfrey (2012),[7] outcomes converge to a rotating dictatorship if players' utilities are linear. If players' utilities are strictly concave, players are averse to sequences of outcomes in which the status quo changes at every period and the incentives for more symmetric allocations among players are stronger. BP present numerical results for highly risk averse players: starting from a dictatorial allocation, the committee moves to a minimal-winning allocation where two players divide the dollar equally or, less frequently, to a universal allocation. These minimal-winning allocations are highly persistent but not absorbing, as the committee transition to a universal allocation about 20% of the time; universal allocations are absorbing states. The risk aversion assumed by Battaglini and Palfrey (2012) to obtain convergence to a universal allocation is too extreme to be plausible in the experiment, so their relevant predictions are rotating dictatorships or rotating minimal winning coalitions.[8]

Anesi and Seidmann (2015) show that, as players become increasingly patient, almost any outcome—the exception being dictatorial ones—is possible with MPE proposals that depend on the identity of players so as to provide a punishment for at least one other player and collectively for all players (what they call *simple solutions*). This result requires that the values of the game to differ among players. Baron and Bowen (2015) characterize MPEs that

[6]Diermeier and Fong (2011) assume a persistent agenda setter. The MPE in Richter (2014) crucially depends on the possibility of waste. The MPEs in Kalandrakis (2009) and Bowen and Zahran (2012) exist only for, respectively, five or more and seven or more players. Therefore, the predictions from these four papers cannot inform behavior in our experiment.

[7]In Battaglini and Palfrey (2012) equilibria are computed as the limit of MLEs by gradually reducing noise in the players reaction functions. In the logit version of quantal response equilibrium, each player, at each information set uses a behavioral strategy where the log probability of choosing each available action is proportional to its continuation payoff.

[8]They specify a utility function $u(x_i) = \frac{1}{1-\gamma} x_i^{1-\gamma}$ with $\gamma = 0.95$. The certainty equivalent for a 50-50 lottery with payoffs 0 and 3, the range of payoffs in the experiment, is 0.0000028.

support allocations with an equal opportunity property that implies that the values of the game are the same for all players. With three players and no waste and for a sufficiently high δ, these MPEs support minimal-winning coalitions with allocations of the form $(c, c, 1-2c)$ for all $c \in \left(\frac{1}{3}, \frac{1}{2}\right]$. The policies supported in an equilibrium in Baron and Bowen are the same as the simple solutions that correspond to MPE in Anesi and Seidmann (with equal values of the game and efficient policies as in the experiment). The equilibrium outcomes in Anesi and Seidmann (2015) and Baron and Bowen (2015) are reached in one bargaining period and are persistent.[9]

The equilibria in these theories are driven by what Diermeier et al. (2008) refer to as the fear of exclusion. That is, a player accepts a proposal in the current period that includes him in the coalition because of fear that if he rejects the proposal he may be excluded from the coalition formed in the next period. If all proposals are required to be efficient, the universal allocation cannot be supported as a MPE for any discount factor in Baron and Bowen (2015) because there is no fear of exclusion. That is, a player expects that next period proposers will propose the universal allocation, so he has no fear of exclusion if he rejects a universal proposal in the current period.[10] In the experiments, we use $\delta = 0.8$ and a feasible allocation is a triplet of integers between 0 and 60 that sum to 60. With this discount factor the outcomes predicted in Anesi and Seidmann and Baron and Bowen are $(30, 30, 0)$, $(29, 29, 2)$, $(28, 28, 4)$ and their permutations.[11] Figures 1 shows the predicted outcomes for each paper whose theory applies to our experimental setting.

The legislative bargaining game we study is a dynamic game with an infinite horizon and has many subgame perfect equilibria. Markovian strategies are conditioned on a state that does not include the history of which individual players took which actions, so the scope for punishments and rewards is limited. It is possible that some other equilibria can

[9] The equilibria in these theories depend importantly on how indifference in voting is broken. Kalandrakis (2004) assumes that a player votes for a proposal when indifferent between it and the status quo, and Battaglini and Palfrey (2012) assume that a player votes for the proposal with probability 0.5 when indifferent. Anesi and Seidmann (2015) assume that the players vote for the status quo when indifferent when it is a simple solution, and for the proposal when the status quo is not a simple solution. Baron and Bowen (2015) assume that players vote for the status quo when indifferent. The indifference rules in the latter two theories yield stability rather than rotation.

[10] Richter (2014) shows that the universal allocation can be supported as a MPE if there is a threat of exclusion created by the possibility of waste.

[11] For comparability the predictions for the Baron and Bowen model use the indifference rule in Anesi and Seidmann. If the values of the game can differ among the players in a simple solution, additional allocations can be supported in a MPE. A simple solution, SS, is a triple of allocations, and allocations to individual players can be as different as in $SS = \{(34, 26, 0), (8, 26, 26), (34, 0, 26)\}$, for which the values of the game are $\left(\frac{78}{3}, \frac{52}{3}, \frac{52}{32}\right)$ for the three players. There is no reason to that the values of the game implemented in the experiment are different.

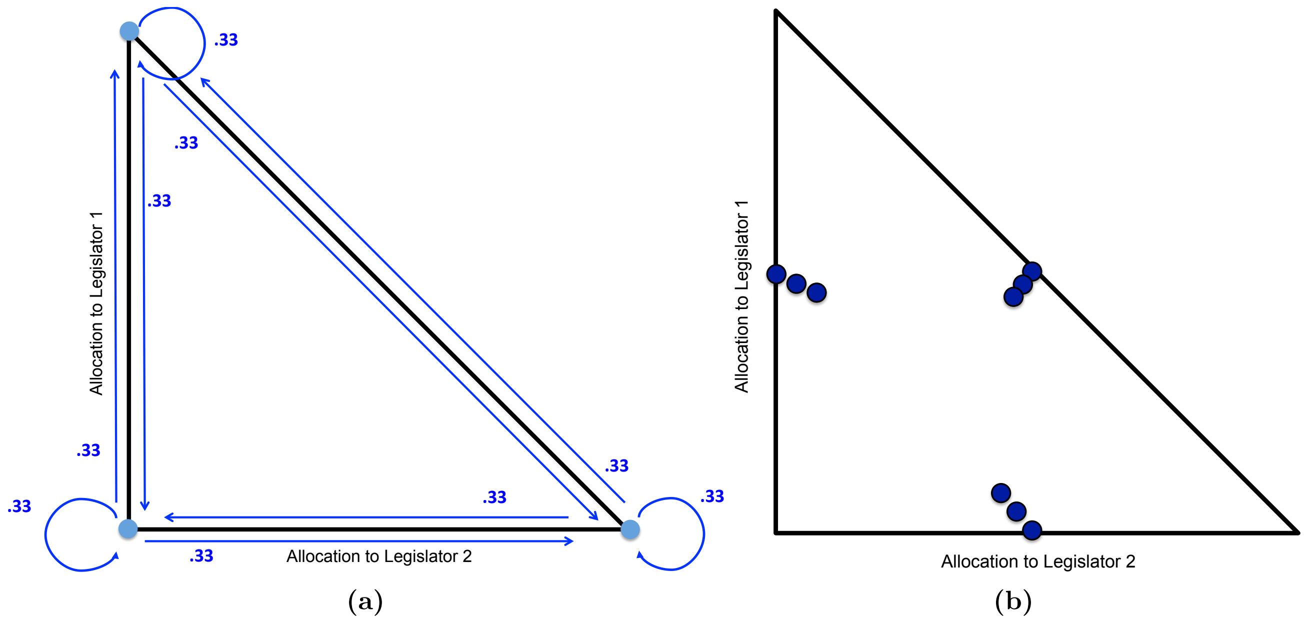

Figure 1: Predictions for Game with No Communication; (a): Stationary Distribution Induced by MPE in Kalandrakis (2004) and Battaglini and Palfrey (2012) for linear utilities; (b):Absorbing Outcomes According to Different MPEs in Anesi and Seidmann (2015) and Baron and Bowen (2015).

sustain different outcomes through the use of history dependent strategies. Neither Anesi and Seidmann (2015) nor Baron and Bowen (2015) predict that the universal allocation $(20, 20, 20)$ is supported in a MPE because there is no exclusion risk. This allocation can be supported in a subgame perfect equilibrium using player-specific punishments in which a player who deviates from the universal allocation receives 0 thereafter and the other two players receive 30 each and hence have an incentive to punish. The universal allocation can also be supported in a MPE if players have sufficiently altruistic preferences.

