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Counting on my vote not counting: Expressive voting in committees ☆

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ABSTRACT

How do voting institutions affect incentives of committees to vote expressively? We model a committee that chooses whether to approve a proposal that some members may consider ethical. Members who vote for the proposal receive expressive utility, and all members pay a cost if the proposal is accepted. Committee members may have different depths of reasoning. Under certain sufficient conditions, the model predicts that features that reduce the probability of a member being pivotal – namely, larger committee size, or a more restrictive voting rule – raise the share of votes in favour of the proposal. A laboratory experiment with a charitable donation framing presents evidence in line with these results. Our structural estimation recovers the distributions of altruistic and expressive preferences, as well as of depth of reasoning, across individuals.

1. Introduction

Decision-making bodies often have to vote on proposals that incur costs but are considered ethical. Corporate boards deciding whether to adopt costly labour or environmental standards; legislatures voting on whether to assist refugees; or committees choosing whether to adopt policies that benefit underrepresented minorities are all examples of collective decisions that involve an ethical dimension. In this paper, we study how the design of a committee affects voting for proposals that are costly for committee members but may be seen as ethical by at least some of them.

Two factors can underlie voting for such alternatives. First, individuals may have consequentialist, or instrumental, motivations: they may be altruistic, and thus derive utility when an ethical choice is implemented. Second, they may receive utility from the act of voting for an ethical option, regardless of the actual outcome of the vote. Voting behaviour that is motivated by such a preference is often referred to as *expressive voting* (see Brennan and Hamlin, 1998; Hillman, 2010).[1]

In this paper, we analyse the effect of voting institutions - in particular, of voting rule and committee size - on expressive voting by committee members. We model a committee that decides whether or not to adopt a costly proposal. The proposal involves moral considerations. Specifically, each committee member who

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[1] Some papers distinguish expressive voting from other non-conseqentialist motivations such as moral reasons and duties, and self-image concerns (Shayo and Harel, 2012). In our paper, we refer to all non-consequentialist motivations as expressive.

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votes for the proposal receives an expressive payoff irrespective of the outcome of the vote. These payoffs are drawn independently across members from a distribution with full support on the real line - thus, members do not necessarily agree about the ethical value of the proposal, and some may even dislike the act of voting for it. Each member is privately informed about her expressive payoff. If the share of members voting for the proposal reaches a certain quota, the proposal is adopted. In this case, all members, regardless of their individual votes, must pay a cost. Furthermore, each committee member receives altruistic utility if the proposal is approved.

Thus, the setting involves a voting game with many privately informed players and a continuum of types. Playing Nash equilibrium best responses in this environment would require committee members to make inferences about preferences and actions of other members. Existing research suggests that individuals often fail to do so even in simpler games (Brocas et al., 2014; Esponda and Vespa, 2014; Choi et al., 2019). Because of this, to account for possible cognitive limitations of players, we use level-k best responses (Stahl and Wilson, 1994) as a solution concept. Under this solution concept, each player has depth of reasoning $k = 0, 1, ..$, which describes her strategic sophistication. A player with depth of reasoning 0 randomises uniformly between the actions available to her, while a player with depth of reasoning $k > 0$ plays a best response to players with depth of reasoning $k - 1$. A number of past studies have shown that level-k best responses fit experimental data in voting games (Dittmann et al., 2014; Bassi, 2015; Le Quement and Marcin, 2019).[2]

The key theoretical predictions stem from the interaction of expressive and instrumental motivations. Committee members whose expressive payoffs are negative strictly prefer voting against the proposal as long as the altruistic utility is lower than the cost. However, each member with positive expressive payoffs faces a tradeoff. On the one hand, she receives a positive payoff from voting for the proposal. On the other hand, by doing so she runs a risk of moving the collective decision towards the ethical choice, which entails a cost. The latter risk, however, only matters in the event in which the voter is pivotal. Hence, features of committee design that reduce members' perceived probability of being pivotal increase the incentive to vote for the ethical alternative.

