Logrolling affects the relative performance of alternative q-majority rules

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Abstract

We investigate the performance of alternative q-majority rules when voters can engage in logrolling agreements. The environment we consider involves a group of n voters who make a number of binary decisions, e.g. whether to undertake some 'projects'. Each voter obtains a payoff (positive or negative) from each project. When voters vote sincerely, and if payoffs are independently drawn from a symmetric distribution, simple majority rule maximizes the expected sum of payoffs. We propose an algorithm to identify the likely outcomes when voters can instead form logrolling agreements - i.e. mutually beneficial agreements among two or more voters to vote insincerely on some set of projects. In a simulation exercise, this algorithm is applied to a large number of randomly generated payoff matrices. The simulation results suggest that the possibility to logroll significantly and systematically alters the relative performance of alternative q-majority rules: As the number of potential projects (as well as the ability of voters to construct logrolling agreements) increases, rules requiring larger-than-simple majorities (including unanimity rule) 'catch up' to and eventually outperform simple majority rule. We conduct laboratory experiments to investigate whether human subjects engage in the types of agreements assumed by our algorithm, as well as how their payoffs are affected relative to sincere voting. The set of situations we consider is such that simple majority rule would outperform unanimity rule under sincere voting, but both rules are predicted to perform equally well when logrolling is introduced. We find that subjects do engage in the agreements we predict, though less than we predicted. Compared to sincere voting, the payoffs achieved under majority rule are slightly smaller, and those achieved under unanimity rule are substantially larger than they would be under sincere voting. As predicted, both rules perform roughly equally in an aggregate payoff sense and the possibility of logrolling under unanimity rule allows Pareto-improvement. JEL codes: C92, D72, P16.
Keywords: logrolling, vote trading, majority rule, unanimity rule, experiment.

1 Introduction

We revisit a classic problem in the literature on collective decision making: choosing between alternative q-majority rules. That is, how many members of a decision making body should be required to vote "yes" in order for some collective undertaking to be initiated? In a seminal contribution, Buchanan and Tullock (1962) identified a fundamental trade-off between what they called the 'external costs' of decisions made and the 'decision costs' associated with the process of decision making itself.[1] As the number of votes required for agreement increases, so they argue, 'external costs' will fall, but 'decision costs' will rise, such that the 'optimal' rule (the one that maximizes a representative individual's expected payoff behind a veil of uncertainty) will depend upon the relative magnitude of these two types of costs.[2]

Guttman (1998) reconsidered these general (and largely informal) arguments in a more specific formal framework. In his analysis, a group is faced with a number of binary decisions as to whether or not to undertake certain 'projects', each of which generates a vector of individual payoffs. Following Buchanan and Tullock (1962), Guttman considers the problem from the perspective of a representative individual who, behind a veil of uncertainty, is interested in maximizing the sum of payoffs achieved by all members of the group. He distinguishes between two types of costs: those associated with the passage of projects that produce net losses (i.e. those associated with 'external costs' that outweigh the benefits accruing to supporters), and those associated with the *failure* to pass projects that produce net benefits (i.e. where the *foregone* benefits outweigh the 'external costs').[3] Guttman then argues that the optimal decision rule will depend upon the (expected) relative intensity of preferences among those who favor and those who oppose a typical project. For example, unanimity rule would be optimal only if the losses to be expected from a typical project to which only one person is opposed are larger than $(n-1)$ times the average benefit among those supporting such projects. If proponents and opponents tend, in expectation, to have similar preference intensities, Guttman argues that simple majority rule maximizes the expected aggregate payoff.[4]

To illustrate the argument in a simple framework, consider Table 1. Each row of the table represents a 'project' that a group of 3 individuals might undertake. As we will be considering many such tables, we pause briefly to explain how they are constructed and substantively interpreted. The numbers in each column represent the utilities that a given voter attaches to each project. We treat these utilities as cardinal and interpersonally comparable, reflecting the idea that the problem is being considered from behind a 'veil of uncertainty', such that each payoff is part of a lottery being evaluated by a single (representative) individual.

Project A is associated with positive net benefits. Behind a veil of uncertainty, a representative individual would want such projects to pass, as it would if majority rule is used and voters vote

[1] The concept of 'external costs' refers to the possibility that a (representative) individual may be harmed by some agreements reached under a given rule, while the concept of 'decision costs' refers to costs arising in the process of decision making, such as those associated with bargaining and coalition formation.

[2] The analysis of the problem we are considering goes back at least to Condorcet (1785), who argued that simple majority rule is the best rule for choosing between two alternatives. Condorcet's approach differs from Buchanan and Tullock's in two respects. The first is that Condorcet assumes that the group members have common preferences, and that differences of opinion reflect differences in beliefs (information). The second is that neither option is privileged, whereas in Buchanan and Tullock's analysis there is a natural asymmetry between the status quo (*not* agreeing to engage in a collective action) vs. a change. Despite these substantive differences, Condorcet's arguments are relevant to the problem considered here, as we will see.

[3] Guttman (1998) frames his contribution as a critique of Buchanan and Tullock (1962), and it generated critical responses from both Buchanan and Tulock. In our opinion, the disagreement seems somewhat artificial, and it can easily be overcome by interpreting the concept of 'decision costs' as including the benefits foregone due to disagreement. In any case, we are not concerned here with the consistency or not of these approaches, but with an analysis of the problem as it is presented by Guttman.

[4] The astute reader will recognize that there is a close connection between this argument and Condorcet's (1785) Jury Theorem: If preference intensities are equal in expectation, then for any project that produces positive aggregate benefits, it is true that a given individual voter obtains a positive payoff with probability greater than one half, and vice versa for projects producing negative aggregate benefits. Thus, simple majority rule maximizes the probability of making the 'correct' (aggregate payoff maximizing) choice on every individual project, provided that voters vote sincerely.

Table 1: External and decision costs.

	Voter			
Project	1	2	3	Net benefits
A	1	-1	1	1
B	-3	1	1	-1

sincerely. In contrast, project A would fail under unanimity rule with sincere voting. Guttman refers to the losses caused by the failure of such projects as 'Type-I' costs. Project B benefits two voters but harms another. Moreover, the *net* benefit is negative. From an ex-ante perspective, a representative individual would want project B to fail, as it would under unanimity rule and if voters vote sincerely. Under majority rule with sincere voting, project B will pass. Guttman refers to the losses cause by the passage of such projects as 'Type-II' costs. Unanimity rule eliminates 'Type-II' costs because all voters have veto power. However, it makes it difficult to pass anything, resulting in larger 'Type-I' costs than, say, majority rule.

As the number of individuals required for agreement (q) increases, Type-I costs become more likely and Type-II costs become less likely. The optimal decision rule therefore depends on the relative magnitude of these two types of costs. In our example, they exactly balance out and so the expected total benefits under both decision rules are equal (to zero). As is immediately apparent, the reason for this is that the average cost imposed on the single opponent to each project (-2) is exactly twice as large (in absolute terms) as the average benefit to the two members in favor (1). If the average preference intensity among the opposing members were larger than this, majority rule would produce negative net benefits and unanimity rule would be better. If instead the benefits to those in favor were larger, majority rule would be optimal. More generally, unanimity rule will produce larger overall net benefits only if the average cost associated with projects supported by exactly two members are more than twice the average benefits (i.e. if such projects were, on average, similar to project B). An important caveat to Guttman's argument is that it applies only if compensation payments are excluded. If a given project generates positive net benefits, such as project A above, then even if some members are opposed, some combination of the project and appropriate transfer payments can, at least in principle, achieve unanimous support. In our example, voters 1 and 3 could each pay the equivalent of $1/2$ a utility unit to voter 2 in return for his support. Naturally, an infinite number of other agreements are also conceivable, and it may be costly to achieve agreement on one of them. Guttman's argument would apply without modification only if these ('decision') costs are prohibitively large. As will become clear, the impact of logrolling on the analysis is closely related to the possibility of compensation payments. In particular, vote trades constitute *imperfect* substitutes for compensation payments, imperfect because they could achieve the same outcomes only if a very large number of potential projects exists. Given a sufficiently large number of projects, there will always exist some (bundle) of project(s) that mimics a given combination of transfers.

Our goal in the present paper is to investigate how this conclusion is affected when we relax Guttman's assumption of sincere voting but still excluding compensation payments. In particular, we want to consider the possibility that voters can engage in logrolling (or vote trading) agreements.[5] We use both terms interchangeably. Such an agreement specifies that some set (or 'coalition') of two

[5]In a reply to Guttman (1998), Tullock (1998) criticized his approach for not taking logrolling into account. However, Tullock did not explicitly investigate the consequences of doing so.

or more voters change their votes on some set (or 'bundle') of projects such that the corresponding voting outcomes are changed and all members of the coalition are better off than they would be under the sincere voting outcome. Logrolling is a common practice in professional legislatures such as the European parliament (Mattila and Lane (2001), König and Junge (2009) and Aksoy (2012)) and the US Senate and House of Representatives (Matter et al. (2016) and Matter et al. (2017)). Despite the fact that logrolling 'deals' can generate mutual benefits for those involved, they are often a source of controversy, and some observers regard the practice as unethical (as explained by Casella and Palfrey (2017b), Stratmann (1992) or in philosophy on the ethics of logrolling by Thrasher (2016)).

We discuss these papers in more details in Section 2.

Table 2: Example 2.

	Voter			
Project	1	2	3	Net benefits
A	-4	-4	2	-6
B	5	-2	-1	2
C	-4	4	3	3

To illustrate the effects of logrolling in our context, consider Game 2. Suppose the decision rule is simple majority rule. If voters vote sincerely, only Project C would pass. But voters 1 and 3 could agree to vote yes on projects A and B, such that all three projects would pass. (Alternatively, an agenda setter could literally *bundle* the two projects into one proposal, and voter 1 and 3 would sincerely vote yes on the bundle.) As this example illustrates, logrolling under majority rule may impose costs on other voters (here, voter 2 loses 6 utils), and indeed may lead to a decline in aggregate net benefits (here, a loss of 4 utils). Naturally, it is possible to construct examples in which logrolls produce positive externalities and/or raise aggregate payoffs.

Now turn to unanimity rule. If voters vote sincerely, no project would pass and individual and aggregate benefits would be zero. However, the coalition consisting of all three voters could agree to vote yes on projects B and C. This makes all three voters better off. As this example illustrates, a logrolling agreement can only *increase* both individual and aggregate payoffs under unanimity rule.[6] However, as we will see, such agreements may involve passing individual projects that generate negative net benefits.

In this example, logrolling reduces the aggregate payoff under majority rule (from 3 to -1), and increases it under unanimity rule (from 0 to 5), and thereby causes the relative ranking of the two rules (in terms of aggregate payoffs) to reverse. As already indicated, there are of course cases where logrolling has a positive impact under majority rule as well. One of our goals in the following analysis will be to assess how common the type of ranking reversal observed in our example is, and how alternative rules perform on average when applied to a large number of 'situations' (payoff tables). We approach this question using simulations, i.e. by applying a logrolling 'algorithm' to a large number of randomly generated payoff tables and inspecting the resulting distribution of aggregate payoffs.

[6] General proof sketch: Suppose the agreement causes some set of projects that fail under sincere voting to pass. Then any voter opposed to a project in that set must be induced by the deal to vote yes, so on balance he must benefit. Any voter not involved in the deal is not changing his vote, so therefore he must be in favor of all the projects anyway. Symmetric argument for bundles that go from pass to fail. For 'mixed' logrolls maybe more complicated...

Naturally, the relative performance of different rules will depend on how the set of 'situations' to which they will be applied is constructed. Following Guttman, we will assume that this set has the property that, in expectation, the intensity of preference of those in favor or opposed to individual projects is the same. More specifically, we will assume that each payoff in every $n \times L$ table (each 'situation') is independently drawn from a distribution that is symmetric about zero. Thus by construction, Guttman's argument applies and *majority rule maximizes the expected aggregate payoff under sincere voting*. In other words, averaging over a large enough number of randomly generated situations, we can be (nearly) certain that the average aggregate payoff under majority rule will be larger than any other rule if voters vote sincerely.[7]

While this conclusion is relatively straightforward when considering sincere voting, predicting the pattern of outcomes becomes significantly more difficult when the possibility of logrolling is taken into account. Perhaps the most fundamental problem is the fact that logrolling opportunities logically imply the existence of *cycles*, as first shown by Bernholz (1978).[8] A number of authors have used cooperative solution concepts (the Von-Neumann-Morgenstern solution, the bargaining set, uncovered set and the competitive solution, and others) to study 'committee games' (McKelvey and Ordeshook, 1980). However these solutions are difficult to compute and do not yield unique solutions in most situations. The approach taken in this paper is to propose a relatively simple computer algorithm to identify the likely voting outcome in a particular situation. The details are described in section 3. Essentially, the algorithm simulates a process whereby players can sequentially propose 'deals' as to how to vote on some subset of all (L) available 'projects'. To capture (cognitive or other) limits as to the complexity of logrolling deals, the number of projects which a single deal can 'contain' is limited to $K \leq L$ (a parameter). After a deal is agreed to, the corresponding projects are immediately voted on. This process continues until no player wishes to propose a further deal, at which point voters vote sincerely on any remaining projects.

Our simulation results indicate that logrolling changes the relative performance of simple majority, qualified majority, and unanimity rule whenever the set of potential projects (L) as well as the permitted size of a 'deal' (K) are large enough.

Once the possibility to engage in logrolling agreements is introduced, the relative merits of majority and unanimity rule are significantly modified. Intuition suggests that allowing for logrolling will improve the relative performance of unanimity rule. After all, if the argument for majority rule is that it allows for a larger set of projects to pass, and that this makes all voters better off, then it follows immediately that this larger set of projects, when presented as a bundle, would pass under unanimity rule as well. This last conclusion is valid only if certain conditions are satisfied. First, the set of projects that can be 'bundled' must be large and diverse enough, such that any project that creates net benefits but imposes some costs could indeed be combined with another project such that the bundle benefits all voters. Second, the corresponding logrolling agreement must itself be organized, either by agreements regarding the separate votes − explicit logrolling −, or by literally combining multiple projects into a single bill − implicit logrolling.[9] If this type of agreement is difficult or costly to organize, it may not occur.[10]

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[7] Since the situations are randomly constructed, it is of course possible that preference intensities will not be symmetric and another rule would produce a larger payoff in some *individual* situations.

[8] Bernholz emphasizes that

[9] In November 2018, the Constitution Revision Commission asked the population of Florida to vote on new amendments. Some of these amendments were bundles of multiple and unrelated issues. Voters had to weigh their preferences on each issue included in these amendments. This is different from what we study here, as we do not constrain voters to vote on bundled projects, but this illustrates how logrolling is topical.

[10] In this case, majority rule may be regarded as a sort of 'substitute' for logrolling. I.e. voters may agree, at

Observing logrolling in empirical data is extremely hard. In order to analyze the effects of logrolling under majority and unanimity rule, we use two methodologies: simulations and lab experiments. Based on randomly generated matrices of values (like Game2), we compute the payoffs with sincere voting and in the presence of logrolling. We develop a theoretical setting and a logrolling algorithm to predict the logrolling agreements and the outcomes. Our simulations provide us some insights in our research and allow to generate precise predictions in specific situations that can be tested in the lab. During the experiment, groups of three voters have to vote on some projects. A period consists in voting on three projects and voters will face 18 different games, representing the 18 periods. Voters face the same games in the same order in the Majority and the Unanimity treatment. They have a public chat box during the voting process to communicate with their group members and form verbal agreements.

The results from our simulations show that unanimity rule outperforms majority rule when the number of projects available is large enough. We test some matrices of our simulations in the lab. Our experimental results show that logrolling allows groups to increase their gains compared to sincere voting under unanimity, while the impact of logrolling under majority is more mixed; it is sometimes beneficial and sometimes detrimental compared to the sincere gains. Thus, Type-I costs decrease under unanimity while Type-II costs are still high under majority. Moreover, more Pareto outcomes are played under unanimity, thus almost all the voters improved their gains compared to the sincere gains.

The remainder of this paper is organized as follows. In Section 2, we briefly review the empirical and experimental literature on logrolling. In Section 3, we describe our logrolling algorithm and the results from our simulations. In Section 4, we describe our experimental design, some particular games that participants face and we make some hypotheses. In Section 5, we present our experimental results. Finally, Section 6 discusses the results and concludes.

2 Literature

Theoretical literature The theoretical literature on vote trading has been very rich until the 70s. But due to theoretical difficulties (this is a dynamic process, there is no price mechanism to reach equilibrium, it uses concepts of cooperation game theory, vote trades lead to externalities for non-traders, etc.), the literature ran dry after the 70s. Thus, we do not review the theoretical literature, but the interested reader can see for instance Buchanan and Tullock (1962), Riker and Brams (1973), Stratmann (1992), McKelvey and Ordeshook (1980) or Bernholz (1978).

Empirical findings Collecting data on vote trading is very hard, especially because this practice may be considered as unethical. However, some authors managed to show that vote trading is not rare in our political institutions. With the increasing number of countries in the European Union, making unanimimous decisions become more and more difficult. Based on some date of the European Parliament, König and Junge (2009) show that many proposals are accepted by consensus in the Council while some members actually would prefer the status-quo. The authors explain that member states who have this veto power often do not use it in order to trade on another proposal.

a constitutional stage, that majority rule will be used, with the expectation that the resulting bundle of projects passed is one that could have been passed unanimously absent the associated bargaining costs.

Logrolling explains why consensus is still possible in the European Parliament.

However, it is extremely challenging to identify the exact logrolls. Mattila and Lane (2001) use spatial models of decision-making to compare the predicted votes and the true votes in the European Council. They show that vote trading occur as agents do not vote according to their true preferences and they identify the restrictions and driving forces of vote trading.

Aksoy (2012) study the position changes of legislators on single and multiple issues votes. They assume that initial positions represent the true preferences of voters. If they change position after the negotiation step, it means that they probably traded their vote for another issue to pass. They study vote trading in the European Union parliament where some decisions are taken under qualified majority (a large proportion of the countries and population shares must agree) and others under unanimity rules (all countries must agree). The authors show that there are less position changes (difference between initial and final position) under unanimity than under majority rule.

To identify more precisely which individuals trade their votes, Matter et al. (2016) and Matter et al. (2017) use network science. They define a logrolling agreement across two voters as a deviation of votes that is reciprocal and mutually beneficial for the voters and can model a network of vote traders. They empirically find that vote trading is bipartisan (across Republicans and Democrats) and that the longer relationships in the Senate increase the intensity of vote trading. Cohen and Malloy (2014) also find that relationships have a significant impact on voting. They analyze the network of legislators, more particularly their alumni connections, and its impact on legislators vote. They find that friends of legislators have an impact on "irrelevant votes", i.e. when the legislator has no intense intrinsic interest in the bill, he is highly influenced by his network.

The cited papers use different approaches to identify logrolling, but as this practice is not transparent, it may be difficult to have a good representation of it and to measure its effects. Therefore, the lab, despite its abstract environment, is a good tool to clearly identify the trades of votes and to measure the optimality of both rules when logrolling is possible.

Logrolling in the lab The experimental literature on logrolling has highlighted the advantages but also the drawbacks of logrolling. McKelvey and Ordeshook (1980) designed the first experiment on vote trading under majority rule. They describe the advantages of logrolling, but also one particular drawback, i.e. the paradox of voting. The paradox of voting, identified by Riker and Brams (1973), is that vote trading can lead to inefficient outcomes, in the sense that it creates negative externalities on third parties that can make everyone worse off compared to the sincere voting outcome. This can only happen if there is no communication and coordination across voters.[11] To test the paradox, the authors design two experimental contexts: one with unrestricted communication and another one with a ballot system (where formal agreements are possible). They also vary the situations; the number of voters and projects and of course the values in the tables. They observe the paradox of voting in the lab, i.e. Pareto inferior outcomes emerge, but indeed much less in the

[11] As stated by McGann (2019), this is what differentiate the analysis of Riker and Brams (1973) and Buchanan and Tullock (1962): while Riker and Brams (1973) use a setting where communication and coordination is impossible, Buchanan and Tullock (1962) assume that voters would be able to avoid the negative effects of logrolling.

presence of communication.