The dynamic bargaining games studied in the literature all assume complete information with no role for communication. That is, players are assumed to know a profile of equilibrium strategies, and the players find they individually have no incentive to deviate from those strategies. In the theories there is a set of subgame perfect equilibria, including rotating dictatorships, universal, minimal winning, and surplus coalitions, and symmetric and asymmetric allocations among coalition members. Moreover, players can have differing utility functions, which allows for additional equilibria. This leaves the questions of which, if any, of these equilibria would be played in a setting in which players may not know the equilibrium strategies or which strategies the other players will use. The experiment provides evidence on what players do as a function of communication that could support coordination on particular equilibria. Our main experimental treatment is the ability of players to negotiate with one another through unrestricted cheap-talk communication. Our hypothesis is

that communication serves as a selection device and can make some outcomes focal. For example, the coalition equilibria in Anesi and Seidmann and Baron and Bowen are particularly simple, are identity free, exhibit outcome and coalition stability, provide equal allocations to coalition members, and could be coordinated on through straightforward communication between the originator of the coalition and potential coalition partners.

4 Experimental Design

The experiments were conducted at the Columbia Experimental Laboratory for Social Sciences (CELSS) in March 2014 using students from Columbia University. Subjects were recruited from a database of volunteer subjects. Six sessions were run with a total of 120 subjects, and no subject participated in more than one session. All the interactions between subjects were performed through computers.[12] The 60 tokens available to each committee in each period corresponding to US$3.

In all committees the discount factor was $\delta = 0.8$. Discounting was induced by a random termination rule: after each period of the same game, a random number between 0 and 100 was drawn by the computer with the outcome determining whether the game continued to another period (with probability δ) or was terminated (with probability $1 - \delta$). This is a standard technique used in the experimental literature to preserve the incentives of infinite horizon games in the laboratory (Roth and Murnighan 1978, Palfrey and Rosenthal 1994, Dal Bo 2005, Duffy and Ochs 2009).

We use a novel implementation of this methodology introduced by Fréchette and Yuksel (2013), the block random termination rule: subjects play as in the standard random termination but in blocks of four periods. Within a block subjects get no feedback about whether or not the game has continued to that period, and they make choices that will be payoff-relevant contingent on the game actually having reached that point. After each block of four periods, subjects are told whether the game ended within that block and, if so, in what period; otherwise, they are told that the game has not ended yet, and they start a new block. Subjects are paid for periods only up to the end of a game, and all decisions for subsequent periods within that block are void with respect to payment. As shown by Fréchette and Yuksel (2013), this alternative implementation of an infinitely repeated game results in the same theoretical properties and in similar laboratory behavior as the standard random termination rule. This implementation is appealing for studying the formation and stability of coalitions, because it allows us to observe subjects' behavior for a greater number of

[12]Sample instructions are provided in Appendix E. The computer program used in the experiment was an extension to the open source software Multistage.

periods without changing the discount factor. In the empirical analysis, we use all available data, including data from periods that, *ex post*, were not used in determining payments to subjects. The methodology we employ ensures that every period played (including periods that, ex post, are not used to determine payments) was properly incentivized.

Sessions were conducted with a minimum of 15 subjects and a maximum of 24 subjects, divided into committees of 3 members each. Committees stayed the same throughout the periods of a given game, and subjects were randomly rematched into committees between games. Each game corresponded to one play of the infinitely repeated game, using the block termination rule.[13]

Our main experimental manipulation is the opportunity for subjects to negotiate with one another through unrestricted cheap-talk communication before a proposal comes to a vote. We compare committees with no communication, committees where communication is public and messages are observed by all committee members, and committees where communication is private and any committee member can send private messages to any other committee member. We conduct two sessions where communication is not allowed, two where only public communication is allowed, and two where only private communication between two committee members is allowed.

At the beginning of each game, subjects are randomly divided into committees of three members each. In each committee, subjects are assigned to be Committee Member 1, Committee Member 2, or Committee Member 3. This member assignment remains the same for all periods of a game. An initial status quo is randomly chosen by the computer, using a uniform distribution on the set of feasible allocations. The drawing of an initial status quo is independent across matches and across committees.[14] At the beginning of each period one of the three members is randomly selected to be the proposer, and his committee member number is revealed to the entire group. When communication is not allowed, the proposer proposes an allocation that is observed by all members of the group with shares to each member clearly indicated. Then, all members of the committee simultaneously vote to accept or reject the proposed allocation. If the allocation is supported by a simple majority of members, it passes, determines the distribution of the 60 tokens in this period, and becomes the new status quo allocation for the next period. If the allocation is rejected, the shares

[13] The length of the games ranged from 4 to 24 periods.

[14] The initial status quo is given exogenously, rather than, for example, being determined by bargaining à la Baron and Ferejohn (1989), to preserve symmetry of the bargaining protocol with the other periods of the game. Note that the theories discussed in the previous Section, do not depend on the initial status quo. Moreover, in Appendix C, we show that the exogenous status quo at the beginning of the game does not anchor outcomes beyond the first period, in particular, that it does not affect the committee allocation in the second round of the same game.

Session	Treatment	n	δ	Games	Subjects	Committees
1	Public Communication	3	0.8	4	21	28
2	Public Communication	3	0.8	4	21	28
3	Private Communication	3	0.8	4	21	28
4	Private Communication	3	0.8	4	24	32
5	Baseline (No Communication)	3	0.8	4	18	24
6	Baseline (No Communication)	3	0.8	4	15	20

Table 1: Experimental Design

in this period are determined by the status quo, which becomes the status quo for the next period. After each game, subjects are randomly re-matched to form new committees and assigned new committee member numbers.

In the Baseline treatment, no communication was allowed. The Public Communication and Private Communication treatments are similar to the Baseline treatment except for one feature. After the proposer was selected and his committee member number revealed, but before the proposer submitted his proposal, members of the committee could communicate with each other using a chat tool. In the Private Communication treatment, subjects could send private messages that were delivered only to a particular member. When a committee member sends a message to another, the third committee member does not know the content of this communication nor the fact that communication took place.[15] In the Public Communication treatment, subjects were only allowed to send messages that would be received by all the other members of their committee. The duration of the communication was in the hands of the proposer: the chat tool was disabled when the proposer submitted his proposal for a vote or after 120 seconds had passed. The software recorded all the messages sent by subjects during the communication stage. Table 1 summarizes the details of all the treatments.

5 Experimental Results

In this Section, we first compare the distribution of resources among committee members in the three treatments. Second, we identify dynamic coalitions and study whether their emergence and duration is facilitated by either type of communication. Finally, we explore the content of conversations to shed light on the mechanism behind the differences we observe in outcomes and coalitions. The statements on the differences among treatments are based on

[15]In the private communication treatment a committee member could send the same message to each other committee member, but one other member would not know the other had received the message.