The effect of voting institutions on a given member's probability of voting for the proposal thus depend on how the institutions affect her probability of being pivotal. If other members did not change their behaviour in response to a change in voting institutions, it would be straightforward to show that an increase in the committee size, or in the required quota of votes would make a member more likely to vote for the proposal. However, voting institutions also affect the behaviour of other members, and this may potentially reverse the above effect. Nevertheless, we show that under certain assumptions, a randomly selected member is still less likely to be pivotal – and hence more likely to vote for the proposal – when the committee is larger, or when the voting rule is more restrictive. In particular, these results hold when the cost of the proposal is sufficiently low, or when sufficiently many members have depth of reasoning below 2.

We test the model in a laboratory experiment. Subjects are randomly divided into committees. They vote for or against donating to a well-known charity (the Red Cross). If the committee votes to donate, the experimenters transfer a fixed amount of money to the charity, at a certain cost to each committee member. Each subject faces the same voting rule throughout the session (either unanimity rule, or simple majority rule), while the committee size and the cost of donation varies within subjects across different rounds. The experimental design enables us to structurally estimate individual-specific expressive payoffs, altruistic preferences, and the distribution of depth of reasoning.

Our experiment yields three main findings. First, in line with the theory, voting institutions that reduce the probability of being pivotal encourage individual members to vote for the costly ethical alternative. In particular, individual subjects are more likely to vote in favour of donating when the committee size is larger, and when voting under unanimity rule rather than simple majority rule. Furthermore, by exploiting additional information from belief elicitation among a subset of our subjects, we test whether the mechanism of our model explains this result. Our estimates suggest that changes of voting institutions alter subjects' perceived probability of being pivotal consistently with the model. Overall, our paper provides evidence supporting the existence of expressive voting. To date, the existing experimental evidence on expressive voting is mixed, as discussed in the next section.

Second, we structurally estimate the distribution of expressive preferences across individuals. To the best of our knowledge, our paper is the first to do so.[3] We find that females and individuals from lower socio-economic background tend to display lower expressive payoffs. Our estimated expressive payoffs correlate positively with self-evaluated social preferences.

Third, our maximum likelihood estimation recovers the distribution of depth of reasoning in a voting environment with imperfect information. We find that approximately 52.6 % of our subjects have depth of reasoning 0, that is, randomise their vote uniformly between the two alternatives. Approximately 34 % are of level-1 depth of reasoning. The rest of the subjects have depth of reasoning 2 or more; in particular, we cannot reject the hypothesis that some of them are of level-3 depth of reasoning.

The expressive preferences that we identify can be seen as a particular form of preferences for ethical actions. A large literature has studied the incentives of individuals to take costly ethical actions, such as donating to charity (Andreoni and Abigail Payne, 2013; Cooper, 2016; Vesterlund, 2016). In particular, researchers distinguish between two potential motivations: pure altruism, in which individuals value the payoffs of others; and non-consequentialist *warm glow*. The latter represents utility from the act of giving itself, similarly to the expressive payoffs in our paper (Andreoni, 1989; Andreoni, 1990; Ottoni-Wilhelm et al., 2017). However, in many cases, decisions that involve costly ethical choices are made not individually, but collectively via voting. Our paper sheds light on such decision-making by analysing the interaction between pure altruism and non-consequentialist utility in a voting context, and in particular, by examining the role of voting institutions.

In addition, our paper extends the existing knowledge about the role of social preferences in political behaviour. Many studies have looked at the interplay of other-regarding preferences with citizens' choices in elections (Fisman et al., 2017), referenda (Epper et al., 2020), and public protests (Ginzburg and Guerra, 2021). In all these contexts, however, the number of participants is large, and an individual is unlikely to be pivotal. Our paper offers an insight into the impact of preferences for ethical actions on voting in small committees, where pivotality considerations play a role.

The results of our paper are also relevant to voting in settings other than electoral politics. For example, behaviour of corporate shareholders is often driven by pivotality considerations, that is, by their perceived ability to affect the decisions of the company (see an overview in Yermack, 2010). A recent empirical paper by

[2] In Section 6.5, we consider Nash equilibrium as an alternative solution concept, and show that under unanimity voting rule the Nash equilibrium produces similar theoretical predictions.