Another phenomenon has been tested in the laboratory; the Farm Bill.[12] Hortala-Vallve (2009) tests their model (Hortala-Vallve et al., 2011) and a particular situation of logrolling; within the group of voters, one is called a generous legislator. This voter is harmed by all the issues, such that his least favorite outcome is that all the issues pass. As he is farsighted, he forms a coalition with a voter to pass the least costly bill for him and block the other bill. Thus, he avoids the worst outcome for him.[13] Their results show that these "generous outcomes" are the most frequent outcomes.

Logrolling is not easy as it requires some coordination across voters. Fischbacher and Schudy (2014) study the relationship between vote trading and trust. In a first step, groups must vote on an efficient comprehensive reform with unanimity rule. If it fails (because they think they can trade votes and earn more in the second step with a bilateral agreement), they go to a second step where the comprehensive reform is divided in three independent bills preferred by a minority. Participants vote on each bill sequentially either in an "open ballot" system (transparent) or a "secret ballot" system (not transparent). The authors show that participants veto the reform, because they think they can earn more by trading. They indeed trade votes (even in the absence of communication and commitment device) and harm the third player. Refusing the comprehensive reform makes voters understand that they can deal with another voter to have a higher payoff than with the comprehensive reform.

In order to facilitate logrolling, another solution proposed by Casella et al. (2014) is to centralize parties decisions thanks to a leader. They test logrolling in the lab with decentralized decisions and centralized decisions by a party leader. They show that the possibility of logrolling in a centralized context allows efficiency gains.

More recently, Casella and Palfrey (2017a) proposed a general framework and a model based on sequential dynamic process. In their model, voters vote sequentially on K proposals. Before voting, they can physically trade their votes thanks to a ballot system. Voters trade their ballot until their reach a vote allocation where no more trades could increase their payoffs. The authors prove that stable vote allocations exist and that they can be reached via decentralized sequential decisions. A Pivot stable allocation of votes always exist. The authors test the predictions of their model (Casella and Palfrey (2017b)). Voters are in groups of 5 and have one vote (one ballot) on each issue at the beginning of a treatment. They study three treatments, represented by 3 tables: AB, ABC1, ABC2. In AB, there are 2 projects, while there are 3 in the two others. The Pivot stable outcome is unique in the three treatments, but the path to reach this outcome is unique only in AB. Multiple paths are possible in ABC1 and ABC2. Voters play the three treatments/tables. Initial vote allocation is always unstable. They designed tables where sometimes the Pivot stable outcome corresponds to

[12] In this example, there are three types of legislators: wheat, peanut and dairy legislators. The wheat and the peanut legislators each favor one issue (the wheat issue and the peanut issue respectively). The dairy legislators dislike both issues. The wheat and peanut legislators can form a coalition to pass both issues, which is the worst outcome for the dairy legislators. A solution to minimize their costs is to offer their support to the type of legislators associated with the least costly issue for them. They "generously" offer their support with no benefit in exchange, but it allows the other issue to fail and so to reduce their costs.

[13] This situation was inspired by negotiations of US legislators for the 1985 Farm Bill. Legislators with interests in dairy were not in favor of the wheat bill and of the peanut bill. In order to avoid both bills to pass, dairy supported offered their vote to the least costly bill for them: the peanut bill. Thus, they avoided the peanut bill and some additional costs.

the Condorcet winner and sometimes not. Voters can trade their votes during 3 minutes by making bids to specific partners (pairwise trade only). Vote is then automatically applied. Their results show that there is less long trade paths in AB as predicted. They find that their Pivot stability concept is a good predictor, that the final vote allocations are well predicted by the model but they are still few divergences: some trades do not lead to strict gains for all voters in the coalition and voters are prudent (they like to accumulate votes on their favorite proposal). Finally, in the model, they assume myopia (trades lead to myopic gains), but results seem to show farsightedness of voters.

All the cited papers study logrolling under majority. To our knowledge, only one experimental paper studies logrolling both under majority and unanimity rule; the paper of Lehmann-Waffenschmidt and Reina (2003). The authors study logrolling under both rules in a three-person bargaining game. Each voter faces a table with 28 numbers. Each number corresponds to a certain value and these values differ from one voter to another. They have to coordinate on a number. The number and the corresponding values are applied if 2 voters agree on the same number (majority) or if the 3 voters agree (unanimity). Voters take multiple decisions, such that logrolling is possible. The authors analyze the bounded rationality and cognition of subjects by varying the decision rule and the complexity of the game. They find that under majority, sub-optimal outcomes emerge while subjects managed to find optimal outcomes under unanimity even when the game is more complex.

In this paper, we first want to study how voters trade votes under different decision rule: majority or unanimity. Second, we allow for more complex and "free" trades by letting voters chat freely and publicly. It allows them to build coalitions and bundles of proposals of any size. We aim at creating a more realistic and natural way to trade votes, as if legislators could speak with their co-workers to find agreements. We also test different situations where logrolling has different impacts under both rules. To have a clean and more simple analysis, we use a stranger matching to avoid reputation effect. We are not interested in the effect of relationship and trust.

3 Simulations

To start our analysis on the effect of logrolling on the relative performance of alternative voting rules, we develop a theoretical setting and an algorithm to predict logrolling agreements, outcomes and payoffs. This algorithm is implemented as a computer program and applied to a large number of randomly generated payoff matrices involving different numbers of voters and projects. We then compare the outcomes under majority and unanimity in the presence or not of logrolling, and investigate how the impact of logrolling varies with the number of voters and projects as well as a parameter that controls the "ability" to logroll. Some of these matrices will then be used in our experimental design; they represent interesting *situations*, i.e., cases in which logrolling is predicted to occur and to have different effects (or similar effects) depending on the decision rule. We now describe more precisely the algorithm, simulations and our results.

3.1 Environment

Let $N = 1, ..., n$ be the set of voters, with i a typical voter and let $L = 1, ..., L$ be the set of projects, with j a typical project. We define the matrix of values Z of size $L \times n$, where z_{ji} represents the value of project j for voter i. Finally, q is the number of votes required to pass a project. If project j passes, voter i receives value v_{ji}, otherwise he receives 0 for this project. The payoff of voter i; π_i, is defined as the sum of the values from the projects that pass. The payoff vector $\pi = (\pi_1, ..., \pi_n)$ summarizes the payoffs of all voters.

Before describing the logrolling algorithm in detail, we will provide an informal description of the process which it is intended to capture. This process consists of a sequence of logrolling "deals", i.e. agreements among a coalition of 2 or more voters to change their votes (relative to sincere voting) on some set of 2 or more projects. To capture a possible limit to the "ability" to logroll, the size if the set of projects is limited to K, a parameter.[14] Each such deal is followed by an immediate vote on the relevant set of projects, where it is assumed that all voters not involved in the deal will vote sincerely. Each deal is initiated by a voter in the role of "proposer", and voters take turns in this role according to a fixed sequence. When it is a given voter's turn to propose, she looks at all projects that have not yet been voted on, identifies the set of feasible deals which she would benefit from in the sense that her payoff increases relative to sincere voting on the remaining projects, and myopically chooses from this set the deal that leads to the greatest increase in her own payoff. (Indifference between multiple deals will not occur in our simulations, as payoffs from projects are continuously distributed such that there will always be at least a minute difference in the payoffs resulting from alternative deals.) This process continues until no voter wishes to propose another deal, at which point any remaining projects are resolved by sincere voting.

With this description in mind, we now describe in detail how the algorithm is implemented more formally. For a given matrix of payoffs Z, we first construct a "sincere vote matrix" S, with $S(j,i) = 1$ if $Z(j,i) \geq 0$ and $S(j,i) = -1$ otherwise. The interpretation is that $+1$ denotes a (sincere) yes and -1 a (sincere) no vote, and voters are assumed to vote yes when indifferent. We then obtain the L-vector of (sincere) "vote margins" m^s on all projects, with $m_j^s = \sum_i S(j,i)$. Next we construct the corresponding (sincere) "outcome vector" o^s, with $o_j^s = 1$ if $m_j^s \geq \hat{m}$, where $\hat{m} = 2q - n$ is the necessary vote margin under any given q-majority rule, and $o_j^s = -1$ otherwise. The interpretation is that $o_j^s = 1$ means the project j passes under sincere voting, while -1 means failure. Next, we construct what we will call a "utility from flipping projects" matrix F, with $F(j,i) = -o_j Z(j,i)$. That is, each row of F is equal to the corresponding row in Z multiplied with $-o_j$. The interpretation is that the jth row of F represents the vector of payoff changes, relative to sincere voting, that would occur if the voting outcome on project j were reversed. Next, we construct the list of all subsets of the project numbers $1, ..., L$ consisting of between 2 and K elements. (E.g. if $L = 3$ and $K = 3$ this is $1,2,1,3,2,3,1,2,3$.) For each of these subsets, we calculate the sum of the corresponding rows in F. The interpretation is that this is the vector of utility changes that would occur if the outcomes on all projects contained in a given set were reversed. (This allows for some projects within the set to go from "pass" to "fail" while others go from "fail" to "pass", i.e. it allows for "mixed" logrolls.) We then construct a new matrix $\tilde{Z}$, each row of which is one such payoff. (E.g. in the $L = 3$ and $K = 3$ case, this matrix will have four rows, the first corresponding to the payoff changes resulting from "flipping" projects 1 and 2, and so on.) For each row of this matrix, we identify the set of voters whose payoffs are *strictly* positive. These are the potential "beneficiaries" from "flipping" the corresponding outcomes.[15] We then return to

[14] An alternative approach would be to limit the number of voters within a coalition, or some combination of these factors. We do not believe that our substantive / qualitative conclusions would change if such an approach were implemented.

[15] We require "beneficiaries" to obtain a strictly positive payoff from a deal because any log-rolling deal involves at least some risk on the part of the coalition members, and therefore we assume that a voter must (at the least) receive a strictly positive payoff in order to participate in such a deal.

the sincere voting matrix and modify it by replacing, for each project j in the set being considered, and for each voter i in the set of "beneficiaries", the entry $S(j,i)$ with $-o_j^s$. That is, we assume that all beneficiaries will vote "yes" on projects which would fail under sincere voting, and "no" on projects that would pass.[16] Following these modifications, we obtain a new (hypothetical) outcome vector $\tilde{o}$, the interpretation of which is that this is the outcome that would result if (all) those who would benefit from "flipping" a given set of outcomes were to vote in opposition to the sincere outcome on each project within that set. Finally, we check whether $\tilde{o}_j = -o_j^s$ for all j in the set of projects to be flipped. If so, the interpretation is that the set of potential beneficiaries is *capable* of flipping the outcomes, i.e. a "deal" to flip them is feasible. All such "feasible" deals are added to a list of potential deals. In a final step, we remove from this list all deals which "contain" others in the sense that there exists another potential deal to flip only a subset. (This step ensures that players cannot propose deals in which some projects are "piggy-backing" on a deal that benefits others and which makes that deal worse for them.) The final result of the steps described thus far is a set of "available deals" for the matrix Z, where this set depends on the decision rule q and the parameter K.[17] Once this set is constructed, we cycle through the sequence of turns. At each time step, we identify, from the set of "available" deals, the one which is associated with the greatest payoff increase for the current proposer. We add the set of projects being "flipped" to a list and remove from the set of available deals all those which contain at least one of the projects in that set. The interpretation is that we assume that these projects are immediately voted on so that a deal to "flip" them is no longer available. This process is repeated until the set of available deals is empty.

We assume that our voters are myopic. We then apply the algorithm to randomly generated matrices.

3.2 Matrices

Matrices V of size $l \times n$ are randomly constructed for different l. We keep $n = 3$ voters and create matrices with $l = 3, 5, 7, 9, 15, 18$ projects. Values v_{ki} are independently drawn from $U[-3, +3]$. We generate 5000 matrices for each $l = 3, 5, 7, 9, 15$ and 2000 matrices for $l = 18$ due to long computation time. Note that since the distribution of payoffs is symmetric, average intensity of preferences for and against are equal in expectation. Thus, by construction, Guttman's argument applies and majority rule is optimal when no logrolling is allowed. We apply our algorithms to all matrices thanks to Mathematica.

3.3 Analysis and results

The main outputs that we analyze are the payoffs vector and the aggregate payoffs achieved for each matrix under sincere voting and with the possibility to logroll. We inspect the distributions of individual and aggregate payoffs achieved under different rules with sincere voting and with our model. Our main hypothesis is that the relative performance of unanimity rule improves as l and K get larger.

[16] It is easy to verify that $S(i,j) \neq -o_j^s$ for some, but not necessarily all beneficiaries.

[17] A more efficient approach is to construct this set once and to apply the restriction on deal size during the proposal stage.

Our results are displayed from Figure 1 to Figure 6. When the number of projects l lies between 3 and 5, we use $K = l$. Then we fix $K = 6$ as it allows to speed up the simulations and we do not lose informative results as groups never bundle more than 6 projects. We start with $n = 3$, $l = K = 3$ (see Figure 1). The 3-dimension graph on the top-left shows the payoffs of each voter under sincere voting. The blue dots represent the individual payoffs under majority and the orange dots represent the individual payoffs under unanimity in each matrix. Under unanimity, no voter has a negative payoff, while this is often the case under majority. The top-right graph show the distribution of average payoffs under sincere voting. Despite few negative average payoffs, the mean average payoff under majority is higher than under unanimity as the average payoff is often null under unanimity (because no projects pass). The two others graphs represent the same types of graphs but in the presence of logrolling. We can see that under unanimity, payoffs slightly spread more on the top-right of the graph, while under majority there does not seem to have any changes. The distributions show that under majority, the mean average payoff slightly decreases and that it slightly increases under unanimity. But the difference is very small.

We now increase l to 5 (see Figure 2). We see that with sincere voting, under majority, average payoffs are higher. With logrolling, the mean average payoffs are very close under both rules. If we keep increasing the number of projects, we can see that in the left graphs, with logrolling the orange dots expands and spreads to the top-right of the graph. The graphs on the right show that the distributions and the means are closer and closer when we increase the number of projects available. When $l = 9$ (see Figure 4), in the presence of logrolling, the mean average payoffs are equal under both rules and the distribution is slightly more on the right under unanimity. Finally, with $l = 15$ (see Figure 5) and $l = 18$ projects (see Figure 6), the means are higher under unanimity and the distribution of average payoffs is more on the right under unanimity. Compared to the distribution with sincere voting, we see that the ranking between both rules has shifted.