Allocation Type	Baseline	Private	Public
DICTATOR	1%	5%†	1%
MAJORITY	27%	51%†	4%†
Even	11%	34%†	2%†
Uneven	16%	17%	2%†
UNIVERSAL	71%	45%†	95%†
Even	49%	31%†	90%†
Uneven	22%	14%†	5%†
Observations	328	472	252

Table 2: Allocation Types by Treatment. †: Significant Difference with Baseline ($p < 0.05$)

Wilcoxon-Mann-Whitney tests.[16] To allow for learning in the initial repetition of our infinite horizon divide-the-dollar game, we present and analyze the data from games 2 through 4 in each session. Unless stated explicitly, our statements about statistical significance are robust to considering the whole sample (that is, including data from the first game in the analyses).

5.1 Distribution of Resources

We begin the analysis of the experimental results by examining the bargaining outcomes, that is, the distribution of resources (60 tokens) at the end of a period. We define as "Dictatorial" allocations that give at least 50 tokens (that is, 83% of the pie) to a single committee member and define as "Universal" allocations that give at least 10 tokens (that is, 17% of the pie) to every member of the committee. All other allocations give a significant fraction of the pie to exactly two committee members (that is, to a minimal winning coalition) and we label them as "Majoritarian". In the latter two categories, we highlight allocations that give members an even number of tokens. For the Universal allocations, this correspond to the outcome [20 20 20]; for the Majoritarian allocations, this includes all outcomes of the form $[b, b, 60 - 2b]$ where $b \in (25, 30]$. Table 2 presents the distribution of these outcome types across different treatments.[17]

[16] We use as significance threshold a p-value of 0.05. The comparisons are unchanged if we use independent samples t-tests whose standard errors are clustered by groups composed of the same subjects.

[17] In Appendix A, we show that our results are robust to a different definition of Majoritarian and Universal allocations: we define allocations that give at least 50 tokens (that is, 83% of the pie) to a single member as Dictatorial; allocations that give at least 15 tokens (that is, 25% of the pie) to every member as Universal; and allocations that give at least 20 tokens (that is, 33% of the pie) to two members and less than 15 to the other as Majoritarian.

FINDING 1: Private communication makes Majoritarian outcomes—in particular, those with even sharing between two group members—more likely and Universal outcomes less likely. Public communication makes Majoritarian outcomes less likely, and Universal outcomes more likely.

Table 2 shows that the frequency of Majoritarian outcomes is 27% when communication is not allowed, 51% when only private communication is allowed, and 4% when public communication is allowed. The frequency of universal outcomes is 71% with no communication, 45% with private communication, and 95% with public communication. These differences are statistically significant.[18] The difference in the incidence of Majoritarian allocation between the treatment with no communication and the treatment with private communication is due to the difference in Majoritarian allocation with equal resource sharing between two committee members, which triples (from 11% to 34%). Strikingly, subjects who communicate publicly divide resources perfectly evenly (that is, 20 tokens each) 90% of the time.

Private communication increases the frequency of outcomes with even distribution among the members of a minimal winning coalition, which is consistent with the prediction of Baron and Bowen (2015) and supportive of the even distribution outcomes in Anesi and Seidmann (2015). While Dictatorial outcomes are more frequent when subjects can communicate privately, the findings for all treatments are inconsistent with a rotating dictator equilibrium as in Kalandrakis (2004) and Battaglini and Palfrey (2012) (for a linear utility function), where allocations belong to the Dictatorial region in almost every period.

The results from Table 2 suggest that the opportunity to communicate favors the emergence of outcomes where two or three committee members share the resources more evenly than in the baseline treatment where no communication is allowed. What does this mean for the share allocated to the proposer, or for the *proposer's advantage*?

FINDING 2: Public communication decreases the proposer's advantage. Private communication does not affect the proposer's advantage.

Table 3 shows the results of Tobit regressions where the dependent variable is the share allocated to a committee member at the end of a period. This amount depends positively on the share to a committee member in the status quo at the beginning of that period. It also depends on the role a committee member serves in that period, with proposers receiving more than non-proposers. Interestingly, this proposer's advantage is unchanged with private communication and severely dampened by public communication. This result is in stark

[18] When using the whole sample, the fraction of Dictatorial outcomes is significantly higher in Public Communication than in the Baseline (3% vs. 1%); the fraction of Majoritarian Even in Public Communication is indistinguishable from the Baseline (9% vs. 12%). All other comparisons are unchanged.

Dependent Variable: Share Allocated to Member i		
Share to i in Status Quo	0.12*	0.13*
	(0.07)	(0.07)
i Proposes	6.88***	6.75***
	(1.49)	(1.46)
i Proposes * Private	-0.95	
	(1.93)	
i Proposes * Public		-5.89***
		(1.51)
Constant	15.04***	15.11***
	(1.23)	(1.18)
Treatments	Base & Private	Base & Public
Observations	2,400	1,740
Pseudo R-Squared	0.0504	0.0211

Table 3: Tobit Regressions. SE Clustered by Groups. Other Regressors: Treatment Dummies and Interaction with Share in SQ. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

contrast with experiments on the static bargaining game à la Baron and Ferejohn (1989) studied by Agranov and Tergiman (2014*a*,*b*) and Baranski and Kagel (2015), where, under simple majority, the proposer gains from the introduction of either type of communication due to the reduction in uncertainty and to the competition among potential coalition partners for inclusion in the coalition.[19] This suggests that a different mechanism might be at play in the dynamic game studied here. However, notice that, in both the static and the dynamic games, communication gets the observed allocations closer to the allocations from an equilibrium. In the static bargaining game there is a unique stationary SPE outcome, and the question is whether play is according to that equilibrium. In our dynamic legislative bargaining game, proposers can prefer to sacrifice proposal power for durability of their coalition. Many outcomes are supported by a stationary MPE, and the question is which equilibrium is selected with communication. To explore this question, we next move to the analysis of coalitions.

5.2 Coalition Formation and Duration

In Table 2, we classified outcomes in types which do not take into account the identity of the members who share the resources (in particular, for the Dictatorial and Majoritarian

[19]These experiments are with committees composed of five members. In the communication treatments of Agranov and Tergiman (2014*a*,*b*), subjects can send a message to any subset of members in their group (that is, they can send messages both privately and publicly). Baranski and Kagel (2015) have two communication treatments, analogous to our private and public communication. Agranov and Tergiman (2014*b*) also provide evidence on committees deciding with unanimity rule.

allocations). We define a *dynamic coalition* as a committee that continues from one period to the next with the same outcome.[20] To investigate the emergence and persistence of dynamic coalitions, we study the evolution of outcomes over time. Since the status quo in the first period of a game is exogenous, we exclude the first period from the analyses presented in this subsection (that is, we only include periods whose status quo is endogenous).[21]

	Pr(Allocation = Status Quo)		
Status Quo Type	**Baseline**	**Private**	**Public**
DICTATOR	0.33 (3)	0.38 (21)	-
MAJORITY	0.18 (79)	$0.58^{\dagger}$ (219)	0.00 (9)
UNIVERSAL	0.67 (213)	0.69 (187)	$0.93^{\dagger}$ (201)
Observations	295	427	210

Table 4: Allocation Stability. Number of observations for each status quo type and treatment in parentheses. †: Significant Difference with Baseline ($p < 0.05$).

FINDING 3: Private communication increases the persistence of Majoritarian outcomes or, in other words, increases the frequency of Majoritarian coalitions. Public communication increases the persistence of Universal coalitions or, in other words, increases the frequency of Universal coalitions.