[3] Some previous studies (for example, Ottoni-Wilhelm et al., 2017) structurally estimate the distribution of payoffs from making ethical choices individually, but not from the act of voting for ethical alternatives.

Dressler (2020) finds that voting choices of Israeli shareholders are consistent with the mechanism proposed by our model: a shareholder is more likely to vote expressively against a management-sponsored proposal when her vote is less likely to be pivotal.

The remainder of the paper is organised as follows. The next section discusses the related literature. Section 3 introduces the theoretical model, and derives the main theoretical results. Section 4 describes the experimental design. Section 5 presents the results of the experiment. Section 6 analyses potential mechanisms, investigates outcomes of collective decisions, checks for robustness of the results under supermajority voting rules, and discusses the relation between our solution concept and Nash equilibrium. Section 7 concludes. All proofs are in the Appendix.

2. Related literature

A number of studies have tested the hypothesis that voters vote expressively by examining the impact of the probability of being pivotal on voting decisions. Most often, this analysis aimed at explaining behaviour in elections. To identify expressive voting, researchers have largely followed two approaches. The first approach elicits the subject's expectations about the likelihood of being pivotal. Using this method, Bischoff and Egbert (2013) find evidence of expressive voting, while Tyran (2004) and Tyran and Sausgruber (2006) find no evidence. The second approach directly induces the probability of being pivotal by randomly assigning subjects to be dictators. Researchers can then check whether an increase in the probability of being a dictator makes subjects more likely to choose the ethical alternative, as the expressive voting hypothesis suggests. With this approach, Feddersen et al. (2009) and Shayo and Harel (2012) find evidence for expressive voting in a setting where subjects make decisions to redistribute money across a group of subjects. On the contrary, Carter and Guerette (1992) finds no clear support for the expressive voting hypothesis in a setting where subjects choose whether to donate to charity. Combining both approaches, Fischer (1996) and Kamenica and Brad (2014) compare subjects who are randomly chosen to be dictators to those who vote as part of a group.[4]

In contrast, our treatment variable is not the elicited or directly induced probability of being pivotal, but rather the voting institutions – the size of the voting body, and the voting rule. Hence, we are able to analyse how exogenous features of committee design affect the incentives to vote expressively. In particular, we show that committee members understand how voting institutions influence the probability of being pivotal, and adjust their behaviour accordingly. Thus, our analysis is particularly suited for studying committees, in which (in contrast to elections) the probability of being pivotal can be substantial, and depends on committee design.

Our paper also contributes to the literature on cognitive limitations in voting. A number of papers have applied the level-k model model of Stahl and Wilson (1994) to the study of voting. Dittmann et al. (2014) find that level-k best responses fit experimental data in a costly voting setting. Bassi (2015) uses level-k model to compare voting strategies under approval voting, Borda count, and plurality voting. The paper finds that under plurality voting, which is similar to our setting under simple majority, most players play level-k best responses. Le Quement and Marcin (2019) find that a level-k model with two cognitive levels (zero and one) is best at explaining behaviour in a setting in which there is communication prior to voting. Our paper adds to this line of research by structurally estimating the distribution of depth of reasoning in a voting context.

In addition to expressive voting, the literature has identified other channels through which perceived pivotality affects incentive to take ethical actions. One such a channel is diffusion of responsibility: individuals may be more willing to take immoral actions when their choice is less likely to make a difference (see Latane and Darley, 1968). Thus, in contrast to the expressive voting mechanism, the diffusion of responsibility mechanism predicts that individuals are *less* likely to vote for an ethical alternative when they believe themselves to be less likely to be pivotal. Falk et al. (2020) compare individual choices between moral and immoral alternatives to group choices,[5] and find evidence of diffusion of responsibility. Our experiment suggests that the opposite mechanism, in which decreased probability of being pivotal leads to a greater probability of voting for the ethical alternative, is also present.