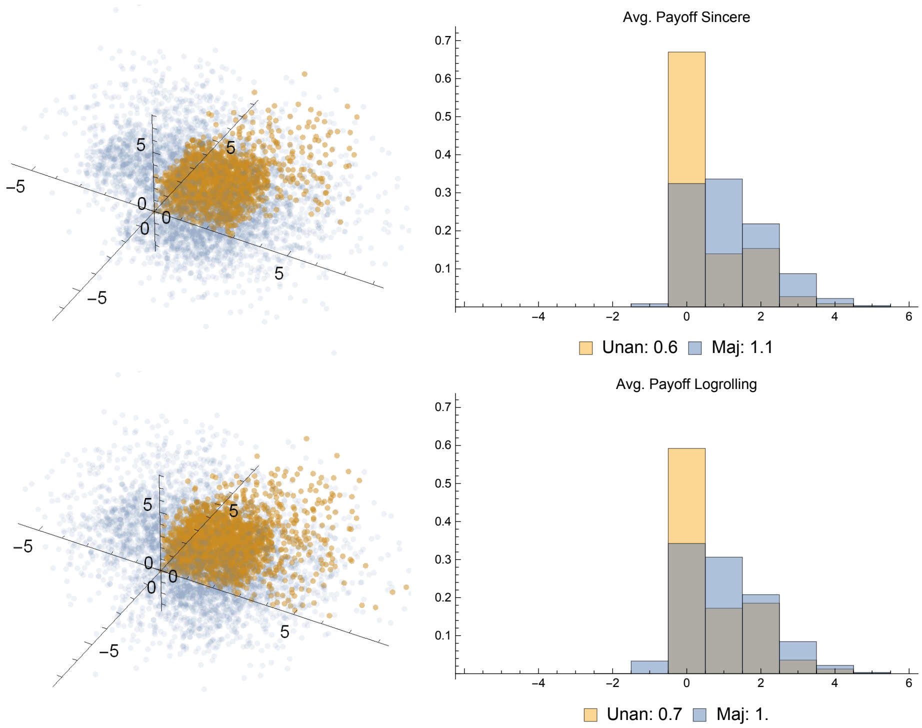


Figure 1: Individual and average payoffs, $n = 3$, $K = l = 3$

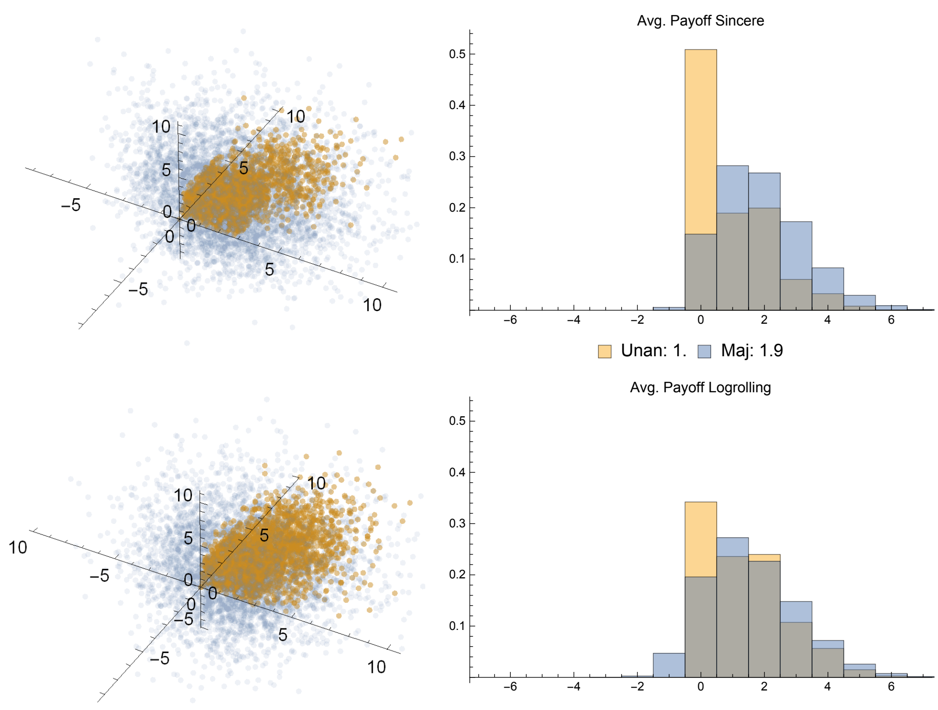


Figure 2: Individual and average payoffs, $n = 3$, $K = l = 5$

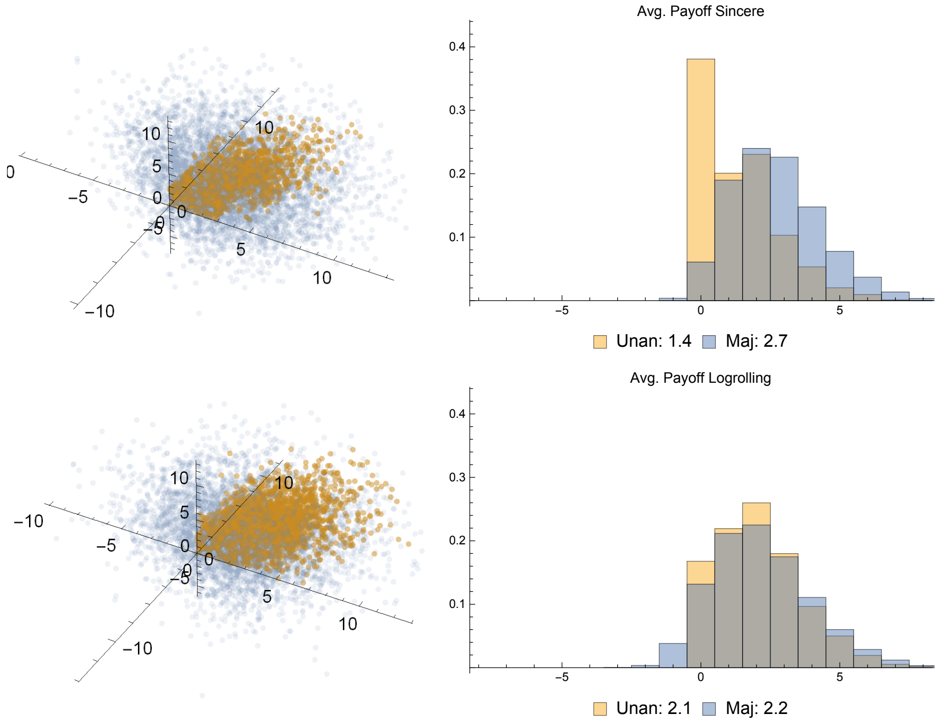


Figure 3: Individual and average payoffs, $n = 3$, $K = 6$, $l = 7$

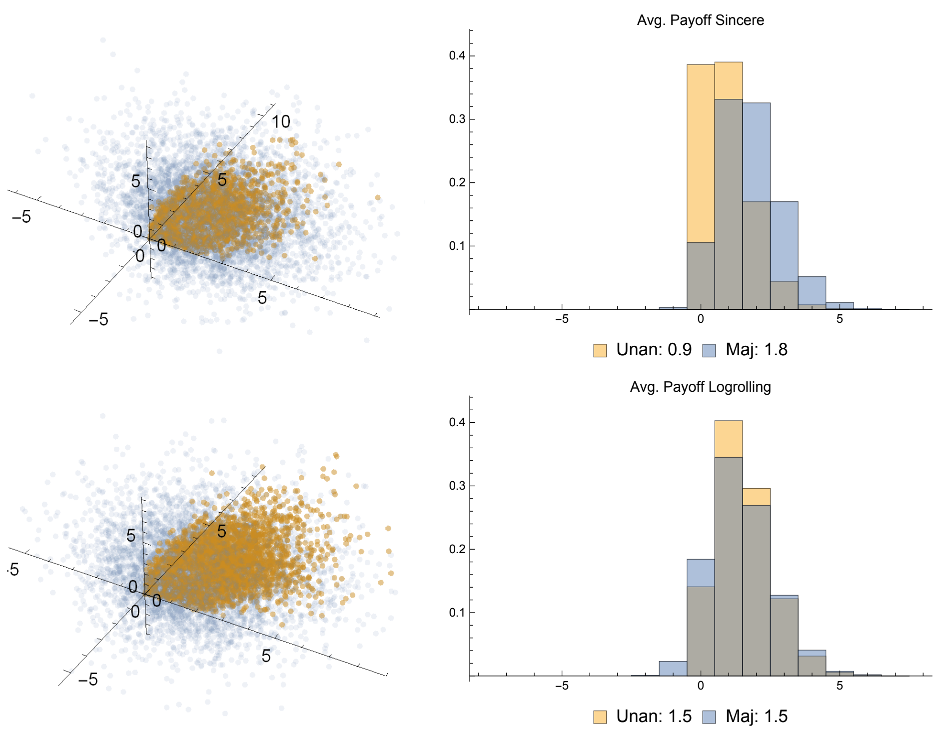


Figure 4: Individual and average payoffs, $n = 3$, $K = 6$, $l = 9$

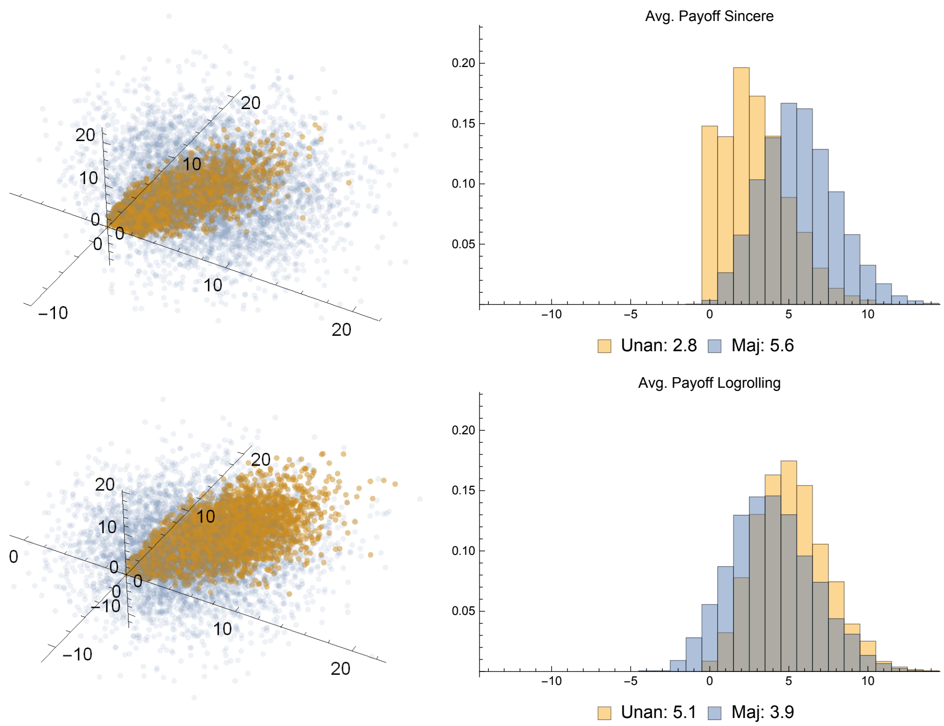


Figure 5: Individual and average payoffs, $n = 3$, $K = 6$, $l = 15$

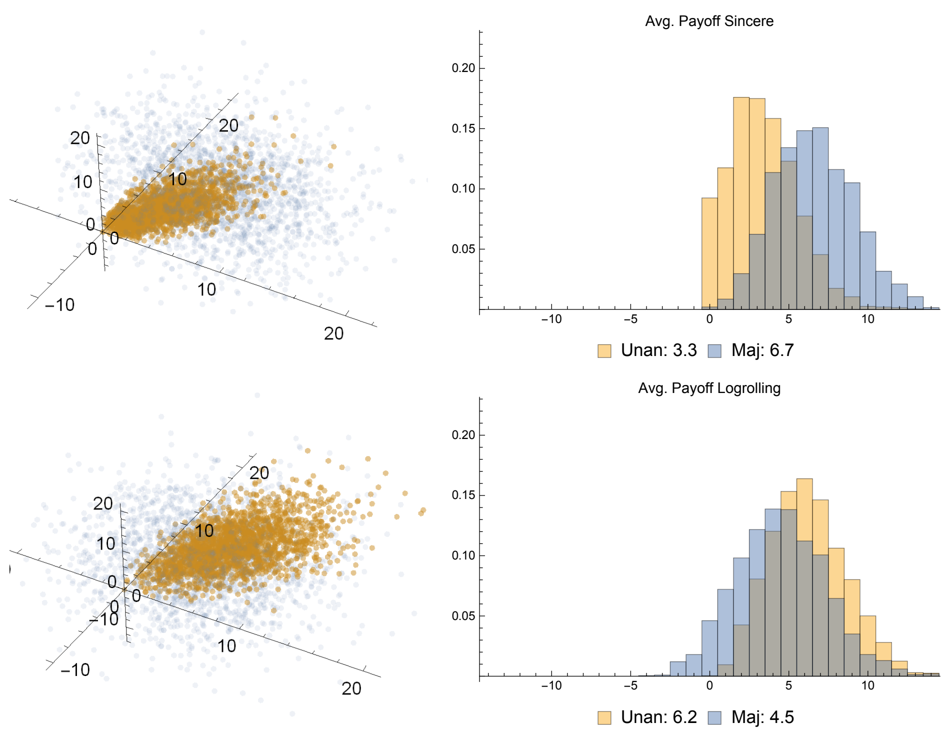


Figure 6: Individual and average payoffs, $n = 3$, $K = 6$, $l = 18$

Note that the mean average payoffs under majority with sincere voting is always higher than the mean average payoffs under unanimity with logrolling. We do not state with our simulations that unanimity rule in the presence of lo-rolling is the best "combination". But as it has been proven that logrolling is present in many real-life settings and cannot be excluded from the analysis, we try to find how both rules react to the presence of logrolling.

To summarize, logrolling always improves the distribution of payoffs under unanimity. This is trivial, as no logrolling agreement would be made if not all voters earn more than with sincere voting. However, under majority, logrolling worsens the distribution of payoffs and the negative impact is more and more important when we increase the number of projects. When the number of projects is high enough, unanimity outperforms majority once logrolling is allowed.

We cannot test in an experiment whether this general statement is true. But we can test some of the matrices used in the simulations. We choose specific *interesting situations*, i.e., situations where logrolling occurs and has a different impact on both rules. Figure 17 shows the same graphs but for the matrices we selected for the lab experiment. With sincere voting, payoffs are null under unanimity. With logrolling, majority sometimes perform better than unanimity, sometimes not.

4 Experimental design

4.1 General design: n=3 and L=3

At the beginning of the experiment, participants are randomly assigned to groups of three voters. Our sessions always contain 18 participants, divided into two subgroups of 9 participants. Groups are reassigned at every period (stranger matching) within each subgroup such that the same group never forms twice and that pairs of players meet at most twice in a row.[18] As they are simply identified by ID numbers (1, 2 or 3) and that these labels change, they cannot know or recognize their group members.

During the experiment, groups vote on three different projects: Project A, Project B and Project C. Each project can either pass or fail and depending on the outcome, it will determine the payoffs of players. The payoffs are given in a 3×3-table. A project is favored by a voter if the corresponding cell indicates a check mark, otherwise the corresponding cell indicates a cross. The number next to the check mark or the cross corresponds to the intensity of preference of the voter. Figure 7 shows an example of table that participants saw in the lab. The "✓ 6" in the first cell (Project A, Participant 1) means that voter 1 earns 6 points if Project A passes, otherwise he earns 0. The "✗ 3" below means that this same voter earns 3 points if Project B fails, 0 otherwise. We choose to implement costs as opportunity costs in order to avoid negative payoffs like in Hortala-Vallve et al. (2011). We call the way of framing the payoffs in the experiment the "transformed payoffs" in opposition to the "untransformed payoffs" which use negative numbers for unfavored projects like in the first examples of the paper in the introduction. Of course, using transformed or untransformed payoffs would not change the outcomes or the predictions of our model. This is just a different frame.

Each voter votes Yes or No on each project. In the Majority treatment, a project passes if at

[18] We did two subgroups in order to have at least two independent observations per session.

Projects	Participant 1	Participant 2	Participant 3	Your vote
Project A	✓ 6	✗ 12	✗ 12	◯Yes ◯No
Project B	✗ 3	✗ 6	✓ 15	◯Yes ◯No
Project C	✓ 9	✓ 12	✗ 12	◯Yes ◯No

Figure 7: Screenshot: Example of a table.

least two voters voted Yes on that project, while in the Unanimity treatment, the three voters must vote Yes for a project to pass. This is the only difference between the two treatments. Participants either play the Majority treatment or the Unanimity treatment (between-subject design).

Individuals can signal their intentions to vote and can see the intentions to vote of their group members. We implement a color system; when people tick the Yes box for a project, the corresponding cell becomes light green and when people tick the No box for a project, the corresponding cell becomes light red. They can change their votes as many times as they want and all the group members can see these changes thanks to the color system. To confirm their vote on a project, they have to click on the Confirm button. The corresponding cell becomes dark green or dark red depending on the intention to vote that they confirm and their vote cannot be changed anymore. Group members can communicate via a chat box below the table. Communication is public and unstructured. We do not explicitly tell participants to trade their votes. Figure 8 shows a screenshot of the voting process from the point of view of Participant 1 with the color system we just described.

Groups have three minutes to vote on all three projects. After these three minutes, all the unconfirmed votes (even if voters gave their intention to vote) are considered as confirmed No votes.[19] We then show the outcomes of the round to the participants during at most 20 seconds and we give them their payoffs for the round (see Figure 15 and 16 in Appendix for an example under majority and under unanimity). Groups play 18 rounds, where games change in each round. The games are the same across groups and across treatments (all the games can be found in Appendix). Five rounds are randomly drawn at the end of the experiment to compute the final payoff (average number of points, conversion rate: 1 point = 1 Euro).

[19]Very few votes were unconfirmed. Indeed, on overall 3.42% of the votes were not confirmed on time, 2.08% under majority and 4.76% under unanimity rule.

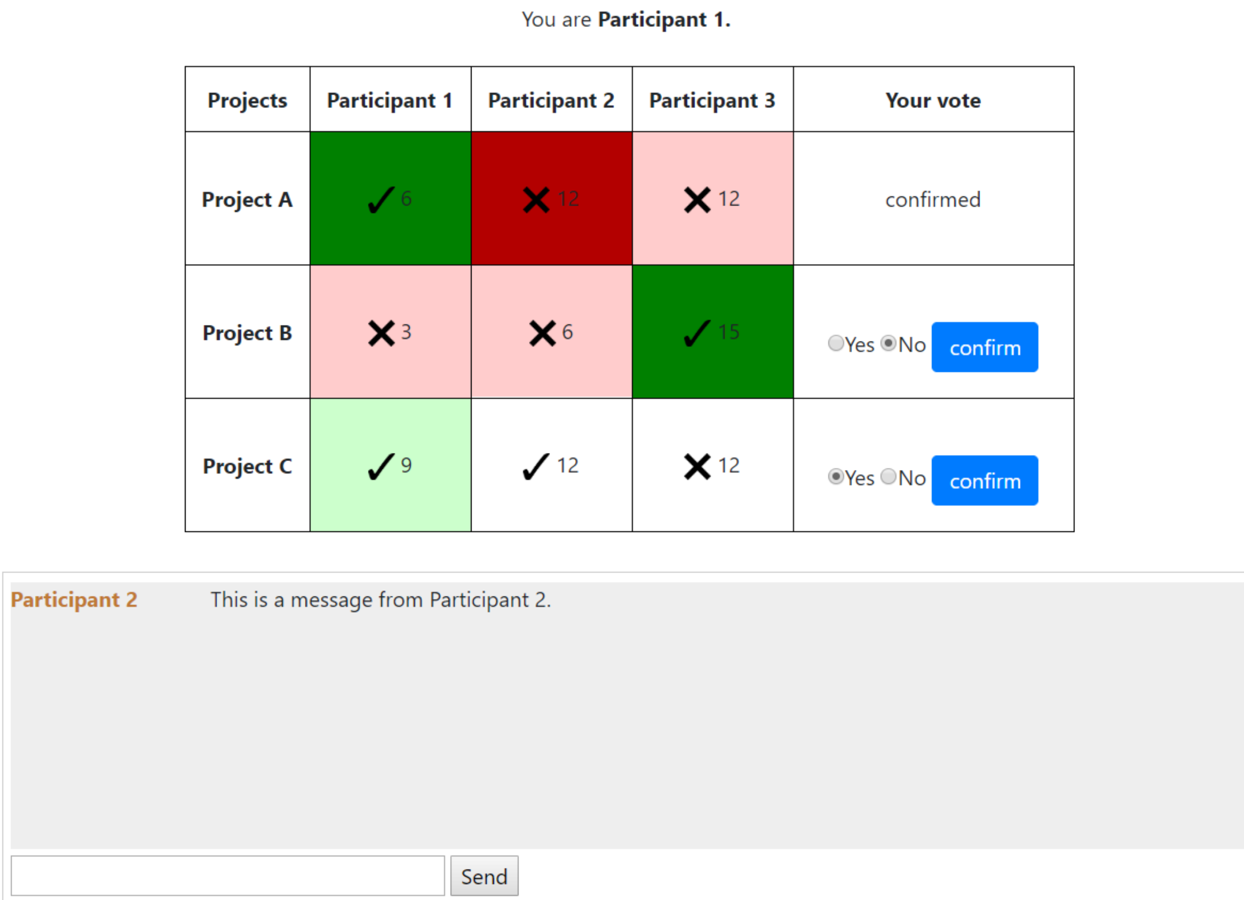


Figure 8: Screenshot of the voting decisions.

Notes: Participant 1 voted yes on Project A and confirmed his vote, he voted no on Project B and yes on Project C but did not confirm these votes yet. Participant 2 confirmed his no vote on Project A but did not confirm his no vote on Project B yet and voter 3 did not confirm his no vote on Project A but already confirmed his yes vote on Project B.

4.2 Games used

We test different situations/games from the simulations we did. Thanks to our simulations, we know the outcome and the payoff vector when votes are sincere and the predicted outcome and the predicted payoff vector in the presence of logrolling under each rule. We choose some games where majority rule should perform better in the presence of logrolling (8 games),[20] others where unanimity rule should perform better (8 games) and some where both should perform the same (2 games). Thus, the matrices we choose are such that majority rule performs better (in sum) under

[20] By performing better, we mean that the aggregate payoff is higher under one decision rule than under the other decision rule.

sincere voting, while we predict similar performances (in sum) with logrolling.

Games always contain 3 rows/projects and 3 columns/voters and only differ in the payoffs for each voter and each project. We selected 9 games and we replicated almost identically each of these 9 games to create "variants", where only few numbers slightly change.[21] The predictions (logrolling agreements predicted by the algorithm) are the same in the original version and in its variant such that we can test the robustness of voters' behavior after a small cardinal change. Each subgroup of 9 participants tests the games in a particular order to control for order effect. We design these two sequences of games such that participants first face a block of 9 different games before facing their variants. Additionally, we make sure that games look quite different from one period to the next one to avoid automatic response from our participants. The games (original + variant) and the sequence of appearance for each subgroup can be found in Section A.2 in Appendix. The numbers associated to each game is purely arbitrary. We will present three games in more details in Section 5.1 to explain our predictions and precisely describe what happened in the lab.

Note that in some cases, we predict constructive logrolling agreements and in some cases mixed logrolling agreements.[22] These agreements may consist in two or three voters and two or three projects. We will analyze how these different types of logrolling agreements emerge. Indeed, in the lab it may be more cognitively difficult and harder to coordinate on agreements that are mixed and on agreements that involve more people or more projects.

4.3 Procedures

The experiment was programmed using the software o-Tree (Chen et al., 2016) and run at Heidelberg University in Germany. Participants were students from different disciplines and were recruited thanks to the online recruitment system H-root (Bock et al., 2014).

Before starting the experiment, participants had to read the instructions on their screen and to answer a comprehension questionnaire. The experiment started when all the participants answered correctly to the questions. At the end of the experiment, participants answered few questions about the experiment as well as few demographic questions.[23] The experiment lasted between 75 to 90 minutes and subjects earned on average 21.11 euros (SD: 4.18).

4.4 Hypotheses

Thanks to our algorithm and simulations, we can make precise predictions of what should happen in the experiment at the individual level, game level and aggregate level under both rules. The predicted outcome, payoff vectors and aggregate payoffs for each game can be found in Section A.2 in Appendix. We also display in Section A.2 the outcomes and payoffs that arise if voters vote

[21] The sums of each column and row (calculated with the untransformed payoffs) are the same in the original game and in its variant. Thus, the net benefit of each project is the same in the original game and in the variant.

[22] We have no predicted destructive logrolling agreements as no project is unanimously supported in the games we chose. For the same reason, we have no mixed logrolling agreements in the Unanimity treatment.

[23] The ex-post questions were the following: 'Have you ever voted for a project even though you would get points if it fails (that is, you had a ✘)? If yes, please explain briefly why you did it.', 'Have you ever voted against a project even though you would get points if it passes (that is, you had a ✓)? If yes, please explain briefly why you did it.' and 'What do you think about the behavior of the other participants?'. The demographic characteristics are the following: age, gender and field of study.

sincerely and if voters maximize the aggregate payoffs (utilitarian). Each logrolling agreement predicted by the algorithm is described for each game and each decision rule. So all the predictions at the game level can be found in Appendix. Here, we only give general hypotheses.

We start our hypotheses with the occurrence of insincere votes. We want to study whether subjects vote insincerely and under which rule it occurs mostly.

Hypothesis 1 (Number of insincere votes) *There are more insincere votes under unanimity rule than under majority rule.*

As more votes need to be changed for a logrolling agreement to be formed and that no project is unanimously supported in our games, we predict more insincere votes under unanimity rule. Now, we look more precisely at the number of logrolling agreements predicted under both rules.