Table 4 shows the probability that an outcome persists or, in other words, the probability that a dynamic coalition is in place, for each of the three treatments. The same Majoritarian outcome persists 18% of the time without communication, 58% of the time with private communication and 0% of the time with public communication. The difference between private communication and the baseline is statistically significant. The same Universal outcome persists 67% of the time without communication, 69% of the time with private communication and 93% of the time with public communication. The difference between public communication and the baseline is statistically significant.[22]

[20]In Appendix B, we show that our results are robust to a different, less stringent, definition of dynamic coalitions. We define a *weak dynamic coalition* as a committee that channels resources to the same subset of members as in the previous period. In particular, we consider three dictatorial allocation types (those that give most of the resources, respectively, to member 1, 2, or 3), three Majoritarian allocation types (those where the resources are divided between members 1 and 2; members 1 and 3; and members 2 and 3) and one Universal allocation type. A weak dynamic coalition is a committee that continues from one period to the next with an allocation of the same type.

[21]The results presented in this subsection (and in the following one, when discussing dynamic coalitions) are unchanged if we include the first period in the analysis of status quo persistence and if we allow a dynamic coalition to start in the first period of a game.

[22]When using the whole sample, Majoritarian allocations are more stable in Public Communication than

Private communication, thus, is associated with coordinating on Majoritarian outcomes and sustaining a bilateral coalition over time. Public communication, instead, is associated with coordinating on Universal outcomes and sustaining a trilateral coalition over time. This finding suggests that players are less willing to participate in coalitions that disadvantage one player when communication is public and exposed to all players. This could be due to a fear that they will be the disadvantaged player in a future period. It could also be due to a desire to be fair to all players in public. This interpretation is supported by the players' use of words corresponding to fairness as discussed in Section 4.3 below.

Finally, we investigate whether the duration of a coalition is affected by the opportunity to communicate. To do this, we focus on Majoritarian and Universal coalitions.[23]

	Dependent Variable: Coalition Duration		
Private Communication	1.94***	-1.16	
	(0.45)	(1.02)	
Public Communication			2.91***
			(0.68)
Game Length	-0.03	0.22*	0.65***
	(0.06)	(0.13)	(0.14)
Constant	1.43*	2.32*	-2.31**
	(0.74)	(1.38)	(1.13)
Treatments	Base & Private	Base & Private	Base & Public
Coalition Type	Majoritarian	Universal	Universal
Observations	56	66	72
R^2	0.0908	0.0983	0.3822

Table 5: OLS Regressions. SE Clustered by Groups. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Note: In Public Communication, there is no Majoritarian coalition.

FINDING 4: Private communication increases the duration of Majoritarian coalitions; public communication increases the duration of Universal coalitions.

Coalitions exogenously dissolve when a game ends. Since the length of a game is stochastic, it is important to control for the number of periods in a game when assessing whether the duration of coalitions is statistically different in different treatments. To do so, we run a OLS regression where the dependent variable is the number of periods a dynamic coalition persists. The independent variables are the treatment (public communication or private communication, compared to the baseline, that is, no communication) and the length of a

in the Baseline (46% vs. 22%). The other comparisons are unchanged.

[23]We exclude persisting dictatorial outcomes, which are approximately 1% of the data.

game. The results from Table 5 indicate that, introducing private communication, increases the duration of a Majoritarian coalition of around 2 periods (with respect to the baseline with no communication; at the average game length). Introducing private communication does not affect the duration of a Universal coalition but introducing public communication increases the duration of a Universal coalition of around 3 periods (with respect to the baseline with no communication; at the average game length).[24]

5.3 Analysis of Conversations

The analyses presented above show marked differences in outcomes between the baseline treatment with no communication and the treatments with private or public communication. To shed light on the mechanism underlying these differences, we now analyze the messages exchanged in the treatments allowing for communication. In this Section, we answer the following questions: How does private communication differ from public communication? What aspects of communication (volume, participants, direction, content) matter for the allocation of resources and the duration of a dynamic coalition?

We start by noting that subjects did take advantage of the possibility to communicate with other committee members. Some conversation preceded most decisions, especially at the beginning of a game: the fraction of periods with some conversation is 62%; 92% of committees communicated in the first period of a game. Moreover, 99% of committees has conversations in at least one period of the game. Table 6 gives the breakdown of communication usage by treatment and presents the average number of messages (overall as well as by sender and by recipient), for each treatment.

	Private Comm.	**Public Comm.**
Any Message Sent (All Periods)	66%†	55%
Any Message Sent (Period 1)	91%	93%
Number of Messages (All Periods)	4.22†	3.36
From Proposers	1.51†	1.20
From Non-Proposers	2.70†	2.15
Non-Proposer $\rightarrow$ Proposer	1.67	—
Non-Proposer $\rightarrow$ Non-Proposer	1.03	—
Number of Messages (Period 1)	6.00†	3.86

Table 6: Use of Communication. †: Significant Difference with Public Communication($p < 0.05$).

[24] With experienced subjects, there are no Majoritarian coalitions with public communication. This can also be seen from Table 4: there are 9 Majoritarian status quo allocations and none of them persists. When using the whole sample, public communication does not affect the duration of either type of coalition.

FINDING 5: Subjects communicate more privately than publicly.

There are more decisions preceded by conversations with private than with public communication (66% versus 55%) and the average number of messages exchanged in a period is higher with private than with public communication (4.22 versus 3.36 in all periods; 6.00 vs. 3.86 in the first period of a game). These differences are statistically significant.[25]

Table 6 shows two other interesting results: a proposer does not send a different number of messages than a non-proposer in either treatment.[26] At the same time, when communication is private, non-proposers are more likely to contact the proposer rather than the other non-proposer.[27] Non-proposers might feel that communicating with the member who has the power to set the agenda is more fruitful in terms of steering the decision of the committee towards what they prefer. This is in line with the experimental literature on unrestricted communication in bilateral bargaining, which has highlighted the positive effect of asking on receiving more resources (Andreoni and Rao 2011). We next investigate whether this is true also in our dynamic multilateral bargaining setting.

FINDING 6: With private communication, receiving (sending) more messages is correlated with being assigned more (less) resources.

Table 7 reports the results of Tobit regressions where the dependent variable is the allocation to each committee member at the end of a period and the independent variables are the allocation to this member in the status quo at the beginning of that period, and the number of messages sent or received by this member in the period. In the private communication treatment, the sender can choose the recipients of his/her message, so we differentiate the number of messages sent (received) by the role of the recipient (sender). For all treatments and all roles, sending a message is negatively correlated with the tokens assigned at the end of the period, while receiving a message is positively correlated with the tokens assigned at the end of the period. With the exception of the number of messages sent from a non-proposer to a non-proposer, these correlations are statistically significant in

[25]When including unexperienced subjects, the only statistically significant difference is for number of messages exchanged in the first period of a game.

[26]This statement takes into account that there are two non-proposers and only one proposer in each period and in each group. Table 6 reports the average number of messages sent by the two non-proposing members in a period. The average number of messages sent by a single non-proposing member in a period is 1.35 with private communication, and 1.08 with public communication. These averages are not statistically distinguishable from the average number of messages sent by a proposer in the respective treatments.

[27]The difference between the average number of messages sent by a non-proposer to a proposer and the average number of messages sent by a non-proposer to a non-proposer (0.64) is statistically significant at the 1% confidence level.