More broadly, a number of papers have compared the likelihood of making an ethical choice of individuals to that of small groups in interactions such as dictator game (Luhan et al., 2009), public good game (Gillet et al., 2009; Cox and Stoddard, 2018), or prisoner's dilemma (Cason and Mui, 2019). In these experiments, group decisions are reached via deliberation, rather than through voting, which eliminates the uncertainty about being pivotal that drives the trade-off in our model.

Several studies have also developed theoretical models of collective decisions in which voting for a certain alternative carries an additional payoff. Morgan and Várdy (2012) analyse expressive voting in a Condorcet setting in which voters are imperfectly informed about which alternative is the best. Huck and Konrad (2005) analyse expressive voting, using payoff-dominant Nash equilibrium as a solution concept. In Rothenhäusler et al. (2018), voters choose between an ethical and an unethical option, and suffer moral costs if the unethical option is collectively chosen - thus, ethical motivations are instrumental rather than expressive. Several papers model imperfectly informed committee members who, if they vote against the alternative that turns out to be optimal, receive a negative payoff, either directly (Midjord et al., 2017), or via reputation (Visser and Swank, 2007).

3. Theory

3.1. Model

A committee consisting of n members, where $n \geqslant 3$, needs to decide whether to adopt a proposal that is considered to be ethical. The decision is made by simultaneous voting: each member votes for one of the alternatives, and the proposal is accepted if and only if the number of members who vote in favour of is at least qn, where $q \in \left[\frac{1}{2}, 1\right]$ denotes the voting rule. To simplify notation, we will assume throughout the paper that the (q, n) pairs are always such that $q(n-1)$ is an integer. Hence, the proposal is adopted whenever the number of votes in favour of it is strictly larger than $q(n-1)$.

If the proposal is adopted, each member pays a cost $c > 0$. In addition, if the proposal is adopted, each member receives a payoff of $a < c$, which reflects her (consequentialist) altruistic preferences.[6] Let $\delta := c - a > 0$ denote the loss of utility of each member if the proposal is accepted. Furthermore, each member who votes for the proposal receives, regardless of the outcome of the vote, a (non-consequentialist) expressive payoff $x_i \in \mathbb{R}$. Expressive payoffs

[4] More generally, a number of experimental studies have looked at the role of prosocial preferences in inducing members of voting bodies to vote for proposals that affect the payoffs of others, such as redistribution (Agranov and Palfrey, 2015) and information acquisition (Ginzburg and Guerra, 2019).

[5] In the language of our model, Falk et al. (2020) compare decisions of groups of size 8 under unanimity rule to decisions of individual subjects.

[6] To keep the model and structural estimation tractable, we are assuming that the altruistic payoff is homogeneous across committee members.

are drawn from an atomless distribution F with full support over the real line,[7] independently across committee members. Each member is privately informed about her expressive payoffs. All other aspects of the game are common knowledge.

As a solution concept, we use level-k best responses. We assume that each member has a type $k \in \{0, 1, \ldots, \bar{k}\}$with probability α_k. The type corresponds to the player's depth of reasoning. Individuals of type 0 randomise uniformly between the two actions (voting for or against the ethical alternative). For all types $k > 0$, players of type k play a best response to players of type $k-1$.

The timing of the game is as follows. First, nature draws the type and the expressive payoff of every committee member. Types and expressive payoffs are drawn independently. Each member learns her type and the expressive payoff. Next, members simultaneously vote for or against the proposal. Finally, payoffs are realised. We will focus on strategy profiles that are symmetric, in the sense that two players who share the same depth of reasoning and expressive payoff vote the same way.

3.2. Voting strategies

Take a member i with type $k > 0$. That member assumes that all other players are of type $k-1$. Let $p_{k-1}(m)$ be the probability that she assigns to the event that at least m of the other members vote for the proposal.

If i votes for the proposal, it will be adopted if and only if at least $q(n-1)$ other members vote for it. If i votes against the proposal, it will be adopted if and only if at least $q(n-1)+1$ other members vote for it. Hence, i's expected payoff equals $-p_{k-1}(q[n-1])\delta + x_i$ if she votes for the proposal, and $-p_{k-1}(q[n-1]+1)\delta$ if she votes against it. She thus votes for the ethical proposal if and only if

$$x_i > \delta\gamma_{k,q,n} \tag{1}$$

where $\gamma_{k,q,n} \equiv p_{k-1}(q[n-1]) - p_{k-1}(q[n-1]+1)$ denotes the probability of being pivotal as perceived by a member of type k – that is, her perceived probability that the number of other members who vote for the proposal is exactly $q(n-1)$.