Hypothesis 2 (Logrolling agreements) *There are more logrolling agreements under majority rule. While all the logrolling agreements benefit the three voters under unanimity rule, logrolling agreements are always detrimental for the minority and often for the group on average under majority rule.*

While we predict more insincere votes under unanimity rule, we predict more logrolling agreements under majority rule. There are 4 games out of 18 where we predict no logrolling agreements under unanimity rule and only 2 games under majority rule. This is due to the matrices that we chose. Only Pareto-improving agreements should occur under unanimity rule while it is not the case under majority rule. Only agreements that improve the payoffs of all the voters should be supported under unanimity rule, while under majority rule, the voter that is not part of the coalition will be harmed by the agreement.

Now, we predict which kind of projects will pass under both rules.

Hypothesis 3 (Beneficial and detrimental projects' passage rate) *More beneficial projects (with a positive net benefit) pass under majority rule; lower Type-I costs, but more detrimental projects (with a negative net benefit) pass under majority rule; higher Type-II costs. Detrimental projects can pass under unanimity rule.*

It is easier in general to pass projects under majority rule. It is an advantage as it should allow a higher passage rate of beneficial projects but it also allows more detrimental projects to pass. While under sincere voting, no detrimental projects can pass under unanimity rule, in the presence of logrolling such projects can pass in order to form a beneficial bundle. Groups can pass a detrimental project to compensate the loss of a voter in a beneficial project. This is the case in Table 2 (our second example), where voters trade to pass Project A with vector of payoffs (-9, -3, 9) and Project C with payoff vector (15, 12, -3). Project A is clearly detrimental but allows to compensate voter 3 and pass Project C. On overall, passing both projects is beneficial.

Finally, we make one hypothesis regarding the optimality of decisions rules in terms of aggregate payoffs.

Hypothesis 4 (Aggregate payoffs) *Aggregate payoffs should be similar on average under majority and unanimity rule. Logrolling always has a positive impact on aggregate payoffs under unanimity rule but has a mixed impact under majority rule.*

Logrolling can only improve the payoffs of the three voters compared to the status-quo, otherwise voters would not make a logrolling agreement. Otherwise, under majority rule, logrolling hurts the voter that is not part of the logrolling agreement and may even reduce the aggregate payoff cpm-poared to the aggregate payoff under sincere voting. On average, we predict very similar aggregate payoffs under both rules. The predicted payoff vectors and aggregate payoffs of each matrix can be found in Section A.2 in Appendix.

5 Results

Our result section is divided into two parts. We start by looking at the voting behavior in three games. We cannot give the precise results on the 18 games in the body of the text (more precise results, game by game, can be found in Appendix), but we think it is useful for the reader to have a concrete idea of voting behavior in particular situations. In a second part, we will give aggregate results on voting behavior and resulting payoffs for all games. In the second part, we first study whether individuals engage in logrolling agreements. Then, we examine which type of outcomes they reach in the presence of logrolling and we finally show the impact of logrolling on payoffs under both rules.

In order to be in line with our simulations, we present and analyze the results with the untransformed payoffs. As we said, it does not change the predictions, the results, nor the interpretation of our results.

Each subgroup of 9 participants represents an independent observation. Therefore, we have 2 independent observations per session, so 8 in each treatment. Thus, non-parametric tests are based on averaged measure per subgroup. Mann-Whitney tests (MW, hereafter) are two-tailed.

5.1 Voting behavior in three particular situations

We only present in details three games to explain some of our choices and show the results in these particular cases. We use the untransformed payoffs but the predictions are exactly the same if we use the transformed payoffs (with the opportunity costs). We present one game where we predict unanimity rule to perform better, one game where we predict majority rule to perform better and one game where we predict similar performances.

For each game presented, we first analyze the occurrence of insincere votes, i.e. a voter votes insincerely on a project if he votes yes while he dislikes the project or if he votes no while he favors the project. We check whether these insincere votes correspond to our predictions.

Then we analyze which type of outcomes groups play. The outcome reached by a group is the set of projects that pass and the set of projects that fail due to their votes. If a group decides not to pass any project, the outcome is called *empty outcome* or *status-quo*. An outcome can be classified in different categories of outcomes:

- Sincere outcome: the outcome corresponds to the sincere outcome if the projects that pass (and fail) would have passed (and failed) under sincere voting. It does not mean that all the votes were sincere votes.

- Predicted outcome: the outcome corresponds to the predictions of our simulation. The projects that are predicted to pass (and fail) by the simulation, passed and failed during the experiment. Again, it does not mean that all the votes they made corresponds exactly to the votes predicted by the algorithm.

- Utilitarian outcome: the outcome maximizes the aggregate payoffs. The group passed the set of projects that allow to reach the highest payoff for the group.

- Core outcome: the outcome (weakly) Pareto-dominates the empty outcome, i.e. every voter has a weakly higher payoff with this outcome than with the empty outcome (no one is strictly harmed by the outcome), and the outcome is not Pareto-dominated by any other outcome, i.e. there exists no other outcome where a voter could strictly improve his payoff without harming at least one other voter. The core outcomes for each game are displayed in Table 28 in Appendix.[24] There may be more than one outcome that are core outcomes within one game. In Game 4, no outcome strictly Pareto-dominates the empty outcome, because one voter dislikes every project. We consider that the empty outcome is part of the core in this case. Table 28 also displays Pareto-dominated outcomes. If an outcome is not part of "core outcomes", it does not mean that it is Pareto-dominated.

- Other outcome: the outcome does not belong to any of the four categories described.

Note that an outcome may be part of multiple categories.

Third, we study how the outcome played impacts their payoffs; aggregate and individual payoffs and the distribution of payoffs.

The first game is the following:

Table 3: Example 1: Game 9a and percentage of insincere votes.

(a) Majority.

	Voter		
Project	1	2	3
A	**-6**	-3	15
	58.33	25	0
B	12	6	-6
	4.17	4.17	37.5
C	15	-15	**-3**
	12.5	8.33	**45.83**
Pred. combi.	41.67%		

(b) Unanimity.

	Voter		
Project	1	2	3
A	**-6**	**-3**	15
	70.83	91.67	4.17
B	12	6	**-6**
	8.33	0	**87.5**
C	15	-15	-3
	54.17	0	4.17
Pred. combi.	66.67%		

If voters vote sincerely, no projects pass under unanimity rule and payoffs are null, while project B passes under majority rule and payoffs are $(12, 6, -6) = 12$. However, if voters logroll, they can increase the aggregate payoffs. Under majority rule, voter 1 can deal with voter 3 to pass Projects A and C (it costs them respectively 6 and 3 to vote yes on these projects but they both earn 15 thanks

[24] This table describes the payoff vector and aggregate payoff for each game in all the possible situations; only Project A passes, only Project B, only Project C, Projects A and B pass, Projects A and C, Projects B and C, all the projects pass or no project passes.

to that change). Consequently, every project passes and payoffs are $(21, -12, 6) = 15$. Voters 1 and 3 are better off compared to the sincere outcome. However, voter 2, who is not part of the winning coalition, is worse off. Under unanimity rule, voters 1, 2 and 3 can pass Projects A and B; it costs 6 to voter 1, 3 to voter 2 and 6 to voter 3, but they earn respectively 12, 6 and 15. Payoffs are $(6, 3, 9) = 18$. The three voters are better off compared to the sincere outcome. To sum up, in this case, logrolling improves the aggregate payoffs under both rules, but under majority rule, the voter who is not part of the winning coalition is harmed while every voter improves his payoff thanks to logrolling under unanimity rule. In sum, unanimity rule should perform better than majority rule in this situation. We now check whether this is the case in our results.

Table 3 contains the percentage of insincere votes for each project and each voter under each rule. The percentages are displayed in bold if they are above 50%. Thus, we can have a first glance at the potential trades that occurred. With majority rule, we can see that voters 1 often vote yes on Project A and that voter 3 also vote insincerely relatively often on Project C. These two insincere votes occur simultaneously, i.e. both voters voted insincerely on these respective projects, in 41.67% of the cases. This corresponds to the logrolling agreement predicted by the model. We call that predicted combination of votes. Note that the percentage of predicted combination must be smaller or equal to the smallest percentage in bold in the table (here 45.83%). Under unanimity rule, we can see that the three voters manage to coordinate to pass Project A and B very often, which is the predicted outcome. The three voters make the predicted combination of votes in 66.67% of the cases. As you can see, compared to majority rule, more voters have to vote insincerely to pass Project A for example. It leads to a higher percentage of insincere votes. This will be true on average in the experiment.

Concerning the outcomes groups play, under majority rule, only 20.83% correspond to the sincere outcome and in 41.67% of the cases, groups play the predicted outcome.[25] Under unanimity rule, groups play the predicted outcome in 62.5% of the cases, which is also the utilitarian outcome.[26]

While under sincere voting, majority rule should perform much better, in the presence of logrolling, payoffs are very similar; on average, groups earned 47.62 points under majority rule and 47 under unanimity rule. The difference is not significant (MW, p=0.672). It is true that we predicted unanimity rule to do better, but the fact that voters may not find agreements to convince everyone explains why they did not reach the predicted payoffs. Moreover, while only 29.17% of the outcomes under majority rule are part of the core, it is the case of 62.5% of the outcomes under unanimity rule. The three voters were often able to improve their payoffs compared to the status-quo under unanimity rule. However, 12.5% of the outcomes are dominated under unanimity rule.[27]

Finally, gains within groups are more unequal under majority rule than under unanimity rule (SD of gains = 7.51 under majority and 5.23 under majority). To sum up, in this case, in a lot of aspects unanimity rule performed better than majority rule even if we predicted unanimity to perform even better.

The second game we present is the following:

Under sincere voting, nothing passes under unanimity rule, payoffs are null, while Projects B and C pass under majority rule; payoffs are $(30, 3, 0) = 33$. With logrolling, voters should reach the

[25] The rest of the time, they play the utilitarian outcome: pass A and B.
[26] 12.5% of sincere outcomes (players did not find any agreement) and 25% of other outcomes.
[27] This is due to the fact that players did not find any agreement and passed nothing.

Table 4: Example 2: Game 1a and percentage of insincere votes.

(a) Majority.

Project	Voter 1	Voter 2	Voter 3
A	-9	**-3**	9
	20.83	**62.5**	20.83
B	15	-9	**3**
	4.17	29.17	**45.83**
C	15	12	-3
	0	0	41.67
Pred. combi.		37.50%	

(b) Unanimity.

Project	Voter 1	Voter 2	Voter 3
A	**-9**	**-3**	9
	87.5	**91.67**	0
B	15	-9	3
	4.17	41.67	8.33
C	15	12	**-3**
	0	0	**87.5**
Pred. combi.		79.17%	

same outcome under both rules. Indeed, under majority rule voter 2 can make an agreement with voter 3 to pass Project A and block Project B (mixed logroll: voter 2 votes yes on Project A and voter 3 votes no on Project B), such that Projects A and C pass and voters earn $(6, 9, 6) = 21$. This reduces the aggregate payoff compared to sincere voting, because the cost imposed on voter 1 with this logrolling agreement is very high; he looses 24 points. Under unanimity rule, the three voters should agree to pass Projects A and C. This is the same predicted outcome as under majority rule. As in the previous matrix, one voter is worse off under majority rule with this agreement while all are better off under unanimity rule compared to sincere voting. Logrolling is detrimental under majority rule and beneficial under unanimity rule in this case, but participants should reach the same outcome and so the same payoffs under both rules. We can now check whether groups reached the same outcome and payoffs in the lab under both rules.

Table 4 contains the percentage of insincere votes as in the previous example. Under majority rule, we can see that voter 2 often insincerely voted on Project A. The model predicts that voter 3 should block the passage of Project B (here the percentage of insincere votes is slightly under 50%). The combination of voter 2 voting yes on Project A and voter 3 voting no on Project B occurs in 25% of the cases. Under unanimity rule, voters' behavior is closer to our predictions; they voted in favor of Projects A and C (note that voter 2 also accept often to vote yes on project B). Voters 1, 2 and 3 simultaneously changed their no votes into a yes vote on Projects A and C in 79.17% of the cases.

Under majority and unanimity rule, "only" 37.5% of the outcomes correspond to the predicted outcome (passing A and C). The main difference between both rules is that under majority rule, in almost 30% of the cases, groups passed the utilitarian and sincere outcome (pass B and C) while under unanimity rule, groups often (41.67%) pass everything. In both cases, a large part of the outcomes are part of the core (91.67% under majority and 79.17% under unanimity).

In terms of payoffs, our model predicted a large decrease in aggregate payoffs under majority rule with the presence of logrolling. But voters did not pass Project A which has a net negative benefit and preferred to pass the two beneficial projects (B and C).[28] The aggregate gains are slightly higher under majority than under unanimity rule (MW, $p = 0.081$), but like in the previous case, gains are more unequal within groups under majority rule (SD $= 9.27$) than under unanimity rule (SD $= 6.84$). To sum up, while the model predicts equal performance under both rules, we see

[28] We will see in the general results that under majority rule, much less detrimental projects pass compared to our predictions.

that aggregate payoffs are higher under majority rule.

Finally, we present one last game:

Table 5: Example 3: Game 6b and percentage of insincere votes.

(a) Majority.

	Voter		
Project	1	2	3
A	-6	**-3**	12
	20.83	**79.17**	8.33
B	-3	9	**-3**
	25	16.67	**70.83**
C	12	15	-6
	0	0	45.83
Pred. combi.		62.50%	

(b) Unanimity.

	Voter		
Project	1	2	3
A	**-6**	**-3**	12
	87.5	**95.83**	0
B	-3	9	-3
	20.83	29.17	25
C	12	15	**-6**
	0	0	**83.33**
Pred. combi.		70.83%	

Under sincere voting, nothing pass under unanimity rule and Project C passes under majority rule, thus the payoff vector is $(12, 15, -6) = 21$. With logrolling, under majority rule voters 2 and 3 can agree to pass Projects A and B, such that everything pass. The payoff vector is $(3, 21, 3) = 27$. Voter 1 is harmed compared to the sincere outcome but the aggregate payoff is higher. Under unanimity rule, the three voters must agree to pass Projects A and C. The payoff vector will be in this case $(6, 12, 6) = 24$. This logrolling agreement leads to a higher aggregate payoff level than under sincere voting, but majority rule should perform better, in terms of aggregate payoff, in this situation.

Table 5 shows the percentage of insincere votes. We can see that under majority rule, voters 2 and 3 voted insincerely respectively on Projects A and B, which was predicted by the model. This combination happened in 62.50% of the cases. We will see in the following Section that constructive logrolling agreements are more likely than mixed ones. It is probably cognitively easier to form them. Under unanimity rule, it is also clear that voters 1, 2 and 3 traded their votes on projects A and C, which was predicted. The combination of insincere votes occurs in 70.83% of the cases.

Due to these insincere votes, under majority and unanimity rules, 62.5% and 58.33% of the outcomes correspond to the predicted outcomes. Note that under majority rule, the predicted outcome corresponds to the utilitarian outcome. We will see in our general results that outcomes are more likely to arise if they are part of multiple categories. Almost the same percentage of outcomes are part of the core under both rules (79.17% under majority and 70.83% under unanimity rule)

However, aggregate gains are higher under majority rule (46.5) than under unanimity rule (41.65) and the difference is significant (MW, p=0.007). Again, payoffs are more unequal under majority rule (5.45) than unanimity rule (3.16). To sum up, unanimity rule was supposed to perform worse than majority rule and that is indeed the case, despite a large improvement of payoffs under unanimity rule compared to the status-quo. Under unanimity rule, Project B cannot pass while it is efficient.It shows that some Type-I costs persist even in the presence of logrolling.

5.2 General results

After the description of voting behavior in some specific cases, we can now present our main results and compare the optimality of both rules when logrolling is possible. We will keep a similar structure to analyze the general results; First, we will analyze the proportion of sincere and insincere votes and we will identify more precisely the number of logrolling agreements under both rules. Then, we study which outcome groups play in the presence of logrolling and finally how logrolling impacts their payoffs (individual, aggregate and distribution of payoffs).

5.2.1 Logrolling agreements

Our first question is to know whether voters indeed made logrolling agreements. Logrolling implies a certain combination of insincere votes that strictly improves the payoffs of the voters part of this logrolling agreement.[29] We start by looking at the occurrence of insincere votes and whether they correspond to our predicted insincere votes.

Insincere and predicted insincere votes There are two types of insincere votes: 'insincere-yes votes', i.e. the participant votes yes while he prefers the project to fail and 'insincere-no votes', i.e. the participant votes no while he prefers the project to pass.

Result 1 (Insincere votes) *There are more insincere votes under unanimity rule than under majority rule.*

Support for Result 1 This supports Hypothesis 1. The insincere votes are summarized in Table 6 that displays the number of votes where voters voted yes or no when they are either in favor or opposed to the project. In other words, the cell *In favor/Voted no* corresponds to insincere-

Table 6: Sincere and insincere yes and no votes, majority and unanimity rule

Majority	Voted yes	Voted no	Total
In favor	1758	258	2016
Opposed	642	1230	1872
Total	2400	1488	3888

Unanimity	Voted yes	Voted no	Total
In favor	1767	249	2016
Opposed	938	934	1872
Total	2705	1183	3888

no votes and the cell *Opposed/Voted yes* corresponds to insincere-yes votes. Under majority rule (unanimity rule), 34.3% (50.11%) of the voters who are opposed to a project insincerely voted yes and 12.8% (12.35%) of the voters who are in favor of a project insincerely voted no. On average 23.15% of the total votes are insincere under majority rule and 30.53% are insincere under unanimity

[29]As forming a logrolling agreement with another voter is risky, i.e. the partner may not honor his part of the bargaining deal, we consider that voters do not engage in logrolling agreements if they are indifferent between the sincere outcome and the outcome when the agreement is made.

rule.[30] There are significantly more insincere votes under unanimity than under majority rule (MW, p=0.006) and this is due to the higher number of insincere-yes votes (MW, p=0.003).[31]

However, it is important to check which proportion of these insincere votes were predicted by the model. Under majority rule, we predicted that there would be 768 insincere votes and 960 under unanimity rule. This is logical as more voters under unanimity rule need to change their votes for a project to pass. Table 7 shows that there are more insincere votes than predicted by the model under both rules. 41.41% of the votes predicted to be insincere were insincere under majority rule while 71.87% of the votes predicted to be insincere were insincere under unanimity rule.[32]

Table 7: Predicted and observed sincere/insincere votes

Majority	Observed sincere	Observed insincere	Total
Predicted sincere	2538 (81.35%)	582 (18.65%)	3120 (100%)
Predicted insincere	450 (58.59%)	318 (41.41%)	768 (100%)
Total	2988 (76.85%)	900 (23.15%)	3888 (100%)

Unanimity	Observed sincere	Observed insincere	Total
Predicted sincere	2431 (83.03%)	497 (16.97%)	2928 (100%)
Predicted insincere	270 (28.12%)	690 (71.88%)	960 (100%)
Total	2701 (69.47%)	1187 (30.53%)	3888 (100%)

Logrolling agreements It is not because voters voted insincerely that they traded votes. To study whether voters formed logrolling agreement, we use two different ways to identify logrolling agreements in our results.

The simplest way is to look whether the voters who are predicted to vote insincerely did vote insincerely on the predicted projects. In this case, we only focus on the simultaneous occurrence of these insincere votes (like we did to describe the results in the three particular situations). This is a simple way to explain and calculate the occurrence of vote trading. We call this definition "predicted combination". However, it does not consider at all the other votes (of the other voters and/or on the other projects).

We develop another way of identifying logrolling agreements that takes into account all the votes in a game. In order to consider a vote as part of a logrolling agreement, it needs to fulfill three criteria: being insincere, useful and beneficial for the voters involved in the coalition. More precisely,

[30] No participant only voted sincerely; the most sincere participant under majority rule made 3 insincere votes (over his 54 votes) and the most sincere participant under unanimity rule made 8 insincere votes. The most insincere voter under majority (unanimity) rule made 23 (27) insincere votes.

[31] We do not see any strong time effect in the number of insincere votes by comparing the two blocks of 9 matrices. There is a bit more insincere votes in the second block under majority rule but the difference is not significant. And there is marginally (p=0.087) less insincere votes under unanimity rule in the second block than in the first one. There is no clear trend if we look period by period. It seems that voters quickly understood the possibility to vote insincerely. Additionally, we do not find any order effect when we compare the two subgroups of 9 participants. They do not vote more insincerely in one subgroup than in the other subgroup.