	Dependent Variable: Own Allocation			
Own Allocation in SQ	0.70***	0.57***	-0.02	-0.03
	(0.06)	(0.07)	(0.11)	(0.05)
# Messages to Non-Prop	-1.35***	-0.49		
	(0.42)	(0.51)		
# Messages from Non-Prop	1.13***	1.04**		
	(0.29)	(0.47)		
# Messages to Prop		-0.68*		
		(0.39)		
# Messages from Prop		2.44***		
		(0.58)		
# Messages to All Others			-0.12	-0.06
			(0.09)	(0.07)
# Messages from Any Other			0.07	0.02
			(0.10)	(0.02)
Constant	9.36***	4.10***	20.94***	20.25***
	(1.93)	(1.44)	(2.31)	(0.90)
Role	Proposer	Non-Proposer	Proposer	Non-Proposer
Treatment	Private	Private	Public	Public
Observations	472	944	252	504
R^2	0.094	0.051	0.001	0.001

Table 7: Tobit Regressions. SE Clustered by Groups. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

the private communication treatment.[28] Being on the receiving end of communication might increase the resources to oneself because communication initiators, or senders, use private messages with the goal of building a coalition. In what follows, we explore this possibility, investigating the content of messages.

In analyzing the content of communication, we search for expressions or keywords and assign messages containing them to one or more semantic domain. First, we identify all messages that include a numerical suggestion on how to divide the 60 tokens among the three committee members. In particular, we classify messages that contain '30-30' as 'Suggest 30-30-0'; messages that contain '20-20-20' as 'Suggest 20-20-20'; and messages that contain any other triplet of numbers summing to 60 as 'Suggest Other Allocation'.[29] Second, we identify the messages that contain at least one word or expression about fairness ('Lobby

[28] When using the whole sample, the coefficient for Own Allocation in SQ in the last two columns is positive and significant at the 1% confidence level; the coefficient of # Messages to Non-Prop in the second column is negative and significant at the 10% confidence level.

[29] In identifying messages that belong to the domains 'Suggest 30-30-0' and 'Suggest 20-20-20', we consider all possible variations of presenting these numbers in a message, as '20-20-20', '20/20/20', '202020', '20 20 20', and so on.

	Private Comm.					Public Comm.		
	ALL	P	NP	NP > P	NP > NP	ALL	P	NP
Lobby Themselves	0.02†	0.02	0.03	0.03	0.03	0.01	0.01	0.01
Lobby Fairness	0.06	0.08⋆	0.05	0.06	0.04	0.06	0.04	0.07
Form Coalition	0.14†	0.16	0.13	0.12	0.14	0.03	0.02	0.03
Suggest 20-20-20	0.06	0.07	0.06	0.05	0.06	0.05	0.03⋆	0.06
Suggest 30-30-0	0.04†	0.06⋆	0.04	0.04	0.03	0.01	0.01	0.01
Suggest Other	0.03†	0.05⋆	0.03	0.03	0.02	0.01	0.00	0.01

Table 8: Fraction of Messages Belonging to Semantic Domain. ALL is for all members; P is for Proposers; NP is for Non-Proposers; NP > P is for Non-Proposers speaking to Proposer; NP > NP is for Non-Proposers speaking to Non-Proposer. †: Significant Difference with Public Communication Treatment ($p < 0.05$). ∗: Significant Difference with Non-Proposers in Same Treatment ($p < 0.05$). There is no significant difference between Non-Proposers speaking to Proposer and Non-Proposers speaking to Non-Proposer.

for Fairness'), about obtaining resources for oneself ('Lobby for Themselves'), and about forming a coalition ('Form a Coalition').[30] Table 8 shows the frequency of messages related to each of these semantic domains by treatment, by sender and by receiver.

FINDING 7: The content of messages is different in different treatments and for different type of senders.

Private messages are more likely than public messages to be about lobbying for oneself, forming a coalition or proposing an allocation of resources other than [20-20-20]. Messages advocating for fairness and proposing an even allocation of resources have similar frequencies in both communication treatments. In both treatments, proposers are more likely than non-proposers to advocate for fairness (in private messages with words; in public messages, with a numerical suggestions to divide the pie evenly) and to make a precise suggestion for an allocation. Private messages sent by non-proposers do not statistically differ in content depending on whether they are directed to the proposer or to the other non-proposer.

Finally, we investigate whether we can relate the content of conversations to actual outcomes and coalitions. Tables 9 and 10 show how outcome type and the duration of dynamic

[30] Examples of words or expressions that lead a message to be classified as 'Lobby for Fairness' are 'equal', 'fair', 'give him'. Examples of words or expressions that lead a message to be classified as 'Lobby for Themselves' are 'give me', 'help me', 'I want'. Examples of words or expressions that lead a message to be classified as 'Form a Coalition' are 'alliance', 'trust', 'team', 'loyal', 'deal'. Some messages were classified as belonging to multiple semantic domains, for example: 'any chance you could make it a little more fair? help me out!'. The messages that do not belong to any of these semantic domains have mostly to do with timing, wanting the game to end, discussing the rules of the experiment, and interpreting the incentives. The complete list of words and expressions determining whether a message was identified as belonging to each of these semantic domains is available in Appendix D. We performed the search both algorithmically and manually. The full transcripts of the chats and the classifications are available from the authors upon request.

	Pr{Universal Outcome}			
# Messages	-0.05*	-0.00	-0.02	-0.00
	(0.03)	(0.03)	(0.04)	(0.04)
% Lobby for Themselves	- 1.15	-6.49**	-0.61	-9.77
	(1.23)	(2.62)	(1.34)	(5.99)
% Lobby for Fairness	2.73***	8.24***	3.23***	3.82
	(0.94)	(2.93)	(1.15)	(2.93)
% Form a Coalition	-1.30*	-0.93	-1.39	-0.81
	(0.68)	(1.55)	(0.89)	(1.91)
% Suggest 20-20-20	5.32***	4.65*	5.77***	
	(1.19)	(2.57)	(1.38)	
% Suggest 30-30-0	-3.45***	-0.83	-4.06***	
	(0.99)	(3.32)	(1.42)	
Constant	0.28	1.55***	-0.09	3.04***
	(0.28)	(0.47)	(0.33)	(0.53)
Treatment	Private	Public	Private	Public
Subjects	All	All	Experienced	Experienced
Observations	638	433	450	251
Pseudo R^2	0.078	0.064	0.087	0.018

Table 9: Logit Regressions. SE Clustered by Group.* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Note: Observations do not include periods with Dictatorial outcomes. In last column, '% Suggest 20-20-20' and '% Suggest 30-30-0' are dropped because positive values predict success perfectly. For this reason, we also show regressions for the whole sample.

coalitions are correlated with the total number of messages exchanged, and the fraction of messages belonging to each semantic domain (respectively, in a period and for the whole duration of the dynamic coalition). These tables do not identify whether the messages help in attaining a particular outcome or coalition or whether the messages are used to explain an action taken on other grounds.

FINDING 8: The content of messages is correlated to allocation types and to the duration of dynamic coalitions.

With private communication, messages advocating for fairness and suggesting a 20-20-20 allocation are positively correlated with Universal allocations; suggesting a 30-30-0 allocation, on the other hand, is negatively correlated with a Universal allocation. With public communication, proposing a 20-20-20 allocation is correlated with Universal allocations.[31]

[31] As shown in Table 9, when using the whole sample, the number of messages in a period and the fraction of messages about forming a coalition are significantly and negatively correlated with Universal allocations when communication is private; the fraction of messages advocating for fairness is significantly and positively correlated with Universal allocations when communication is public.