For any depth of reasoning k, denote by $\pi_{k,q,n}$ the probability that a randomly selected member with type k votes for the proposal under voting rule q when the committee size is n. Then $\pi_{0,q,n} = \frac{1}{2}$ for all n and q. For $k > 0$, the fact that x_i is drawn from F implies that

$$\pi_{k,q,n} = 1 - F\left[\delta\gamma_{k,q,n}\right] \tag{2}$$

Since a member is pivotal whenever exactly $q(n-1)$ other members vote for the proposal, $\gamma_{k,q,n}$ for all $k > 0$ is given as

$$\gamma_{k,q,n} = \binom{n-1}{q(n-1)} \pi_{k-1,q,n}^{q(n-1)} \left(1 - \pi_{k-1,q,n}\right)^{n-1-q(n-1)} \tag{3}$$

Eqs. 2 and 3, together with the fact that $\pi_{0,q,n} = \frac{1}{2}$, recursively define $\pi_{k,q,n}$ for any $k > 0$.

Since $\gamma_{k,q,n} \in (0,1)$, we have $\pi_{k,q,n} \in (1 - F[\delta], 1 - F[0])$ for all k, q, and n. As seen from Eq. 2, $\pi_{k,q,n}$ increases whenever $\gamma_{k,q,n}$ decreases. Intuitively, voting for the proposal gives member i an expressive payoff x_i. On the other hand, doing so can change the collective decision from rejecting the proposal to accepting it, which reduces i's utility by δ. The latter, however, only happens when i is pivotal, that is, with probability $\gamma_{k,q,n}$. Hence, a decrease in $\gamma_{k,q,n}$ makes i willing to vote for the proposal at lower values of x_i. Thus, the probability $\pi_{k,q,n}$ of a randomly selected member voting for the proposal increases.

3.3. Effect of voting institutions

This section will analyse the effect of voting institutions on the perceived probability of being pivotal $\gamma_{k,q,n}$, and through it – on $\pi_{k,q,n}$. Committee size n and voting rule q drive $\gamma_{k,q,n}$ directly, as well as indirectly through the probability of voting for the proposal, $\pi_{k-1,q,n}$.

As discussed earlier, members with $k = 0$ vote for the proposal with probability $\frac{1}{2}$ irrespective of voting institutions. We begin the analysis by describing the effect of voting institutions on members with $k = 1$.

Proposition 1. *For any $q \geqslant \frac{1}{2}$, a member with depth of reasoning 1 is more likely to vote for the proposal when n is larger. Furthermore, for any n, a member with depth of reasoning 1 is more likely to vote for the proposal when q is larger.*

Intuitively, from the point of view of a member with depth of reasoning 1, the vote of each of the other members is an independent random event that does not depend on voting institutions. From her point of view the total number of other members' votes follows a binomial distribution with $n-1$ trials. The probability of exactly $q(n-1)$ of the other members voting for the proposal is lower when q or n increase.

If the committee consists of members with depth of reasoning 0 and 1 only, Proposition 1 implies that a member is more likely to vote for the proposal in a larger committee, or under a more restrictive voting rule. Furthermore, if many members have depth of reasoning 1, and few members have depth of reasoning greater than 1, then it is likely to be true that an average member becomes more likely to vote for the proposal when n or q is larger.

In general, however, members can have greater depth of reasoning. From the point of view of a member i with depth of reasoning $k > 1$, the votes of other members depend on voting institutions. Hence, the effect of voting institutions on i's probability of being pivotal is, in general, ambiguous. Nevertheless, the rest of this section will show that under certain assumptions, the logic of Proposition 1 holds for members with any depth of reasoning k. In particular, it holds when the cost of the proposal is sufficiently low.