[32] We better predicted the insincere votes under unanimity rule because a large proportion of the votes under majority are what we call "useless insincere" votes, i.e., insincere votes that have no impact on the outcome. For example, an insincere vote is useless if the voter voted insincerely yes while the project is already favored by two voters.

to be considered as part of a logrolling agreement, a vote first needs to be *insincere*. Second, this insincere vote needs to be useful. We define a vote as a *useful* insincere vote if this insincere vote modifies the outcome of the project; it would (not) have passed if the voter voted sincerely and with this insincere vote, it does not pass (it passes). Finally, a *logrolling agreement* is composed of *two or more useful insincere* votes and requires that the voters who made these insincere votes (there may be two or three voters involved) *earn more* than what they would have earned under sincere voting. Thus, it is possible that some voters voted insincerely but that these insincere votes were not part of the predicted combinations. It is also possible that some predicted combinations occurred but that additional insincere votes modified the outcomes and the payoffs of the voters part of the predicted combination. Consequently, we do not have the same number of predicted combinations and logrolling agreements. Having these two definitions (predicted combinations and logrolling agreements) acts as a robustness check and allows to confirm that no other logrolling agreements were possible.

We have very small differences if we take one or the other definition. Under majority rule, in 6 observations (matrices), groups made the predicted combination but that are not considered as log-rolling agreements, because voters voted insincerely on other projects (or they did not confirm their vote on time) than the one predicted and it decreased the payoffs compared to the sincere voting. Under unanimity rule, this happened only 4 times. And it happened only once, under unanimity rule, that a group made a logrolling agreement that does not correspond to the predicted combination. We mainly use the second definition (logrolling agreement) in the following results but all results hold if we take the first definition.

Then, we distinguish two types of logrolling agreements: efficient and inefficient ones. An efficient logrolling agreement is a logrolling agreement where the aggregate payoff is higher with the logrolling agreement than without (sincere voting). With an inefficient logrolling agreement, the aggregate payoff is lower after the logrolling agreement. By definition, there cannot be any inefficient logrolling agreement under unanimity as the 3 voters must be part of the logrolling agreement.

Result 2 (Logrolling agreements) *There are more logrolling agreements under unanimity than majority. While there are only efficient logrolling agreements under unanimity, there are some inefficient logrolling agreements under majority but less than predicted.*

Support for Result 2 This partially supports Hypothesis 2. In Figure 9, we distinguish efficient and inefficient logrolling agreements. To the question "Do voters logroll?", we can answer that yes, they do, but not as much as predicted. In total, 31.39% (108/344) of the predicted logrolling agreements occurred under majority rule. 45.83% (66/144) of the predicted efficient logrolling agreements occurred under majority rule, while we reach 60.71% (204/336) under unanimity rule. What we see is that few inefficient logrolling agreements (21.67%) occurred even if these logrolling agreements would have been beneficial for the voters within the winning coalition.[33]

The logrolling agreements occur more or less depending on the matrices. Table 8 displays the marginal effects of a probit regression with panel data clustered at the subgroup level. The dependent variable "Logrolling agreement" is a dummy variable that equals 1 if the logrolling agreement occurred and 0 otherwise. The observations of Game 8 in the Majority treatment and of Games 4 and 7 in the Unanimity treatment are not taken into account in these regressions

[33]The predicted combinations of insincere votes (first definition) happened in 32.29% of the cases under majority rule and in 61.61% of the cases under unanimity rule. The difference is significant (MW, p=0.003).

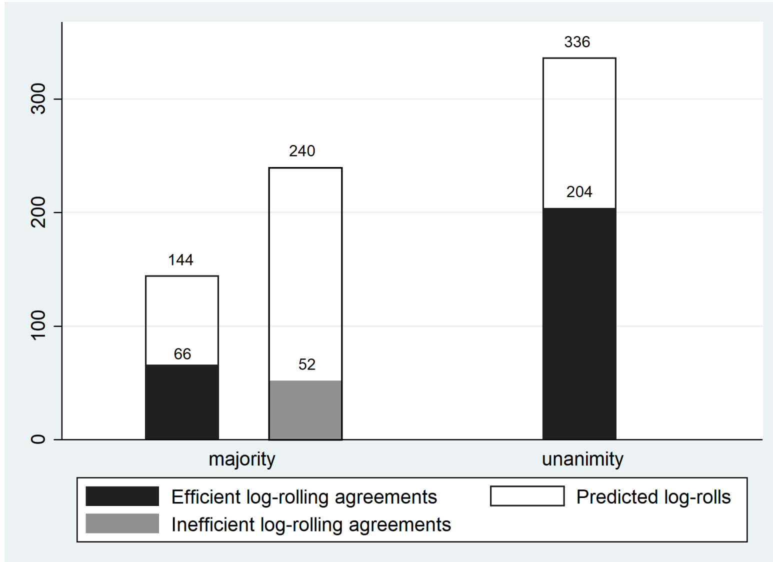


Figure 9: Efficient and inefficient logrolling agreements under majority and unanimity

as no logrolling agreement was predicted in these cases. The regression confirms that logrolling agreements are more likely under unanimity rule than majority rule. Then, we look whether some characteristics of the predicted logrolling agreements have an impact on its occurrence. First, we see that if the logrolling agreement is mixed (variable *Mixed logroll*), i.e. if it consists in blocking a project and pass another project, it is less likely to occur. It means that constructive logrolls, i.e. where all the voters involved in the logrolling agreements change some no votes into yes votes, are more likely. *Three-voter coalition* is a dummy variable that equals 1 when the predicted logrolling agreement requires the coalition of all voters and *Three-project bundle* is a dummy variable that equals 1 when the predicted logrolling agreement involves three different projects. We see that these two variables significantly and negatively impact the likelihood of logrolling agreements. It shows that when the agreement is more cognitively-demanding, because there are more projects involved or more voters that need to be part of the coalition, it may be harder to coordinate. Finally, we check whether the potential gains from logrolling agreements make them more likely. The variables *Positive gains (sincere)* and *Positive gains (status-quo)* are dummy variables that equal one if the logrolling agreement leads to an increase in aggregate payoffs compared to the sincere outcome or the status-quo respectively. It is always the case under unanimity and it is the case in 37.5% and 87.5% of the cases under majority rule respectively. The variables *Gains compared to sincere* and *Gains compared to status-quo* represents the potential gains from logrolling compared to the sincere outcome and the staus-quo. Again, it is the same variable for Unanimity. We can see that if logrolling increases the aggregate payoff, it becomes more likely to occur.

The results are very similar if we use the likelihood of predicted combinations as dependent variable.

The chat allowed groups to coordinate and form logrolling agreements. Under majority rule, only 3 mixed logrolling agreements and 6 constructive logrolling agreements were made without

Table 8: Likelihood of log-rolling agreements

	(1)	(2)	(3)	(4)	(5)
Unanimity	0.347***	0.266***	0.00854	0.246***	0.257***
	(0.0528)	(0.0577)	(0.0847)	(0.0551)	(0.0531)
Mixed logroll	-0.0897*	0.0328	-0.0409	-0.181***	-0.101*
	(0.0516)	(0.0569)	(0.0532)	(0.0457)	(0.0521)
Three-voter coalition	-0.100**	-0.0973**	-0.00509	-0.0981**	-0.0490
	(0.0498)	(0.0485)	(0.0501)	(0.0488)	(0.0506)
Three-project bundle	-0.381***	-0.371***	-0.282***	-0.374***	-0.329***
	(0.102)	(0.0990)	(0.105)	(0.0997)	(0.106)
Positive gains (sincere)		0.247***			
		(0.0373)			
Gains compared to sincere			0.0120***		
			(0.00214)		
Positive gains (status-quo)				0.333***	
				(0.0995)	
Gains compared to status-quo					0.00655***
					(0.00192)
N	720	720	720	720	720

Marginal effects; Standard errors in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

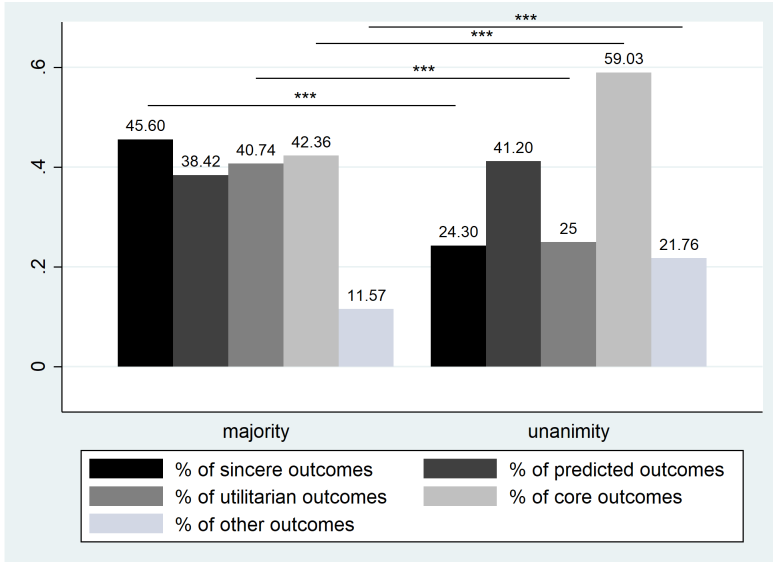


Figure 10: Type of outcomes under both rules.

chatting (7.63% of the logrolling agreements were made without chatting). Under unanimity, 8 logrolling agreements were made without chatting (3.92%).[34]

To sum up on insincere votes and logrolling agreements, there are more insincere votes under unanimity, but fewer logrolling agreements under majority (in absolute value and in percentage of predicted logrolling agreements). Consequently, like in the rest of the literature, voters take more time to confirm their vote under unanimity rule than under majority rule (see Figure 18 in Appendix).

5.2.2 Outcomes reached

After looking at individual votes, we now study which outcomes groups reach. As described earlier, we classify outcomes into five categories: sincere outcome, utilitarian outcome, predicted outcome, core outcome and other outcome. All definitions are at the beginning of Subsection 5.1.

Figure 10 shows the percentage of each category of outcomes under each rule. We can see that groups did not reach the same types of outcomes under both rules. First, we can see that there are more sincere outcomes under majority than unanimity rule (MW, $p = 0.002$). Remember that the sincere outcome under unanimity rule is the empty outcome. So it means that in 24% of the cases, voters did not find any agreement and no project was undertaken. Second, we were as good as predicting outcomes under majority and unanimity rule (MW, $p = 0.792$) and predicted outcomes represent around 40% of the outcomes reached. Third, we can see that there are more utilitarian

[34] Participants chatted more (number of lines written) under unanimity rule (2005 rows of text) than majority rule (1085 rows). This is also true if we look at the group level; 48 groups over 432 (11.11%) did not chat during one period under unanimity rule while 193 groups (44.67%) did not chat during one period under majority rule.

outcomes under majority rule (MW, $p = 0.005$). Groups played outcomes that maximized the aggregate payoff more often under majority rule, so majority rule performed better in this way. However, if we look at the next bar, we see that more outcomes are part of the core under unanimity than under majority rule (MW, $p = 0.001$). With this type of outcomes, all the voters earned more than if they played the status-quo. If we look at the number of outcomes that are part of the core per matrix (pooling the results of the original matrix and the variant), the result is quite robust. In 6 games, there are more outcomes part of the core under unanimity rule (the difference is significant for 3 of them) and in 3 games, there are more outcomes part of the core under majority rule, but none of the differences are significant. From this perspective, unanimity rule performed better than majority.

As we said earlier, an outcome may be part of multiple categories. We hypothesize that outcomes that are part of multiple categories are more likely to occur. For example, if a predicted outcome also maximizes the aggregate payoff (or corresponds to the sincere outcome), it is more likely that groups will be able to coordinate on this outcome. Table 29 shows the percentage of each possible outcome and the percentage of sincere, predicted, utilitarian and core outcomes for each matrix under both rules. We can see for example, under majority rule in Game 8, passing all the projects is the sincere, predicted, utilitarian outcome and is part of the core. This outcome occurs 95.83% of the time. In Table 9, we analyze whether predicted outcomes are more likely to emerge when they also correspond to the sincere outcome, to an outcome part of the core and to the utilitarian outcome. We confirm that the predicted outcome is more likely to occur when it is also part of another category. There are some differences between the two treatments. We can see that under majority rule, the fact that the predicted outcome is part of the core does not significantly increase its likelihood.

Table 9: Likelihood of predicted outcomes, probit model, panel data, cluster at the subgroup level, marginal effects.

	(1) Both treatments	(2) Majority	(3) Unanimity
Sincere outcome	0.771***	1.725***	1.060***
	(0.194)	(0.365)	(0.389)
Core outcome	0.434***	0.166	1.416***
	(0.169)	(0.135)	(0.426)
Utilitarian outcome	0.543***	0.561***	0.359*
	(0.120)	(0.198)	(0.200)
N	864	432	432
ll	-527.8	-237.7	-274.7
chi2	34.62	31.94	13.36

Marginal effects; Standard errors in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

The variable Core outcome is not omitted under Unanimity as the predicted outcome in Game 7 is the empty outcome but there exists an outcome different from the empty outcome that weakly dominates the empty outcome.

Finally, Figure 10 shows that there are more other outcomes under unanimity than majority rule

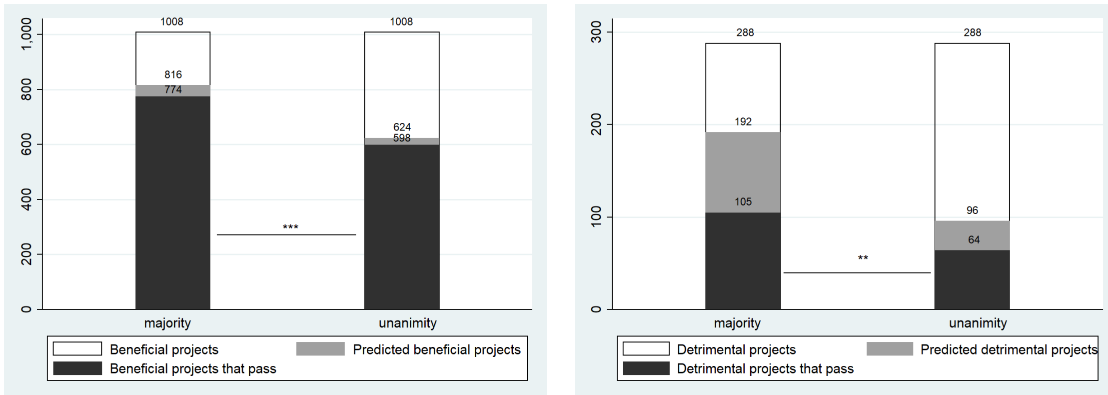
(MW, $p = 0.005$). These outcomes do not belong to any category. They arise when participants did not manage to find any better agreement or when they tried to reach more fair agreements. To sum up, more utilitarian outcomes were reached under majority rule but more outcomes are part of the core under unanimity rule. So both rules outperform the other in one aspect.

For the moment, we focused on the overall outcomes they reached but we can analyze the individual projects that passed and failed under both rules. We define a project as *beneficial* if its benefits outweigh its costs, i.e. if it has a positive net benefit, and *detrimental* otherwise, i.e. if it has a negative net benefit. Beneficial and detrimental projects corresponds to the same projects under majority and unanimity.

Result 3 (Beneficial and detrimental projects) *More beneficial projects pass under majority rule, but more detrimental projects also pass under majority rule.*

Support for Result 3. This supports Hypothesis 3. Our model predicts that under majority rule, 80.95% of the beneficial projects pass and under unanimity rule, 61.90% of them pass. Concerning detrimental projects, we predict that under majority rule, 66.67% of them pass and that under unanimity rule, 33.33% of them pass. Figure 11 represents the number of beneficial projects that pass (Figure a) and the number of detrimental projects that pass (Figure b). The graph also displays the total number of beneficial and detrimental projects (same numbers in the majority and in the unanimity treatment) as well as the predicted number of beneficial and detrimental projects that pass. Our results are very close to our predictions for beneficial projects. Indeed, under majority rule, 76.78% of the beneficial projects pass and under unanimity rule, 59.32% of the beneficial projects pass. Recall that no project would be unanimously supported under sincere voting. Thus, the fact that nearly 60% of the beneficial projects pass is due to insincere voting, indicating that these are gains due to logrolling. A large majority of the beneficial projects passed under unanimity rule, which represents a large reduction in Type-I costs under unanimity rule compared to the sincere voting outcomes, because none of these projects would have passed if participants voted sincerely. Beneficial projects are more likely to pass under majority rule than under unanimity rule (MW: $p = 0.001$). Concerning detrimental projects, the differences are much higher with our results; "only" 36.46% of the detrimental projects pass under majority rule and 22.22% of them pass under unanimity rule. They have a higher passage rate under majority rule (MW, $p = 0.013$), but under both rules, groups minimized the passage of these detrimental projects, to reduce Type-II costs.

Note that no detrimental projects should pass under unanimity rule if participants voted sincerely. In the presence of logrolling, it is now possible under unanimity rule to pass detrimental projects. But as we said a detrimental project is not always "bad for the group". Indeed, if this detrimental project is part of a bundle where the other project(s) compensate(s) the costs of the detrimental project, then the bundle is beneficial. Passing a detrimental project may be necessary to pass a beneficial project and compensate the harmed minority. The passage of detrimental projects under unanimity rule is a strong indicator that people are trading votes and not just seeking a more efficient solution. In order to check whether these detrimental projects do not harm the group at the end, we look at the percentage of bundle of projects that pass which are detrimental. Under majority rule, 6.48% of the bundles of projects that pass are detrimental. It means that the projects which are part of the bundle do not allow to compensate all the voters. While this



(a) Beneficial projects that pass.

(b) Detrimental projects that pass.

Figure 11: Passage rate of beneficial and detrimental projects.

percentage should be equal to 0 under unanimity rule, we still find that 2.31% of the bundle that passes are detrimental but this is significantly lower than under majority rule (MW, $p = 0.009$).

5.2.3 Aggregate payoffs

Now that we saw how groups vote in the presence of logrolling and how it impacts the outcomes played and the passage of projects, we can now study how logrolling impacts aggregate payoffs.