	Dependent Variable: Coalition Duration		
# Messages per Round	-0.06	-0.20	-0.23***
	(0.07)	(0.20)	(0.06)
% Lobby for Themselves	4.13	-1.78	61.14***
	(3.01)	(15.13)	(20.27)
% Lobby for Fairness	2.02	-1.62	4.02***
	(7.90)	(5.12)	(1.47)
% Form a Coalition	0.82	6.39	24.25***
	(1.44)	(5.59)	(6.11)
% Suggest 20-20-20	-4.28**	2.52	2.93
	(1.78)	(4.34)	(1.86)
% Suggest 30-30-0	0.34	-14.08	-23.01***
	(1.49)	(15.40)	(5.79)
Game Length	-0.02	0.23	0.95***
	(0.08)	(0.19)	(0.06)
Constant	3.27***	1.35	-0.97***
	(0.87)	(1.59)	(0.32)
Coalition Type	Majoritarian	Universal	Universal
Treatment	Private	Private	Public
Observations	43	35	41
R^2	0.0470	0.1551	0.9374

Table 10: OLS Regressions. SE Clustered by Groups. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Note: In Public Communication, there is no Majoritarian coalition.

This suggests that both forms of communication support a norm of fairness by making equal divisions more salient and that private communication leads to Majoritarian outcomes when communication is used to suggest a bilateral division of resources to a potential coalition partner.

With private communication, the duration of a Majoritarian dynamic coalition is negatively correlated with the fraction of messages suggesting a 20-20-20 allocation. With public communication, the duration of a Universal coalition is negatively correlated with the average number of messages per period and with the fraction of messages suggesting a 30-30-0 allocation; and positively correlated with the fraction of messages lobbying for oneself, advocating for fairness and discussing the formation of a coalition.[32]

[32]When using the whole sample, % Lobby for Themselves is significantly and positively correlated with duration of Majoritarian coalitions in private communication; # Messages per Round is significantly and negatively correlated with duration of Universal coalitions in private communication; % Form a Coalition and Game Length are significantly and positively correlated with duration of Universal coalitions in private communication; and no independent variable is significantly correlated with duration of Universal coalitions in Public Communication treatment; the other coefficients have the same sign and significance levels.

These findings are consistent with players with preferences for fairness using the expressions in our semantic domain 'Lobbying for Fairness' as well as suggesting a 20-20-20 allocation to obtain even allocations, and it is also consistent with players viewing a universal outcome as focal using fairness terms to communicate their view. As detailed in Appendix D, we included in the 'Form a Coalition' domain keywords and expressions that can be related to history-dependent strategies: 'betray', 'deviate', 'retaliate', 'cheat', 'lie', 'revenge', 'promise', 'punish' (and words sharing the same root). This suggests that Universal dynamic coalitions are supported by threats or punishment. However, the extent to which the effect of these terms is causal cannot be gauged by our experimental design (the content of messages being endogenously chosen by subjects).

6 Conclusions

In this paper, we presented a laboratory experiment to study the formation of durable coalitions in a dynamic bargaining setting. Our experimental manipulation is the opportunity of players to communicate with one another. The three treatments in the experiment are: committees that cannot communicate, committees that can engage in private conversations before a proposal is made, and committees that can engage in public conversations before a proposal is made.

With regard to the research questions posed in the Introduction, we find that the opportunity to communicate has a significant impact on the formation of coalitions and, consequently, on how resources are allocated. When communication is possible, dynamic coalitions emerge more frequently and last longer. Players take advantage of the opportunity to discuss the game with others before a proposal is put on the table. Communication is more intense with private communication than with public communication; players who can communicate privately engage in more lobbying for themselves, are more likely to discuss the formation of a partnership or to suggest a non-universal allocation of the pie. Messages related to fairness are positively correlated with universal allocations in both communication treatments and lead to longer dynamic coalitions with public communication. Communication increases the frequency and duration of dynamic coalitions and selects different outcomes. With public communication, universal coalitions are focal outcomes, and with private communication, minimal-winning coalitions are focal. Compared to the treatment with no communication, private communication increases the selection of majoritarian coalitions and decreases the selection of universal coalitions, whereas public communication has the opposite effect.

The experimental evidence presented in this paper suggest that there is a role for social interaction and communication in theories of dynamic legislative bargaining and points the-

orists to a fruitful direction for future research. This role may be in affecting the norm of fairness, in reducing strategic uncertainty or the fear of exclusion from a less-than-universal coalition, and in coordinating players' strategies to attain particular types of equilibria. Our results suggest that not only the existence of a communication channel but also the mode of this communication matters in selecting equilbria. Selection could be reinforced by experience. With private communication play results in a higher frequency of minimal winning coalitions as players become more experienced, whereas with public communication universal coalitions become more frequent.

Given the absence of theories encompassing communication, this experiment is not a test of the existing theories on the dynamic divide-the-dollar game. Nonetheless, existing theories for the dynamic divide-the-dollar game with no communication help us understand the incentives present in the experiment.[33] The gap in that understanding pertains to universal coalitions. The modal outcome in all the experimental treatments is a universal allocation, and most of the universal outcomes have even sharing among the coalition members. Three explanations of this are consistent with theory.[34] The first is extreme risk aversion as in the Battaglini and Palfrey (2012) model, but the required risk aversion is so extreme as to be unbelievable in the experimental setting. The second is player-specific punishments that deter individual players from deviating from the equilibrium path to take short-term gains. This takes fairly sophisticated strategies and implicit threats of punishment. As discussed in Section 5, messages related to such history-dependent strategies are somehow correlated with the presence and duration of universal coalitions. The third possible explanation is preferences that are not selfish but instead exhibit a degree of altruism that could generate a norm of fairness that supports universal allocations. This explanation is consistent with the overall experimental findings, but experiments designed to identify the foundations of and measure the strength of a norm of fairness are needed before concluding that a norm explains outcomes. As Cooper and Kagel (Forthcoming) note in their survey of the empirical finding in sequential (one-shot) legislative bargaining that distributions within coalitions are more even than predicted by theory, "more is going on in games of this sort than we currently understand."

[33]Note also that the equilibria of the dynamic divide-the-dollar games with no communication are babbling equilibria of the same game with communication.

[34]The universal allocation is also not explained, for example, by the von Neuman-Morgenstern solution concept in cooperative game theory, which selects minimal winning coalitions with even allocations within the coalitions.

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Appendix A: Alternative Definition of Allocation Types

In the paper, we defined as "Dictatorial" allocations that give at least 50 tokens (that is, 83% of the pie) to a single committee member; as "Universal" allocations that give at least 10 tokens (that is, 17% of the pie) to every member of the committee; and as "Majoritarian" all other allocations. Here, we show that the results are robust to a different definition of Majoritarian and Universal allocations. In particular, we define as Dictatorial allocations that give at least 50 tokens (that is, 83% of the pie) to a single member; as Universal allocations that give at least 15 tokens (that is, 25% of the pie) to every member; and as Majoritarian allocations that give at least 20 tokens (that is, 33% of the pie) to two members and less than 15 to the other. As we did for our original classification, in the latter two categories, we highlight allocations that give members an even number of tokens. For the Universal allocations, this correspond to the outcome [20 20 20]; for the Majoritarian allocations, this includes all outcomes of the form $[b, b, 60 - 2b]$ where $b \in (22, 30]$.

Allocation Type	**Baseline**	**Private**	**Public**
DICTATOR	1%	5%†	1%
MAJORITY	36%	58%†	7%†
Even	18%	40%†	4%†
Uneven	17%	18%	3%†
UNIVERSAL	56%	34%†	92%†
Even	49%	31%†	90%†
Uneven	7%	4%	2%†
OTHER	7%	3%†	1%†
Observations	328	472	252

Table 11: Alternative Definition of Allocation Types. Allocation Types by Treatment. †: Significant Difference with Baseline ($p < 0.05$).

Status Quo Type	Pr(Allocation = Status Quo) Baseline	Private	Public
DICTATOR	0.33	0.38	-
MAJORITY	0.19	0.55†	0.13
UNIVERSAL	0.80	0.80	0.95†
OTHER	0.11	0.18	-
Observations	295	427	210

Table 12: Alternative Definition of Allocation Types. Allocation Stability. †: Significant Difference with Baseline ($p < 0.05$).

	Dependent Variable: Coalition Duration			
Private Communication	1.68***	-0.99		
	(0.48)	(1.20)		
Public Communication			-0.82**	2.31***
			(0.34)	(0.66)
Game Length	-0.05	0.50**	-0.06*	0.84***
	(0.06)	(0.21)	(0.03)	(0.11)
Constant	1.95***	0.71	2.05***	-2.74***
	(0.67)	(2.11)	(0.43)	(0.93)
Treatments	Baseline & Private	Baseline & Private	Baseline & Public	Baseline & Public
Coalition Type	Majoritarian	Universal	Majoritarian	Universal
Observations	52	43	10	62
R^2	0.0562	0.3224	0.1486	0.6383

Table 13: Alternative Definition of Allocation Types. OLS Regressions. SE Clustered by Groups. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

		Pr{Universal Outcome}		
# Messages	-0.10**	-0.03	-0.08*	-0.05
	(0.04)	(0.02)	(0.05)	(0.03)
% Lobby for Themselves	-2.58	-5.08***	-3.04	-5.65
	(1.72)	(1.89)	(2.57)	(8.82)
% Lobby for Fairness	2.08**	3.80**	3.32***	1.87
	(0.89)	(1.69)	(1.13)	(1.52)
% Form a Coalition	-1.75**	-0.89	-1.97	-1.49
	(0.85)	(1.51)	(1.26)	(1.48)
% Suggest 20-20-20	4.68***	6.67**	5.74***	9.54*
	(0.96)	(2.61)	(1.25)	(5.74)
% Suggest 30-30-0	-3.81***	0.74	-4.31***	
	(1.11)	(2.84)	(1.57)	
Constant	0.07 1.28***	-0.29	2.56***	
	(0.29)	(0.40)	(0.35)	(0.45)
Treatment	Private	Public	Private	Public
Subjects	All	All	Experienced	Experienced
Observations	638	433	450	251
Pseudo R^2	0.100	0.056	0.118	0.051

Table 14: Alternative Definition of Allocation Types. Logit Regressions. SE Clustered by Group.* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Note: Observations do not include periods with Dictatorial outcomes. In last column, '% Suggest 30-30-0' is dropped because positive values predict success perfectly. For this reason, we also show regressions for the whole sample.

	Dependent Variable: Coalition Duration		
# Messages per Round	-0.06	0.01	-0.24***
	(0.06)	(0.22)	(0.06)
% Lobby for Themselves	2.60		67.52***
	(2.31)		(20.51)
% Lobby for Fairness	-2.68	-3.83	3.48**
	(5.94)	(6.26)	(1.59)
% Form a Coalition	0.81	8.87	22.34***
	(1.40)	(5.53)	(6.10)
% Suggest 20-20-20	-4.49***	-1.43	2.74
	(1.61)	(6.30)	(1.88)
% Suggest 30-30-0	0.06	-34.61*	-21.53***
	(1.22)	(18.67)	(5.85)
Game Length	-0.01	0.55**	0.93***
	(0.06)	(0.27)	(0.06)
Constant	3.07***	-1.16	-0.73**
	(0.70)	(2.37)	(0.28)
Coalition Type	Majoritarian	Universal	Universal
Treatment	Private	Private	Public
Observations	52	24	39
R^2	0.0469	0.4716	0.9532

Table 15: Alternative Definition of Allocation Types. OLS Regressions. SE Clustered by Groups. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Note: In Public Communication, there is no Majoritarian coalition. In second column, % Lobby for Themselves is omitted because of collinearity.

Appendix B: Weaker Definition of Dynamic Coalition

	Pr(Allocation in Same Region as Status Quo)		
Status Quo Type	**Baseline**	**Private Comm.**	**Public Comm.**
DICTATOR	0.33	0.57	-
MAJORITY	0.22	0.71†	0.22
UNIVERSAL	0.88	0.86	0.98†
Observations	295	427	210

Table 16: Weaker Definition of Coalition. Allocation Stability. †: Significant Difference with Baseline ($p < 0.05$). Note: In whole sample, Majoritarian coalitions are more stable in Public Communication than in Baseline (0.59 vs. 0.27; p-value: 0.0000).

	Dependent Variable: Coalition Duration		
Private Communication	1 2.73***	-1.15	
	(0.45)	(1.00)	
Public Communication			2.10***
			(0.68)
Game Length	0.01	0.15	0.57***
	(0.07)	(0.11)	(0.15)
Constant	1.00	3.81***	-0.74
	(0.78)	(1.28)	(1.20)
Treatments	Base & Private	Base & Private	Base & Public
Coalition Type	Majoritarian	Universal	Universal
Observations	57	69	75
R^2	0.1951	0.0589	0.3055

Table 17: Weaker Definition of Coalition. OLS Regressions. SE Clustered by Groups. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Note: In Public Communication, there is no Majoritarian coalition. Note: In whole sample, the coefficient of the dummy for Public Communication treatment is indistinguishable from zero for both types of coalitions.

	Dependent Variable: Coalition Duration		
# Messages per Round	0.11	-0.04	-0.13
	(0.11)	(0.23)	(0.10)
% Lobby for Themselves	-0.11	-4.49	22.69
	(3.09)	(9.60)	(39.38)
% Lobby for Fairness	-0.87	-2.87	2.08*
	(13.53)	(2.23)	(1.06)
% Form a Coalition	5.77***	3.08	15.62**
	(1.94)	(4.23)	(6.98)
% Suggest 20-20-20	3.83	-0.49	-0.46
	(19.21)	(1.79)	(2.93)
% Suggest 30-30-0	1.20	-9.31	-15.15**
	(2.17)	(10.44)	(6.94)
Game Length	0.04	0.13	0.98***
	(0.08)	(0.17)	(0.05)
Constant	2.14**	3.35*	-0.99***
	(0.85)	(1.79)	(0.24)
Coalition Type	Majoritarian	Universal	Universal
Treatment	Private	Private	Public
Observations	41	35	41
R^2	0.1133	0.0874	0.9599

Table 18: Weaker Definition of Coalition. OLS Regressions. SE Clustered by Groups. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Note: In Public Communication, there is no Majoritarian coalition.

Appendix C: Irrelevance of Exogenous Status Quo

Dependent Variable: Share Allocated to Member i			
Share to i in Current SQ (Endogenous)	-0.08	0.51**	-0.05
	(0.23)	(0.20)	(0.09)
Share to i in Initial SQ (Exogenous)	-0.14	-0.11	0.01
	(0.13)	(0.09)	(0.02)
Constant	24.05***	11.24**	21.00***
	(3.56)	(4.82)	(1.96)
Observations	99	135	126
Period	2	2	2
Treatment	Baseline	Private	Public
Pseudo R-Squared	0.006	0.025	0.002

Table 19: Tobit Regressions. SE Clustered by Groups. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. When using the whole sample, the coefficients of Share to i in Current SQ in the last two columns are positive and significant at the 1% confidence level.

Appendix D: List of Keywords for Semantic Domains

A message belongs to a class if it contains the following words or expressions:

1. Lobby for Themselves: 'help me', 'help a friend out', 'give(s) me', 'gimme', 'gave me', 'leave me', 'X would be enough for my vote', 'X is enough for my vote', 'I'll vote for with X', 'as long as I get X', 'can I have more', 'let me earn', 'move me up', 'I (really) need', 'I need', 'I (would) want', 'bump me up'.