Result 4 (Aggregate payoffs) *Aggregate payoffs are significantly higher under majority than under unanimity rule, but compared to sincere voting payoffs, payoffs increased a lot under unanimity rule .*

Support for Result 4. This results partly supports Hypothesis 4. Figure 12 displays different types of payoffs under both rules. In addition to the *real payoffs* from the experiment, we display for comparison the average *sincere payoffs* (payoffs if participants vote sincerely), the average *predicted payoffs* by our model and the average *utilitarian payoffs* (average maximum payoffs). The sincere payoffs are null under unanimity rule as these gains correspond to the failure of all the projects. The predicted payoffs are similar under majority and unanimity rule. Finally, note that utilitarian payoffs are the same under majority and unanimity rule as they face the same matrices in both treatments. Payoffs are significantly higher under majority rule (MW, $p = 0.002$). However, the absolute difference is rather small (groups during the experiment earned on average 3.52 points less under unanimity rule with the "opportunity costs" way of calculating payoffs (transformed payoffs), which represents a bit more than 1 point per voter). Moreover, thanks to logrolling, voters could reach higher payoffs compared to the sincere payoffs under unanimity rule, while under majority rule their payoffs are very close to the sincere and the predicted gains. To sum up, under both rules, aggregate payoffs are relatively high but unanimity performs slightly worse than majority rule. We claim that the payoffs made under unanimity rule are gains from logrolling. The average aggregate payoff under unanimity rule, when no logrolling agreement has been made, equals 7.92 points, whereas when a logrolling agreement has been made, it equals 24.15 points. Under majority rule, in the absence of logrolling agreement, groups earn on average 20.34 points while they

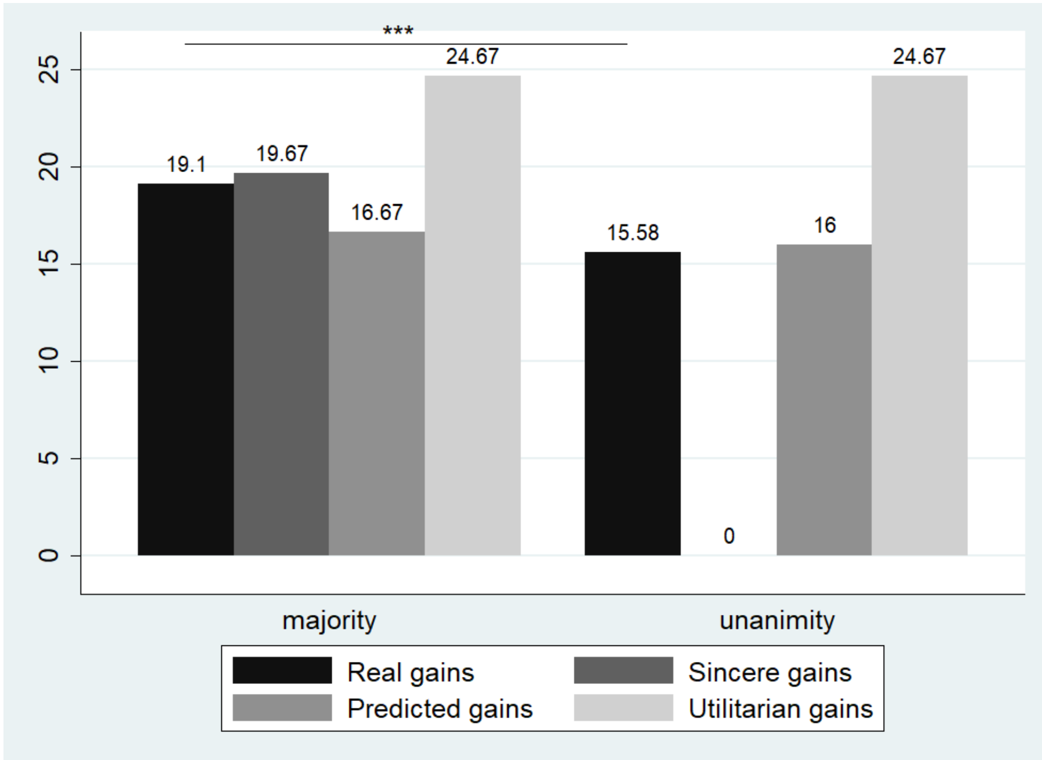


Figure 12: Payoffs under both rules

earn 15.81 points in the presence of a logrolling agreement. Moreover, under unanimity rule, in matrices where groups made at least one insincere vote but no logrolling agreement, groups earned on average 8.85 points. Voting insincerely is not enough tomake gains. To summarize on aggregate payoffs, we showed that even if logrolling allows the passage of detrimental projects under unanimity, it is to allow the passage of beneficial projects. Moreover, aggregate payoffs are much higher than under sincere voting and they are even higher when groups made logrolling agreements.

We can look at payoffs in each matrix to see if this results are robust in each matrix. We look at the aggregate payoffs per matrix (we pool the data of the original matrix and of the variant as predictions are the same and outcomes are pretty similar). Aggregate payoffs are higher under majority rule in each matrix but one. The performance of majority rule is thus very robust, even if differences are significant for 4 matrices and slightly significant for one. In 4 matrices, aggregate payoffs are not significantly different. Instead of just comparing the aggregate payoffs in each matrix, we compare for each matrix the realized and predicted gains from logrolling. Figure 13 displays two types of bars. The colored bars represent the difference between the real payoffs and the payoffs if voters played sincerely. That is what we call *realized gains*, as it represents the gains (or sometimes losses) due to the presence of logrolling. The white bars with a black outline represent the difference between the predicted and the sincere payoffs. That is what we call *predicted gains*,

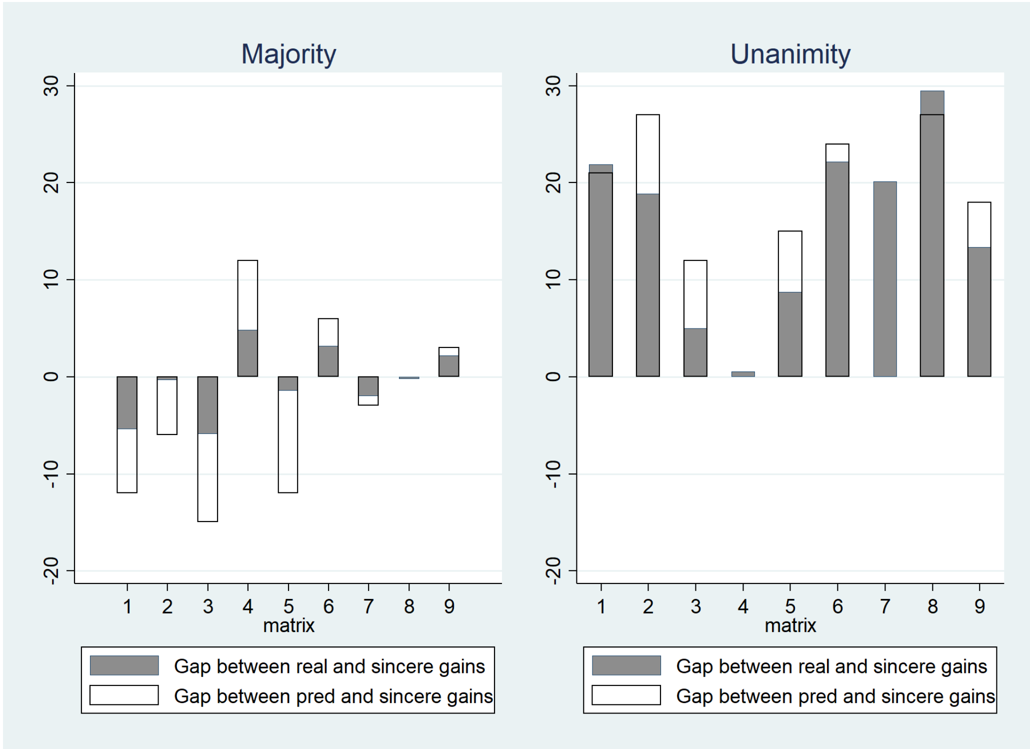


Figure 13: Realized vs. predicted gains from logrolling.

these are the "theoretical" gains (or losses) due to logrolling.[35] We can see that under majority rule, logrolling sometimes has a negative impact (realized and predicted). When we predicted a gain (loss) compared to sincere gains (bar above (below) 0), the gain (loss) occurred but with a lower intensity. The presence of logrolling may indeed be detrimental under majority rule. Under unanimity rule, logrolling cannot be detrimental. Groups made even better than predicted in 4 matrices.[36]

[35]Please note that it does not matter if we use the transformed or the untransformed payoffs. We would have exactly the same graph. Let's illustrate that with an example: Matrix 5a (see Appendix). The aggregate sincere payoffs under majority with the transformed payoffs equal 57 (only C passes) and if the voters pass the predicted outcome (all projects pass), the aggregate real payoffs are 63. The difference is this 6. If we take the untransformed payoffs, the sincere payoffs equal 9 and the real payoffs equal 15, which also make a difference of 6. By substracting the sincere payoffs we "normalize" the payoffs to the same basis.

[36]Game 4 and game 9 are two situations where under unanimity rule, the sincere outcome corresponds to the status-quo. So the predicted payoffs are null. Despite that, voters managed to increase aggregate payoffs.

5.2.4 Individual payoffs and distribution of payoffs

From now, we studied aggregate payoffs under both rules. Having high aggregate payoffs is of course an important criterion for the optimality of a decision rule. However, it is also important to know how these payoffs are distributed. In order to analyze how the payoffs of each voter are affected by logrolling, we use the Pareto criterion. First, it happens that groups play Pareto-dominated outcomes, i.e. outcomes where all three voters would have earned more if they found another agreement. In all the matrices but one, the empty outcome is Pareto-dominated and it may be hard under unanimity rule to find an agreement to pass some projects. Therefore, there are much more Pareto-dominated outcomes in the unanimity treatment (16.20% of the outcomes are Pareto-dominated) than in the majority treatment (2.08%) and the difference is significant (MW, $p = 0.001$).

We study more generally the payoffs of individual voters by making the histogram of individual payoffs under both rules: Figure 14.[37] We can see that under majority rule, 22.84% of the voters have negative payoffs (i.e. they earn less than they would have earned with the status-quo). This is the case for less than 10% of the voters under unanimity rule. The percentage should theoretically be equal to 0 as voters have a veto power. This is because some voters were willing to make a small sacrifice for efficiency or fairness reasons, or due to mistakes, or votes not confirmed on time. Logrolling may have a detrimental impact on individual payoffs under both rules in the lab, but mostly under majority rule.

[37]We remind that we use untransformed payoffs. This graph thus displays the difference between the real transformed payoffs and the payoffs voters would have obtained if nothing passes.

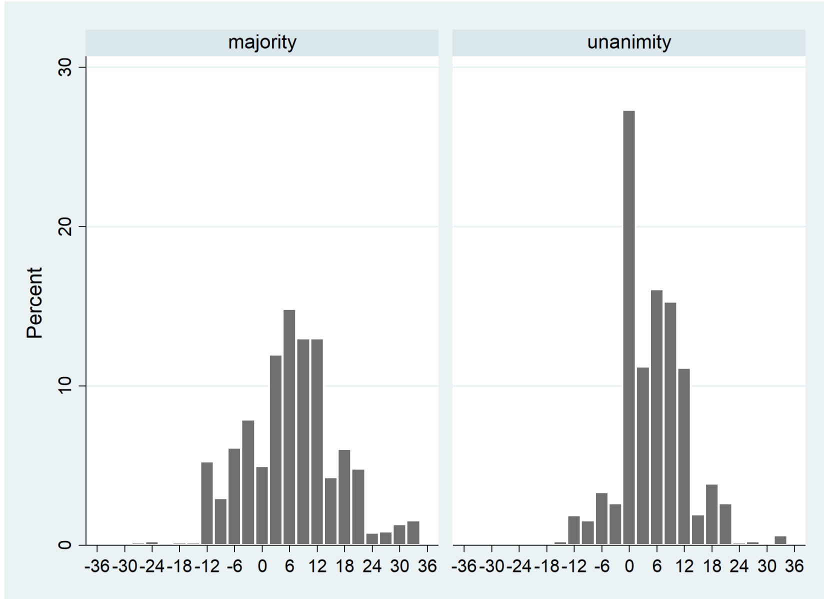


Figure 14: Histogram of individual payoffs.

Notes: Under majority rule, 22.84% of voters makes losses compared to the status-quo, 4.94% maintain same payoffs and 72.22% improve their payoffs compared to the status-quo (77.16% of voters weakly improve their payoffs compared to the status-quo). Under unanimity rule, 9.57% of voters makes losses compared to the status-quo, 27.31% maintain same payoffs and 63.12% improve their payoffs compared to the status-quo (90.43% of voters weakly improve their payoffs compared to the status-quo).

Finally, we study the inequalities of payoffs within groups under both rules. For that, we look at the standard deviation of payoffs within groups. Under majority rule, the average SD of payoffs equals 7.05, while it equals 5.71 under unanimity rule and the difference is significant (MW,$p = 0.003$).

To sum up our results, aggregate payoffs are slightly higher under majority rule than under unanimity rule. However, logrolling allows groups to increase the aggregate payoff under unanimity rule compared to sincere voting, while the overall effect of logrolling under majority rule is mixed. Moreover, under unanimity rule, logrolling allows a more important number of Pareto-optimal outcomes, such that almost no individual voter earn less in the presence of logrolling compared to sincere voting. Finally, payoffs are less unequal under unanimity rule.

6 Conclusion and discussion

In this paper, we compare the performance of majority and unanimity rule in the presence of logrolling. A group of voters decides to undertake or not different projects. Each project is associated with a certain value (positive or negative) for each voter obtains. To evaluate the performance of majority and unanimity rule, we first run simulations on randomly generated matrices of values. As payoffs are independently drawn from a symmetric distribution, on average majority rule leads to higher aggregate payoffs when voters vote sincerely. However, when the possibility of logrolling is taken into account and when the potential number of projects is sufficiently large to allow vote trading opportunities, unanimity becomes more optimal. In order to investigate whether logrolling agreements can be formed by groups of human subjects, we test some of the matrices of the simulations in the lab. While majority rule should perform better if participants vote sincerely, we observe that participants vote insincerely and form the predicted logrolling agreements in the lab. Thanks to these logrolling agreements, aggregate payoffs are relatively high under unanimity rule. Aggregate payoffs are still higher under majority rule, but while logrolling may have a negative impact under majority rule, it mostly allows Pareto improvement under unanimity rule.

There are few points that are subject to discussion with our experiment. First, we do not claim that one decision rule is "better" than the other. We are totally aware that decision rules must be carefully chosen and adapted to the context.

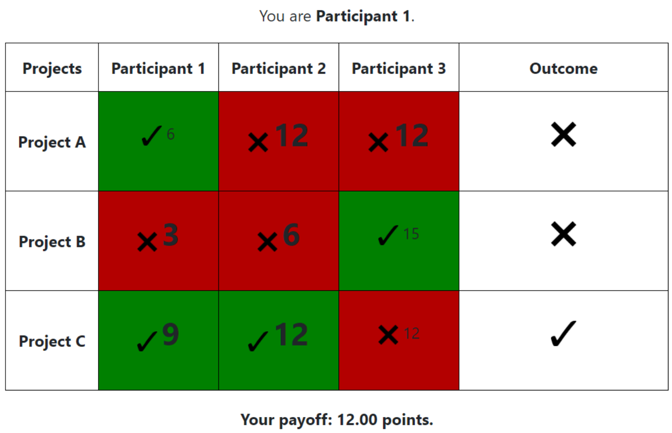
The second point we want to raise if about sincere voting. There are four "combinations" that we talked about: majority with sincere voting, unanimity with sincere voting, majority with logrolling and unanimity with logrolling. with our experiment we do not compare the optimality of each combination. Indeed, it may be noticed that in our simulations, even when unanimity rule with logrolling performs better than majority rule with logrolling, the average aggregate payoffs under majority rule without logrolling is still greater (see Figure 6). Thus we do not claim that one combination is better than the others. What we claim is that if logrolling is allowed/possible, larger majority requirements may be desirable.

The third point we want to address is linked to the second point. We emphasize that unanimity rule has "improved" a lot thanks to the possibility of logrolling while majority rules performs sometimes better but often worse in the presence of logrolling. This is of course partly due to the choice of matrices. Indeed, in the matrices chosen, no project is unanimously supported, so the performance of unanimity rule under sincere voting is null. Under majority rule, as payoffs are relatively symmetric, on average the payoffs are quite high with sincere voting. Thus, while the room for improvement allowed by logrolling is large under unanimity rule, it is not the case under majority rule. For example, under unanimity rule, there always exists (except in 2 matrices over 18) an outcome that Pareto dominates the sincere outcome (empty outcome in this case). But there is no outcome that Pareto dominates the sincere outcome under majority rule.

Finally, there are three aspects of the problem that we let for further research. The first one is the study of qualified majority. In fact, many institutions use this "intermediate" rule to balance the two types of costs defined in the introduction. Our simulations... The second aspect is the number of voters in the group. We only use three voters in the experiments, but we think that even if adding more voters increases the numbers of potential trades, it also increase the complexity of the bargaining game. Finally, to make a more realistic context, it would be interesting to test our games with imperfect information, i.e. for instance where voters do not know the preference intensities of the other voters.

A Appendix

A.1 Screenshots

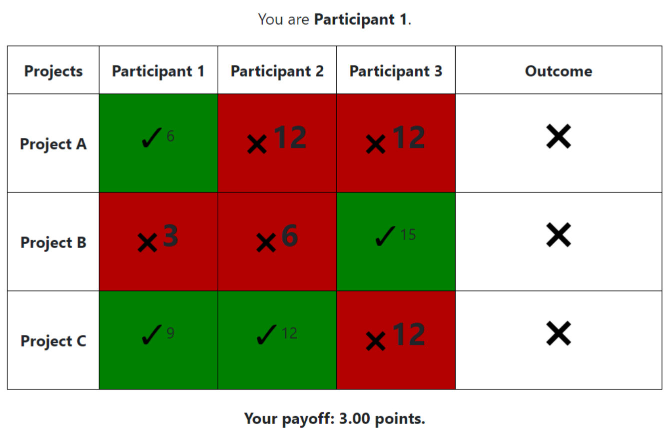


You are **Participant 1**.

Projects	Participant 1	Participant 2	Participant 3	Outcome
Project A	✓ 6	× 12	× 12	×
Project B	× 3	× 6	✓ 15	×
Project C	✓ 9	✓ 12	× 12	✓

Your payoff: 12.00 points.

Figure 15: Screenshot of voting outcomes under majority.



You are **Participant 1**.

Projects	Participant 1	Participant 2	Participant 3	Outcome
Project A	✓ 6	× 12	× 12	×
Project B	× 3	× 6	✓ 15	×
Project C	✓ 9	✓ 12	× 12	×

Your payoff: 3.00 points.

Figure 16: Screenshot of voting outcomes under unanimity.

A.2 Games used in the experiment.

In this section, we display the different games used in the experiment. We provide a very short explanation about why we selected each game. We give a lot of information on each game:

- We describe the values of each project for each voter. We first display the original game and its variant where fey numbers change compared to the original one but the sum of the columns and the rows are the sum in the original game and in its variant.
- Under the values of each project for each voter, we display the average percentage of insincere votes in the experiment.
- We display in bold the predicted vote trading.
- The column *Sinc.* shows which project(s) pass if voters vote sincerely. The column *Util.* shows which projects should pass to maximize the aggregate payoffs under both rules. Note that the Utilitarian outcomes are the same under both rules. Finally, *Pred.* shows which project(s) are predicted to pass with our algorithm. The columns of the original game and its variant are exactly the same. There is only a cardinal difference (so there will be differences in terms of payoffs), but the sincere, utilitarian and predicted outcomes are the same in the original version and in the variant.
- We describe the two sequences of games by providing the round of each game for the first and the second subgroup of 9 participants. The two subgroups face the same game but in a different order to see if there is an order effect.

After the four games (the original game and its variant for each decision rule), we draw a table including different pieces of information:

- We describe for each rule the payoff vectors and the aggregate payoffs depending on each type of outcome (sincere, utilitarian and predicted) for both the original game and the variant.
- The final row of the table shows which logrolling agreement is predicted by our algorithm. Let's take the example of game 1 under majority to explain our notation: {2, 3} means that voter 2 and voter 3 are part of the logrolling agreement and {A, B} means that in this logrolling agreement, they decide to flip the outcome on project A and B compared to the sincere outcome. So here, they decide to pass Project A and to block Project B. For that, voter 2 has to vote yes on Project A and voter 3 has to vote no on Project B. The resulting outcome is that projects A and C pass.

A.2.1 Game 1

With this game, logrolling allows to have the same outcome and thus payoff vector under majority and unanimity rule. We want to analyze whether groups reach this predicted outcome under both rules in the lab.

Game 1: majority.

Game 1a: Round 5 / Round 15.

	Voter					
Project	1	2	3	Sinc.	Util.	Pred.
A	-9	**-3**	9			X
	20.83	**62.5**	20.83			
B	15	-9	**3**	X	X	
	4.17	29.17	**45.83**			
C	15	12	-3	X	X	X
	0	0	41.67			
Pred. combi.		37.50%				

Game 1b: Round 13 / Round 5.

	Voter					
Project	1	2	3	Sinc.	Util.	Pred.
A	-9	**-6**	12			X
	33.33	**37.5**	20.83			
B	15	-9	**3**	X	X	
	4.17	33.33	**37.5**			
C	15	15	-6	X	X	X
	0	0	54.17			
Pred. combi.		25%				

Game 1: unanimity.

Game 1a: Round 5 / Round 15.

	Voter					
Project	1	2	3	Sinc.	Util.	Pred.
A	**-9**	**-3**	9			X
	87.5	**91.67**	0			
B	15	-9	3		X	
	4.17	41.67	8.33			
C	15	12	**-3**		X	X
	0	0	**87.5**			
Pred. combi.		79.17%				

Game 1b: Round 13 / Round 5.