2. Lobby for Fairness: equal, equally, equality, equitability, equitably, equitable, egalitarian fair, fairly, fairer, fairness, unfair, greedy, greed, justice, 'feel bad', 'felt bad', 'feel kinda bad', 'felt a little bad', 'give him', 'leave him', selfish, even, evenly, evens, balance, balances, balancing, unbalanced, generous, parity, 'let him have', 'for everyone', socialism, distribute, redistribution, distribution, 'move him up'.

3. Form a Coalition: alliance, allied, ally, allying, trust, (un)trustworthy, trusted, team(s), teamwork, teammate, loyal, loyalty, betrayal, betray, betrayed, betraying, together, deal(s), 'give you', 'gives you', 'giving you', 'gave you', deviate(s), deviation(s), defect(s), defector, 'help(ing/ed) you', 'each other', revenge, retaliation, unite, promise(d), commit, collude, colluding, stick(ing), stuck, cheated, cheater, cooperating, cooperation, cooperated, punishment, punishing, punished, lie(s), lied, reciprocate, 'I will/'ll do the same', 'I do the same', 'can I count on your vote?', 'support my proposal', 'bump you up', 'bring you up', 'between us', pact, 'both of us'.

Appendix E: Instructions (Private Communication)

This is an experiment in group decision making. The instructions are simple, and if you follow them carefully and make good decisions, you can earn a considerable amount of money which will be paid to you in cash at the end of the experiment. The currency in this experiment is called tokens. The total amount of tokens you earn in the experiment will be converted into US dollars using the rate of 20 Tokens = $1. In addition, you will get a $5 participation fee.

This experiment consists of 4 Matches. In every Match you will each be randomly and anonymously matched with two other participants in the room to form groups of three. Each member of the group will be assigned a group member number (from 1 to 3). Your group as well as your group member number will remain the same within a Match but will change between Matches. Each Match consists of a number of Rounds.

The number of Rounds in a Match is not fixed. Instead, it depends on chance. After each Round in a Match, there is an 80% chance that another Round will take place. In other words, after each Round there is an 80% chance that the Match continues, and a 20% chance that the Match ends.

After each round, there is an 80% probability that the match will continue for at least another round. Specifically, after each round, whether the match continues for another round will be determined by a random number between 1 and 100 generated by the computer. If the number is lower than or equal to 80 the match will continue for at least another round, otherwise it will end. For example, if you are in round 2, the probability that there will be a third round is 80% and if you are in round 9, the probability that there will be a tenth round is also 80%. That is, at any point in a match, the probability that the match will continue is 80%. However, you will play every match in blocks of 4 rounds. At the end of each block you will learn if the match ended in the previous block of 4 rounds or not. If it has not, you will play another block of 4 rounds. If the match has ended in this block, you will see in which round it had actually ended.

In each Round, your group has 60 tokens to allocate among the three members. At the beginning of the first Round of a Match, the computer randomly selects an initial allocation and displays it on your computer as what we call the Status Quo. One of the members of your group then is selected at random by the computer to be the Proposer for this Round. The Proposer makes a Proposal for an alternative allocation he would like the group to choose. This proposal can be any three numbers (including 0s) that add to exactly 60. Once the Proposer in a Round has submitted his Proposal, all members of his group will vote for the Status Quo or the Proposal. If the Proposal receives a simple majority of votes (that is, two or more members in your group vote in favor of the Proposal), then the Proposal passes

and each of you in the group will receive the number of tokens indicated in the Proposal. If the Proposal is rejected instead, each of you receives the number of tokens given in the Status Quo.

Each round, the match continues for another round with probability 80%. When you move to another round of the same match, your group's allocation decision in the previous Round becomes the Status Quo in the new Round. Therefore, if the original Status Quo received a majority of the votes in the previous round, it continues as the Status Quo in this new round. But if the Proposal in the previous round received a majority of the votes, it becomes the Status Quo in this new round. The proposal and voting process then follows the same rules as before. A group member will be selected at random to submit an allocation proposal and a vote is taken between the Status Quo and the Proposal.

Once a match ends, a new Match will begin in which you will be randomly assigned to a new group. If your group finishes early, you may have to wait for other groups to finish. Remember that in each Match you are randomly matched into groups and group member numbers are randomly assigned. Thus, your group member number is likely to vary from Match to Match, while it remains the same within a Match from Round to Round. Once five matches have been completed, the experiment is over. Your total earnings for the experiment are the sum of your earnings over all rounds before each match ends. You will NOT receive any payoff from rounds you've played within a block after the match had ended.

Now please, have a look at the screen in front of the room.

[SHOW SLIDE 1]

This is the first screen you will see in each round of a match if you are not the proposer for this round. You have been assigned by the computer to a group of 3 members, and assigned a group member number 1, 2, or 3. This group number stays the same for all rounds of this match, but will change with each match. The initial Status Quo, which was determined randomly by the computer, is displayed in blue. Information specific to you is highlighted in red. One of the group members (1, 2, or 3) has been randomly selected to be the Proposer for this round in your group.

In each Round, before the Proposer submits his proposal, members of your group will have the opportunity to communicate with each other using the chat box. The communication is structured as follows. On the left of the screen, you will see a box that displays all messages sent to you. You will not see whether the other members have communicated among themselves. In the box below that one, you can type your own message and send it to a particular member of the group. To select the member to receive your message, simply click on the button that corresponds to the member to whom you want to send the message.

The chat box will be available until the Proposer submits his proposal or 120 seconds have passed, whatever comes first. At that moment the chat box will be disabled.

[SHOW SLIDE 2]

This is the first screen you will see in each round of a match if you are the proposer for this round. A proposal consists of three numbers, A1, A2, and A3, where A1 is the allocation to group member 1, A2 is the allocation to group member 2, and A3 is the allocation to group member 3. The three allocations must add to exactly 60. To make a proposal, enter the 3 numbers using your keyboard and then click on the confirm button. If you enter three numbers that do not add to 60 or if you enter a negative allocation, the computer will ask you to try again. As everyone else, you have the opportunity to communicate with any other group member before you submit your proposal, using the same chat interface we described before.

[SHOW SLIDE 3]

Once the Proposer has submitted his allocation proposal, you will see a similar screen where a vote is taken between this Proposal and the Status Quo. Your payoffs for the Status Quo and the Proposal are displayed in red in the table on your screen. You will now have an opportunity to vote for the Status Quo or the Proposal by clicking on the corresponding button.

[SHOW SLIDE 4]

Finally, a screen similar to this will summarize the voting results. Each group member's vote is displayed in the table along with the outcome and your payoff. This marks the end of the round.

[SHOW SLIDE 5]

You will automatically continue on to the next round if you're within a block of 4 rounds. If you're at the end of a block, you will see a screen similar to this one. The computer generated random numbers for all rounds. If all the random numbers are less than 80, this means that the match continues, and you will start another block of 4 rounds. Otherwise, the match will be considered to have ended in the first round where the random number was greater than 80. You will only receive payoffs for rounds before the match ended. Once you're informed that a match had ended, you will be randomly assigned to a new group.

In the second round of a match, you will see a screen similar to this: you have the same group member number as in the first round, and the members of your group all stay the same. The round 2 Status Quo is whatever alternative received a majority of the votes in the first round. The proposal and voting process then follows the same rules as before. A group member will be selected at random to submit an allocation proposal and a vote is taken between the Status Quo and the Proposal.