	Voter					
Project	1	2	3	Sinc.	Util.	Pred.
A	**-9**	**-6**	12			X
	91.67	**87.5**	8.33			
B	15	-9	3		X	
	4.17	54.17	8.33			
C	15	15	**-6**		X	X
	0	0	**79.17**			
Pred. combi.		70.83%				

Game 1	Majority	Unanimity
Sincere	(30, 3, 0) = 33 and (30, 6, -3) = 33	(0, 0, 0) = 0
Utilitarian	(30, 3, 0) = 33 and (30, 6, -3) = 33	(30, 3, 0) = 33 and (30, 6, -3) = 33
Predicted	(6, 9, 6) = 21 and (6, 9, 6) = 21	(6, 9, 6) = 21 and (6, 9, 6) = 21
Logrolling agreement	Mixed: {2,3} {A, B}	Constructive: {1,2,3} {A, C}

A.2.2 Game 2

Log-rolling under unanimity rule allows to have the same aggregate payoff than under majority rule without log-rolling. Unanimity rule with logrolling can be seen as a substitute for majority rule without logrolling.

Game 2: majority.

Game 2a: Round 15 / Round 18.

Project	Voter 1	Voter 2	Voter 3	Sinc.	Util.	Pred.
A	15 16.67	**-3** **37.5**	-6 12.5		X	X
B	6 8.33	15 0	-6 29.17	X	X	X
C	**12** **16.67**	-9 37.5	9 4.17	X	X	
Pred. combi.		12.50%				

Game 2b: Round 8 / Round 2.

Project	Voter 1	Voter 2	Voter 3	Sinc.	Util.	Pred.
A	15 33.33	**-3** **25**	-6 8.33		X	X
B	6 4.17	12 4.17	-3 58.33	X	X	X
C	**12** **4.17**	-6 37.5	6 4.17	X	X	
Pred. combi.		0%				

Game 2: unanimity.

Game 2a: Round 15 / Round 18.

Project	Voter 1	Voter 2	Voter 3	Sinc.	Util.	Pred.
A	15 25	-3 29.17	-6 4.17		X	
B	6 4.17	15 0	**-6** **58.33**		X	X
C	12 4.17	**-9** **66.67**	9 8.33		X	X
Pred. combi.		50%				

Game 2b: Round 8 / Round 2.

Project	Voter 1	Voter 2	Voter 3	Sinc.	Util.	Pred.
A	15 54.17	-3 0	-6 0		X	
B	6 8.33	12 4.17	**-3** **75**		X	X
C	12 4.17	**-6** **79.17**	6 8.33		X	X
Pred. combi.		58.33%				

Game 2	Majority	Unanimity
Sincere	(18, 6, 3) = 27 and (18, 6, 3) = 27	(0, 0, 0) = 0
Utilitarian	(33, 3, -3) = 33 and (33, 3, -3) = 33	(33, 3, -3) = 33 and (33, 3, -3) = 33
Predicted	(21, 12, -12) = 21 and (21, 9, -9) = 21	(18, 6, 3) = 27 and (18, 6, 3) = 27
Logrolling agreement	Mixed: {1, 2,} {A, C}	Constructive: {2,3} {B, C}

A.2.3 Game 3

Our algorithm gives different predictions than the algorithm of Casella and Palfrey (2017a). In their algorithm, voters do not vote immediately after an agreement contrary to our case. Here they would predict that under majority rule,

- voter 2 can deal with voter 1 to block Projects A and B such that everything fails,
- then voter 1 can deal with voters 2 and 3 to pass Projects A, B and C,
- then voter 2 deals with voter 1 to block A and B such that only Project C passes.

Game 3: majority.

Game 3a: Round 18 / Round 7.

Project	Voter 1	Voter 2	Voter 3	Sinc.	Util.	Pred.
A	-12	9	**-3**			X
	0	33.33	**37.5**			
B	9	-12	12	X	X	X
	8.33	45.83	4.17			
C	9	**6**	-6	X	X	
	0	**29.17**	33.33			
Pred. combi.		29.17%				

Game 3b: Round 1 / Round 10.

Project	Voter 1	Voter 2	Voter 3	Sinc.	Util.	Pred.
A	-12	9	**-3**			X
	12.5	29.17	**33.33**			
B	6	-12	15	X	X	X
	8.33	25	4.17			
C	12	**6**	-9	X	X	
	12.5	**37.5**	33.33			
Pred. combi.		25%				

Game 3: unanimity.

Game 3a: Round 18 / Round 7.

Project	Voter 1	Voter 2	Voter 3	Sinc.	Util.	Pred.
A	**-12**	9	**-3**			X
	33.33	33.33	**45.83**			
B	9	**-12**	12		X	X
	20.83	**37.5**	29.17			
C	9	6	**-6**		X	X
	12.5	8.33	**37.5**			
Pred. combi.		20.83%				

Game 3b: Round 1 / Round 10.

Project	Voter 1	Voter 2	Voter 3	Sinc.	Util.	Pred.
A	**-12**	9	**-3**			X
	29.17	33.33	**29.17**			
B	6	**-12**	15		X	X
	16.67	**33.33**	20.83			
C	12	6	**-9**		X	X
	16.67	20.83	**41.67**			
Pred. combi.		25%				

Game 3	Majority	Unanimity
Sincere	(18, -6, 6) = 18 and (18, -6, 6) = 18	(0, 0, 0) = 0
Utilitarian	(18, -6, 6) = 18 and (18, -6, 6) = 18	(18, -6, 6) = 18 and (18, -6, 6) = 18
Predicted	(-3, -3, 9) = 3 and (-6, -3, 12) = 3	(6, 3, 3) = 12 and (6, 3, 3) = 12
Logrolling agreement	Mixed: {2,3} {A, C}	Constructive: {1,2,3} {A,B, C}

A.2.4 Game 4

What happens if one voter dislikes all the projects? This is the "generous legislator" case studied by Hortala-Vallve et al. (2011). Thanks to lab experiments, the author shows that the voter who dislikes all project "generously" offers his support to a voter to form a coalition in order to reduce his cost. This is what we predict under majority rule.

Game 4: majority.

Game 4a: Round 17 / Round 4.

	Voter					
Project	1	2	3	Sinc.	Util.	Pred.
A	**-3** **58.33**	-3 33.33	15 12.5		X	X
B	-15 4.17	3 45.83	-9 16.67			
C	-9 12.5	3 16.67	**3** **37.5**	X		
Pred. combi.		37.50%				

Game 4b: Round 6 / Round 17.

	Voter					
Project	1	2	3	Sinc.	Util.	Pred.
A	**-3** **62.5**	-3 20.83	15 16.67		X	X
B	-12 4.17	3 45.83	-12 8.33			
C	-12 8.33	3 25	**6** **58.33**	X		
Pred. combi.		58.33%				

Game 4: unanimity.

Game 4a: Round 17 / Round 4.

	Voter					
Project	1	2	3	Sinc.	Util.	Pred.
A	-3 41.67	-3 25	15 16.67		X	
B	-15 0	3 58.33	-9 4.17			
C	-9 25	3 12.5	3 16.67			
Pred. combi.	No logrolling predicted					

Game 4b: Round 6 / Round 17.

	Voter					
Project	1	2	3	Sinc.	Util.	Pred.
A	-3 16.67	-3 8.33	15 16.67		X	
B	-12 0	3 45.83	-12 12.5			
C	-12 12.5	3 33.33	6 12.5			
Pred. combi.	No logrolling predicted					

Game 4	Majority	Unanimity
Sincere	(-9, 3, 3) = -3 and (-12, 3, 6) = -3	(0, 0, 0) = 0
Utilitarian	(-3, -3, 15) = 9 and (-3, -3, 15) = 9	(-3, -3, 15) = 9 and (-3, -3, 15) = 9
Predicted	(-3, -3, 15) = 9 and (-3, -3, 15) = 9	(0, 0, 0) = 0
Logrolling agreement	Mixed: {1,3} {A, C}	No logroll

A.2.5 Game 5

Logrolling is detrimental under majority rule. The aggregate payoff is lower than under sincere voting and the predicted aggregate payoff is negative, i.e. the costs are higher than the benefits.

Game 5: majority.

Game 5a: Round 9 / Round 1.

Project	Voter 1	Voter 2	Voter 3	Sinc.	Util.	Pred.
A	**-12**	-12	6			X
	16.67	4.17	54.17			
B	15	-6	**-3**		X	X
	8.33	20.83	**29.17**			
C	-12	12	9	X	X	X
	37.5	4.17	4.17			
Pred. combi.		16.67%				

Game 5b: Round 16 / Round 11.

Project	Voter 1	Voter 2	Voter 3	Sinc.	Util.	Pred.
A	**-12**	-15	9			X
	16.67	8.33	41.67			
B	15	-3	**-6**		X	X
	8.33	33.33	**33.33**			
C	-12	12	9	X	X	X
	54.17	4.17	4.17			
Pred. combi.		16.67%				

Game 5: unanimity.

Game 5a: Round 9 / Round 1.

Project	Voter 1	Voter 2	Voter 3	Sinc.	Util.	Pred.
A	-12	-12	6			
	4.17	4.17	62.5			
B	15	**-6**	**-3**		X	X
	12.5	**62.5**	**58.33**			
C	**-12**	12	9		X	X
	70.83	12.5	4.17			
Pred. combi.		45.83%				

Game 5b: Round 16 / Round 11.

Project	Voter 1	Voter 2	Voter 3	Sinc.	Util.	Pred.
A	-12	-15	9			
	8.33	4.17	45.83			
B	15	**-3**	**-6**		X	X
	8.33	**75**	**45.83**			
C	**-12**	12	9		X	X
	79.17	0	0			
Pred. combi.		41.67%				

Game 5	Majority	Unanimity
Sincere	(-12, 12, 9) = 9 and (-12, 12, 9) = 9	(0, 0, 0) = 0
Utilitarian	(3, 6, 6) = 15 and (3, 9, 3) = 15	(3, 6, 6) = 15 and (3, 9, 3) = 15
Predicted	(-9, -6, 12)=-3 and (-9, -6, 12) = -3	(3, 6, 6) = 15 and (3, 9, 3) = 15
Logrolling agreement	Constructive: {1,3} {A, B}	Constructive: {1,2,3} {B, C}

A.2.6 Game 6

Logrolling allows to increase aggregate payoffs compared to the sincere voting payoffs both under majority and under unanimity rule.

Game 6: majority.

Game 6a: Round 11 / Round 6.

Project	Voter 1	Voter 2	Voter 3	Sinc.	Util.	Pred.
A	-6 29.17	**-6** **45.83**	15 4.17		X	X
B	-3 37.5	12 20.83	**-6** **37.5**		X	X
C	12 4.17	15 4.17	-6 54.17	X	X	X
Pred. combi.		37.50%				

Game 6b: Round 7 / Round 14.

Project	Voter 1	Voter 2	Voter 3	Sinc.	Util.	Pred.
A	-6 20.83	**-3** **79.17**	12 8.33		X	X
B	-3 25	9 16.67	**-3** **70.83**		X	X
C	12 0	15 0	-6 45.83	X	X	X
Pred. combi.		62.50%				

Game 6: unanimity.

Game 6a: Round 11 / Round 6.

Project	Voter 1	Voter 2	Voter 3	Sinc.	Util.	Pred.
A	**-6** **87.5**	**-6** **91.67**	15 8.33		X	X
B	-3 41.67	12 16.67	-6 45.83		X	
C	12 0	15 0	**-6** **95.83**		X	X
Pred. combi.		87.50%				

Game 6b: Round 7 / Round 14.

Project	Voter 1	Voter 2	Voter 3	Sinc.	Util.	Pred.
A	**-6** **87.5**	**-3** **95.83**	12 0		X	X
B	-3 20.83	9 29.17	-3 25		X	
C	12 0	15 0	**-6** **83.33**		X	X
Pred. combi.		70.83%				

Game 6	Majority	Unanimity
Sincere	(12, 15, -6) = 21 and (12, 15, -6) = 21	(0, 0, 0) = 0
Utilitarian	(3, 21, 3) = 27 and (3, 21, 3) = 27	(3, 21, 3) = 27 and (3, 21, 3) = 27
Predicted	(3, 21, 3) = 27 and (3, 21, 3) = 27	(6, 9, 9) = 24 and (6, 12, 6) = 24
Logrolling agreement	Constructive: {2,3} {A, B}	Constructive: {1,2,3} {A, C}

A.2.7 Game 7

There are sometimes multiple ways to form logrolling agreements. It will then depends on which voter "starts". In our case, under majority rule, if voter 1 is the first to make a proposal, he offers voter 2 to form an agreement and switch outcomes on Projects B and C. This is logrolling agreement "a" in the table. If voter 3 moves first, he offers voter 2 to switch outcomes on Projects A and B. This is logrolling agreement "b" in the table. If voter 2 starts, he can choose the agreement he favors most.

Under unanimity, voter 3 is indifferent between forming an agreement and not forming an agreement with voter 1 to pass A and C.

Game 7: majority.

Game 7a: Round 12 / Round 13.

	Voter					
Project	1	2	3	Sinc.	Util.	Pred.
A	15	$\mathbf{6^{b}}$	-9	X	X	X^a
	4.17	**41.67**	33.33			
B	$\mathbf{-3^{a}}$	15	$\mathbf{-3^{b}}$		X	X^{a+b}
	37.5	16.67	**54.17**			
C	-6	$\mathbf{12^{a}}$	9	X	X	X^b
	29.17	**8.33**	0			
Pred. combi. (a or b)		41.67%				

Game 7b: Round 2 / Round 8.

	Voter					
Project	1	2	3	Sinc.	Util.	Pred.
A	15	$\mathbf{9^{b}}$	-12	X	X	X^a
	8.33	**29.17**	29.17			
B	$\mathbf{-3^{a}}$	15	$\mathbf{-3^{b}}$		X	X^{a+b}
	29.17	20.83	**25**			
C	-6	$\mathbf{9^{a}}$	12		X	X^b
	29.17	**16.67**	8.33			
Pred. combi. (a or b)		25%				

Game 7: unanimity.

Game 7a: Round 12 / Round 13.

	Voter					
Project	1	2	3	Sinc.	Util.	Pred.
A	15	6	-9		X	
	4.17	8.33	62.5			
B	-3	15	-3		X	
	41.67	33.33	41.67			
C	**-6**	12	9		X	
	83.33	4.17	0			
Pred. combi.	No logrolling predicted					

Game 7b: Round 2 / Round 8.

	Voter					
Project	1	2	3	Sinc.	Util.	Pred.
A	15	9	**-12**		X	
	4.17	8.33	**41.67**			
B	-3	15	-3		X	
	37.5	16.67	29.17			
C	**-6**	9	12		X	
	66.67	4.17	4.17			
Pred. combi.	No logrolling predicted					

Game 7	Majority	Unanimity
Sincere	(9, 18, 0) = 27 and (9, 18, 0) = 27	(0, 0, 0) = 0
Utilitarian	(6, 33, -3) = 36 and (6, 33, -3) = 36	(6, 33, -3) = 36 and (6, 33, -3) = 36
Predicted	(12, 21, -12) = 21 and (12, 24, -15) = 21 or (-9, 27, 6) = 24 and (-9, 24, 9) = 24	(0, 0, 0) = 0
Logrolling agreement	Mixed: {1,2} {B, C} or {2, 3} {A, B}	No logroll

A.2.8 Game 8

We selected Game 8 for the same reasons as Game 7 but there are two possible agreements under unanimity rule in this case. If voter 2 is the first mover, he offers voter 1 to pass Projects A and C. If voter 3 first makes an agreement, he forms a coalition with voter 1 to pass Projects B and C. Voter 1 can choose one or the other agreement.

Moreover, in Game 8, the sincere, utilitarian and predicted outcomes are the same, which means that no logrolling agreement is predicted, thus no insincere votes should occur.

Game 8: majority.

Game 8a: Round 10 / Round 3.

	Voter					
Project	1	2	3	Sinc.	Util.	Pred.
A	6 0	-3 58.33	6 0	X	X	X
B	9 8.33	3 4.17	-6 62.5	X	X	X
C	-3 54.17	9 0	12 0	X	X	X
Pred. combi.	No logrolling predicted					

Game 8b: Round 4 / Round 12.

	Voter					
Project	1	2	3	Sinc.	Util.	Pred.
A	6 0	-6 33.33	9 0	X	X	X
B	9 0	6 0	-9 37.5	X	X	X
C	-3 41.67	9 0	12 0	X	X	X
Pred. combi.	No logrolling predicted					

Game 8: unanimity.

Game 8a: Round 10 / Round 3.

	Voter					
Project	1	2	3	Sinc.	Util.	Pred.
A	6 4.17	$\mathbf{-3^a}$ **91.67**	6 4.17		X	X^a
B	9 4.17	3 8.33	$\mathbf{-6^b}$ **75**		X	X^b
C	$\mathbf{-3^{a+b}}$ **91.67**	9 0	12 4.17		X	X^{a+b}
Pred. combi. (a or b)		91.67%				

Game 8b: Round 4 / Round 12.

	Voter					
Project	1	2	3	Sinc.	Util.	Pred.
A	6 0	$\mathbf{-6^a}$ **79.17**	9 4.17		X	X^a
B	9 0	6 0	$\mathbf{-9^b}$ **95.83**		X	X^b
C	$\mathbf{-3^{a+b}}$ **100**	9 0	12 4.17		X	X^{a+b}
Pred. combi. (a or b)		100%				

Game 8	Majority	Unanimity
Sincere	(12, 9, 12) = 33 and (12, 9, 12) = 33	(0, 0, 0) = 0
Utilitarian	(12, 9, 12) = 33 and (12, 9, 12) = 33	(12, 9, 12) = 33 and (12, 9, 12) = 33
Predicted	(12, 9, 12) = 33 and (12, 9, 12) = 33	(3, 6, 18) = 27 and (3, 3, 21) = 27 or (6, 12, 6) = 24 and (6, 15, 3) = 24
Logrolling agreement	No logroll	Constructive: {1, 2} {A, C} or {1, 3} {B, C}

A.2.9 Game 9

Logrolling increases aggregate payoffs both under majority and unanimity rule, but especially under unanimity rule. Unanimity rule should perform better than majority rule,k but three voters must coordinate under unanimity rule.

Game 9: majority.

Game 9a: Round 3 / Round 16.

	Voter					
Project	1	2	3	Sinc.	Util.	Pred.
A	**-6**	-3	15		X	X
	58.33	25	0			
B	12	6	-6	X	X	X
	4.17	4.17	37.5			
C	15	-15	**-3**			X
	12.5	8.33	**45.83**			
Pred. combi.		41.67%				

Game 9b: Round 14 / Round 9.

	Voter					
Project	1	2	3	Sinc.	Util.	Pred.
A	**-3**	-6	15		X	X
	62.5	41.67	8.33			
B	9	9	-6	X	X	X
	4.17	4.17	58.33			
C	15	-15	**-3**			X
	29.17	16.67	**58.33**			
Pred. combi.		50%				

Game 9: unanimity.

Game 9a: Round 3 / Round 16.

	Voter					
Project	1	2	3	Sinc.	Util.	Pred.
A	**-6**	**-3**	15		X	X
	70.83	91.67	4.17			
B	12	6	**-6**		X	X
	8.33	0	**87.5**			
C	15	-15	-3			
	54.17	0	4.17			
Pred. combi.		66.67%				

Game 9b: Round 14 / Round 9.

	Voter					
Project	1	2	3	Sinc.	Util.	Pred.
A	**-3**	**-6**	15		X	X
	75	**83.33**	4.17			
B	9	9	**-6**		X	X
	8.33	8.33	**79.17**			
C	15	-15	-3			
	50	0	25			
Pred. combi.		54.17%				

Game 9	Majority	Unanimity
Sincere	(12, 6, -6) = 12 and (9, 9, -6) = 12	(0, 0, 0) = 0
Utilitarian	(6, 3, 9) = 18 and (6, 3, 9) = 18	(6, 3, 9) = 18 and (6, 3, 9) = 18
Predicted	(21, -12, 6) = 15 and (21, -12, 6) = 15	(6, 3, 9) = 18 and (6, 3, 9) = 18
Logrolling agreement	Constructive: {1, 3} {A, C}	Constructive: {1, 2, 3} {A, B}

Table 28: Vector payoffs for each outcome and core outcomes ORIGINAL payoffs.

Game	A passes	B passes	C passes	A and B pass	A and C pass	B and C pass	A, B and C pass	Empty outcome
Game 1a	*(-9,-3,9)*	(15, -9, 3)	(15, 12, -3)	(6, -12, 12)	**(6, 9, 6)**	**(30, 3, 0)**	**(21, 0, 9)**	*(0, 0, 0)*
Game 1b	(-9, -6, 12)	(15, -9, 3)	(15, 15, -6)	(6, -15, 15)	**(6, 9, 6)**	(30, 6, -3)	**(21, 0, 9)**	*(0, 0, 0)*
Game 2a	*(15, -3, -6)*	(6, 15, -6)	(12, -9, 9)	(21, 12, -12)	(27, -12, 3)	**(18, 6, 3)**	(33, 3, -3)	*(0, 0, 0)*
Game 2b	*(15, -3, -6)*	(6, 12, -3)	(12, -6, 6)	(21, 9, -9)	(27, -9, 0)	**(18, 6, 3)**	(33, 3, -3)	*(0, 0, 0)*
Game 3a	(-12, 9, -3)	(9, -12, 12)	(9, 6, -6)	(-3, -3, 9)	(-3, 15, -9)	(18, -6, 6)	**(6, 3, 3)**	*(0, 0, 0)*
Game 3b	(-12, 9, -3)	(6, -12, 15)	(12, 6, -9)	(-6, -3, 12)	(0, 15, -12)	(18,-6, 6)	**(6, 3, 3)**	*(0, 0, 0)*
Game 4a	(-3, -3, 15)	*(-15, 3, -9)*	(-9, 3, 3)	*(-18, 0, 6)*	(-12, 0, 12)	(-24, 6, -6)	(-27, 3, 9)	**(0, 0, 0)**
Game 4b	(-3, -3, 15)	*(-12, 3, -12)*	(-12, 3, 6)	*(-15, 0, 3)*	(-15, 0, 21)	(-24, 6, -6)	(-27, 3, 9)	**(0, 0, 0)**
Game 5a	*(-12, -12, 6)*	(15, -6, -3)	(-12, 12, 9)	*(3, -18, 3)*	(-24, 0, 15)	**(3, 6, 6)**	(-9, -6, 12)	*(0, 0, 0)*
Game 5b	*(-12, -15, 9)*	(15, -3, -6)	(-12, 12, 9)	*(3, -18, 3)*	(-24, -3, 18)	**(3, 9, 3)**	(-9, -6, 12)	*(0, 0, 0)*
Game 6a	(-6,-6, 15)	*(-3, 12, -6)*	(12, 15, -6)	(-9, 6, 9)	**(6, 9, 9)**	(9, 27, -12)	**(3, 21, 3)**	*(0, 0, 0)*
Game 6b	(-6, -3, 12)	*(-3, 9, -3)*	(12, 15, -6)	(-9, 6, 9)	**(6, 12, 6)**	(9, 24, -9)	**(3, 21, 3)**	*(0, 0, 0)*
Game 7a	(15, 6, -9)	*(-3, 15, -3)*	(-6, 12, 9)	(12, 21, -12)	**(9, 18, 0)**	(-9, 27, 6)	(6, 33, -3)	*(0, 0, 0)*
Game 7b	(15, 9, -12)	*(-3, 15, -3)*	(-6, 9, 12)	(12, 24, -15)	**(9, 18, 0)**	(-9, 24, 9)	(6, 33, -3)	*(0, 0, 0)*
Game 8a	*(6, -3, 6)*	*(9, 3, -6)*	*(-3, 9, 12)*	**(15, 0, 0)**	**(3, 6, 18)**	**(6, 12, 6)**	**(12, 9, 12)**	*(0,0,0)*
Game 8b	*(6, -6, 9)*	*(9, 6, -9)*	*(-3, 9, 12)*	**(15, 0, 0)**	**(3, 3, 21)**	**(6, 15, 3)**	**(12, 9, 12)**	*(0, 0, 0)*
Game 9a	(-6, -3, 15)	(12, 6, -6)	*(15, -15, -3)*	**(6, 3, 9)**	(9, -18, 12)	(27, -9, -9)	(21, -12, 6)	*(0, 0, 0)*
Game 9b	(-3, -6, 15)	(9, 9, -6)	*(15, -15, -3)*	**(6, 3, 9)**	(12, 21, 12)	(24, -6, -9)	(21, -12, 6)	*(0, 0, 0)*

Notes: The payoff vectors in bold weakly Pareto-dominate the status-quo payoff vector and are not Pareto-dominated by any other payoff vectors. They correspond to what we call "core outcomes". The payoff vectors in italic are Pareto-dominated.

Table 29: Percentage of sincere, predicted, utilitarian and core outcomes under both rules.

	Majority								Unanimity							
Game 1	Ad(1)	Bd	C	AB	AC	BC	ABC	∅	Ad(1)	Bd	C	AB	AC	BC	ABC	∅d
Original			8.33		37.5	29.17	25		4.17		8.33		37.5		41.67	8.33
Variant			12.5		25	41.67	20.83				4.17	8.33	29.17	4.17	41.67	12.5
Sincere						X										X
Predicted					X								X			
Utilitarian						X								X		
Core					X	X(1)	X						X	X(1)	X	
Game 2	Ad	B	C	AB	AC	BC	ABC	∅d	Ad	B	C	AB	AC	BC	ABC	∅d
Original		4.17	4.17	12.5	4.17	50	25			4.17	16.67	4.17		50		25
Variant		4.17	4.17			70.83	20.83			16.67	20.83			58.33		4.17
Sincere						X										X
Predicted				X										X		
Utilitarian							X								X	
Core						X								X		
Game 3	A	B	C	AB	AC	BC	ABC	∅d	A	B	C	AB	AC	BC	ABC	∅d
Original			8.33	29.17		54.17	8.33			4.17	12.5	8.33		4.17	20.83	50
Variant		12.5	4.17	25	4.17	50	4.17		4.17	4.17	12.5			4.17	25	50
Sincere						X										X
Predicted			CP	X			CP	CP			CP				X	
Utilitarian						X								X		
Core							X								X	
Game 4	A	Bd	C	ABd	AC	BC	ABC	∅	A	Bd	C	ABd	AC	BC	ABC	∅
Original	33.33		33.33	8.33	16.67	4.17	4.17		12.5		16.67		8.33			62.5
Variant	58.33		20.83		4.17	4.17	4.17	8.33			8.33		4.17			87.5
Sincere			X													X
Predicted	X															X
Utilitarian	X								X							
Core								X								X
Game 5	Ad	B	C	ABd	AC	BC	ABC	∅d	Ad	B	C	ABd	AC	BC	ABC	∅d
Original			58.33			20.83	12.5	8.33		4.17	25			41.67	4.17	25
Variant		4.17	45.83		4.17	25	20.83				37.5			37.5	4.17	20.83
Sincere			X													X
Predicted							X							X		
Utilitarian						X								X		
Core						X								X		
Game 6	A	Bd	C	ABd(1)	AC	BC	ABC	∅d	A	Bd	C	ABd(1)	AC	BC	ABC	∅d
Original			50	4.17	4.17	4.17	37.5				8.33		54.17		33.33	4.17
Variant			12.5		16.67	8.33	62.5		12.5		12.5	4.17	58.33		12.5	
Sincere			X													X
Predicted							X						X			
Utilitarian							X								X	
Core					X		X						X		X	
Game 7	A	Bd	C	AB	AC	BC	ABC	∅d	A	Bd	C	AB	AC	BC	ABC	∅d
Original			4.17	4.17	29.17	33.33	25	4.17			12.5	4.17	33.33	12.5	25	12.5
Variant	8.33	4.17	4.17	4.17	41.67	20.83	12.5	4.17			16.67		33.33	8.33	8.33	33.33
Sincere					X											X
Predicted				X		X										X
Utilitarian							X								X	
Core					X								X			
Game 8	Ad	Bd	Cd	AB	AC	BC	ABC	∅d	Ad	Bd	Cd	AB	AC	BC	ABC	∅d
Original					8.33		91.67						16.67		75	8.33
Variant							100							20.83	75	4.17
Sincere							X									X
Predicted							X						X	X		
Utilitarian							X								X	
Core				X	X	X	X					X	X	X	X	
Game 9	A	B	Cd	AB	AC	BC	ABC	∅d	A	B	Cd	AB	AC	BC	ABC	∅d
Original	4.17	20.83		29.17		4.17	41.67		4.17	20.83		62.5				12.5
Variant		20.83		16.67		8.33	50	4.17	8.33	20.83		54.17				16.67
Sincere		X														X
Predicted							X					X				
Utilitarian				X								X				
Core				X								X				

Note: d means that the outcome is Pareto-dominated and (1) means that it is only the case in the original matrix and not in its variant. CP means that these outcomes are predicted by the model of Casella and Palfrey and not by our model.

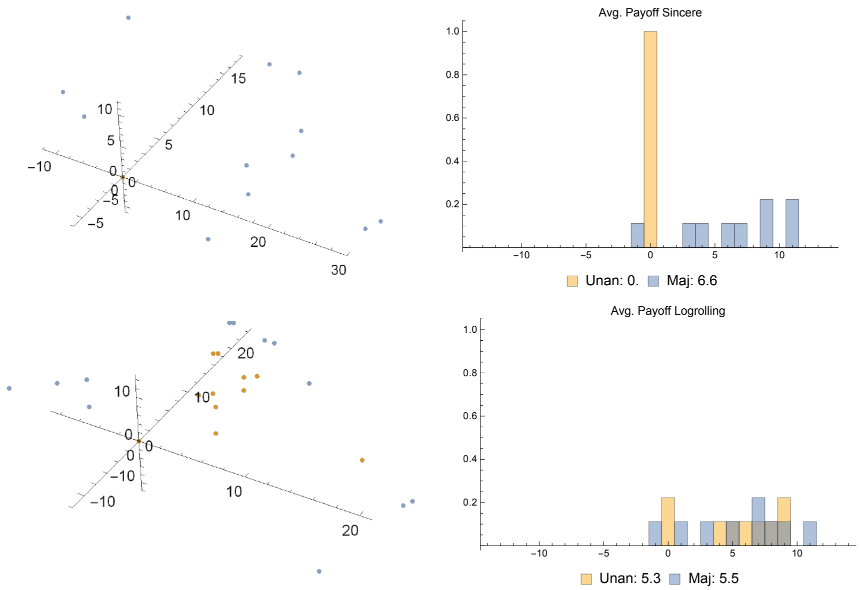


Figure 17: Individual and average payoffs with our chosen matrices.

Table 30: Summary statistics: Socio-demographic individual characteristics

Treatments	Majority-stranger	Unanimity-stranger	p-value
Age	23.46 (2.99)	22.92 (3.19)	0.295
Male (%)	47.22%	50%	0.741
Economic student (%)	23.61%	19.44%	0.546
# sessions	4	4	
# participants	72	72	

Notes: Standard deviations are in parentheses. P-values from t-tests.

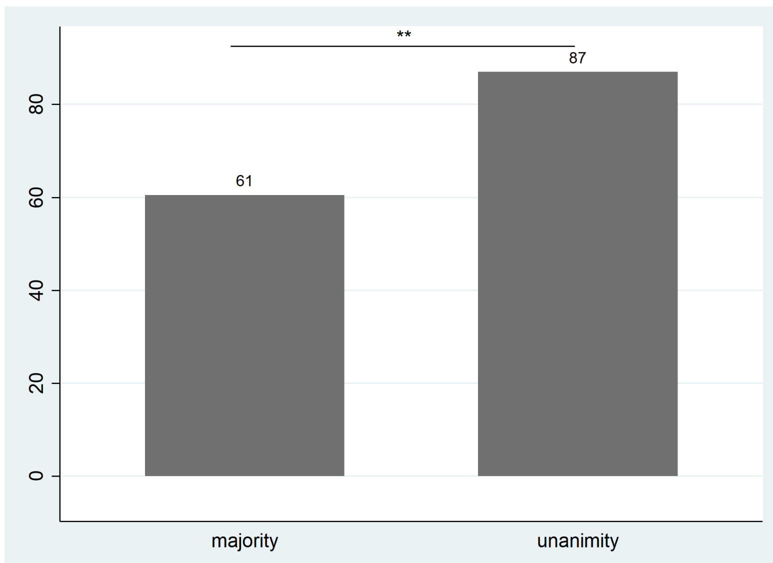


Figure 18: Average time to confirm a vote under each decision rule

Notes: Voters take more time to confirm a vote under unanimity: MW, $p = 0.021$.

B Instructions

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

General rules

- This experiment will take about 90 minutes. During this time, you cannot leave your seat.
- Please turn off your phone. From this point; there should be nothing left on your desk. (A drink is allowed of course.)
- Please remain quiet duing the experiment and do not speak with other participants.
- If you have a question, please raise your hand or say "I have a question".
- Remain seated at the end of the experiment until your seat number is called. You wll then receive your payment and sign your receipt.

Rounds, points, payment

For your participation, you will receive a participation fee of 5 EUR. During the experiment, there is also the possibility to get a higher payoff. Your payoff will depend on your decisions and the decisions of the others participants. The experiment consists in 18 rounds. In each round you have the opportunity to earn points. At the end of the experiment, 5 rounds are randomly chosen for payment. Your payment will depend on your average score in the random rounds. The conversion rate is the following: 1 point = 1 EUR.

Groups and ID numbers

At the beginning of the experiment, groups of 3 participants are randomly formed. Each participant in a group is randomly assigned an ID number (1,2 or 3). The composition of the groups and the ID numbers of participants will be redefined each round, i.e. you will interact with different participants in each round and your ID number as well as the ID numbers of other participants will change. (It may happen that you randomly meet the same participant in several rounds, but it is impossible that the exact same composition of a group repeats itself.

Projects and points

In each round, your group will make three decisions. Each decision corresponds to one of the three projects (A, B and C) that your group will either "pass" or "not pass". Each participant, depending on the decision on projects either receives points when the project passes or when it does not pass. This information is shown in a table. In this table, each row corresponds to a project and each column to a participant. Here is an example:

Each cell shows the outcome for which the corresponding participant would receive points (✘ and ✓), and the number of points he receives if the group decides accordingly.

As an example, consider the first cell (Participant 1, Project A):

- The ✘ means that Participant 1 receives points if Project A does not pass.
- The number "6" means that he receives 6 points if the group decides not to pass the project.
- If Project A passes, Participant 1 will get 0 point.

Project	Participant 1	Participant 2	Participant 3
Project A	✗ 6	✓ 3	✓ 12
Project B	✓ 6	✓ 9	✓ 15
Project C	✗ 12	✓ 15	✗ 3

As another example, consider Project B and Participant 2. The ✓ and the number "9" mean that Participant 2 receives 9 points if Project B passes. Otherwise, he will not receive any points.

The total gain of a participant in a round is given by the sum of points earned from the three projects. The actual content of the table is different in the experiment than in the examples, and changes from round to round.

How the group makes decisions

The members of the group vote separately on each of the three projects. Each participant can vote either with "Yes" or "No". *Majority treatment: A project passes if at least 2 participants in the group vote Yes. Unanimity treatment: A project passes if all 3 participants in the group vote Yes.* Otherwise it does not pass.

To submit a vote for a project, first click on "yes" or "no" in the corresponding row:

- If a participant clicks on "yes", the associated cell to the project and ID number will be colored in light green. If a participant clicks on "no", the corresponding cell is colored in light red.
- Participants may change their decision as often as they like until they clock the "confirm" button.

If a participant clicks on the "confirm" button, the corresponding cell becomes dark green or dark red depending on his vote. At that point, the participant cannot change his vote anymore on this project. All the group members can see how the colors of the cells change. Thus, all the participants can see the votes of the other participants and whether their votes are confirmed or not. Each round lasts 3 minutes at maximum. If at the end of the 3 minutes, a or several participants did not vote and confirm his vote(s) for a or several projects, the unconfirmed votes ae automatically considered as "no" votes.

Example:

In this example, Participant 1 voted "no" and confirmed his vote on Project C. For Project B, he voted "yes" but did not confirm yet. Participant 1 can also see that:

- Participant 2 has voted "yes" on Project C but has not yet confirmed it.
- Participant 3 has voted "yes" on Project B and confirmed his vote.

You are **Participant 1.**

Projects	Participant 1	Participant 2	Participant 3	Your vote
Project A	✗ 6	✓ 3	✓ 12	Yes No
Project B	✓ 6	✓ 9	✓ 15	Yes No confirm
Project C	✗ 12	✓ 15	✗ 3	confirmed

- Particpant 3 has voted "no" on Project C and confirmed his vote.

End of each round
A round ends after 3 minutes, or once all participants have voted on all projects and have confirmed their decisions. After that, you will be informed about the outcomes of the votes, as well as about the points achieved in the round.

The confirmed votes are displayed in the table, with the cells colored in dark green or dark green depending on the votes.(If a participant has not voted on a project or has not confirmed his vote on time, the corresponding cell appears dark red, because in this case it is considered as a "no" vote.)

It also indicates which projects pass and which projects do not pass. If the project passes, a ✓ in displayed in the last column on the right.If the project does not pass, a ✗ is displayed. The points earned in this round are highlighted.

Projects	Participant 1	Participant 2	Participant 3	Outcome
Project A	✗ 6	✓ 3	✓ 12	✓
Project B	✓ 6	✓ 9	✓ 15	✓
Projekt C	✗ 12	✓ 15	✗ 3	✗

Figure 19: *Majority treatment*

The total score you achieved in the round will be displayed below the table. This information remains visible for 20 seconds or until you click "Next". After all the groups have finished the round and have seen the outcome, a new round begins with a new table. Before the start of the next round (as described above) new groups are formed.

Note: Since the next round begins only when all participants are ready, there may be a certain waiting time between two rounds.

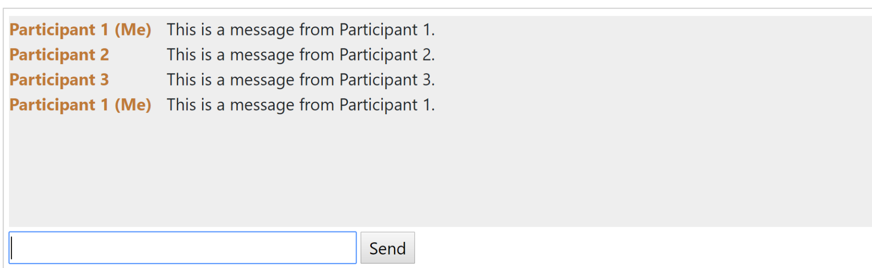
Projects	Participant 1	Participant 2	Participant 3	Outcome
Project A	✗ 6	✓ 3	✓ 12	✗
Project B	✓ 6	✓ 9	✓ 15	✓
Projekt C	✗ 12	✓ 15	✗ 3	✗

Figure 20: *Unanimity treatment*

Communication in the group

Within each round of the experiment, you have the opportunity to exchange messages with your group members. To do this, use the chat window at the bottom of the screen. To send a message, enter your message in the template, then either click "send" or press the entry button of your keyboard.

Please, use communication only to discuss about the experiment and the decisions of your group. It is not allowed to reveal your identity to other participants. For example, your should not mention your name, your seat number or any other identifying features under no circumstances. Participants who do not follow this rule will be excluded from the experiment and will not receive any payment.



Summary: procedure of a round

1. At the beginning of each round random groups of 3 participants are formed. The composition of your group will never be repeated.
2. In each round, the participants see a table representing the points they may earn depending on the group decisions. A ✓ means that a participant receives points, when the corresponding project passes. A ✗ means that a participant receives points if the corresponding project does not pass.
3. *Majority treatment* You have three minutes to vote on each project and to confirm your votes. If at least 2 participants vote "yes", the project passes, otherwise it does not pass. Depending on the voting outcomes, participants receive points.

4. *Unanimity treatment* You have three minutes to vote on each project and to confirm your votes. If all 3 participants vote "yes", the project passes, otherwise it does not pass. Depending on the voting outcomes, participants receive points.

5. You can communicate with other participants using a chat window.

6. At the end of a round; you will learn the voting outcome and the total number of points you earned in this round.

7. At the end of the experiment, 5 rounds are randomly chosen for payment. Your payment in EUR equals the average of the total score you have reached in these rounds.

Before the start of the experiment, we ask you to answer some comprehension questions. If you have a question, please raise your hand or say "I have a question".

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