The following result provides sufficient conditions under which the first statement of Proposition 1 holds for members with any depth of reasoning:

Proposition 2. *Take any member with depth of reasoning $k > 0$. Under any voting rule $q \geqslant \frac{1}{2}$, an increase in committee size n increases the probability that the member votes for the proposal if δ is sufficiently low. Furthermore, under any voting rule $q \geqslant \frac{1}{2}$ and for any δ, an increase in committee size n increases the probability that the member votes for the proposal if $F(\frac{\delta}{2}) \leq 1 - q$.*

Proposition 2 introduces two conditions, each of which is individually sufficient for an increase in n to lead to an increase in $\pi_{k,q,n}$. First, this will happen when the cost of the proposal net of the altruistic payoff is sufficiently low. To see the intuition, take a member i with depth of reasoning k. On the one hand, holding $\pi_{k-1,q,n}$ unchanged, an increase in n reduces the probability that exactly $q(n-1)$ other committee members vote for the proposal. On the other hand, an increase in n can also affect $\pi_{k-1,q,n}$, which may potentially increase the probability that i is pivotal. However, if δ is small, almost all members whose expressive payoffs are positive vote for the proposal - thus, $\pi_{k-1,q,n}$ is sufficiently close to

[7] In particular, this allows expressive payoffs to be zero or negative. For example, some members may think the proposal is not ethical.

$1 - F(0)$, and does not change much with n. As a result, the second effect disappears, and an increase in n makes i more willing to vote for the proposal.

The second sufficient condition is that the fraction of members who have expressive payoffs less than $\frac{\delta}{2}$ is sufficiently small - specifically, smaller than $1 - q$. In particular, under simple majority rule, for the result to hold it is sufficient for the median expressive payoff to be greater than $\frac{\delta}{2}$.

The next result generalises the second statement of Proposition 1 to members with depth of reasoning $k > 1$:

Proposition 3. *Take any member with depth of reasoning $k > 0$, and consider any committee size n. If $F(0) \geqslant 1 - q$ and if δ is sufficiently small, then an increase in q increases the probability that the member votes for the proposal.*

Proposition 3 says that when the cost of the proposal is small, each member becomes more likely to vote for it when the voting rule is made more restrictive, as long as the probability of a member having a negative expressive payoff is greater than $1 - q$, where q is the initial voting rule. The latter condition is more likely to be satisfied when the initial voting rule q is large.

Finally, note also that when the cost of the proposal is sufficiently small, for a given n and q, members with depth of reasoning $k > 0$ are more likely to vote for the proposal than members with depth of reasoning $k = 0$ if and only if $F(0) < \frac{1}{2}$. To see this, recall that a member with depth of reasoning $k = 0$ votes for the proposal with probability $\frac{1}{2}$. At the same time, as $\delta \to 0$, Eq. 2 implies that the probability with which a member with depth of reasoning $k > 0$ votes for the proposal converges to $1 - F(0)$.

3.4. Summary of theoretical predictions

Overall, the model makes two predictions about the effect of voting institutions on the probability of being pivotal, and through it on voting choices. First, Propositions 1 and 2 suggest that a randomly selected member is more likely to vote for the proposal when the committee is larger. Second, Propositions 1 and 3 suggest that members are more likely to vote for the proposal under a more restrictive majority rule. The experiment, described below, focuses on testing these predictions.

Note that for members of depth of reasoning one, the results hold unconditionally, while for members with greater depth of reasoning they hold under certain sufficient conditions. In particular, for members with depth of reasoning greater than one, the first result holds when δ is sufficiently low, while the second result holds when δ is sufficiently low *and* negative expressive payoffs are sufficiently common.

Informally, this implies that the results are more likely to hold when few individuals have depth of reasoning greater than one. Furthermore, for members with $k > 1$, the conditions on δ suggest that the results are more likely to hold when the cost of the proposal is low.

4. Experimental design

The laboratory experiment was conducted at Universidad de los Andes, Bogotá, Colombia. For our main experimental treatment, 328 subjects were recruited from an undergraduate subject pool.[8] We focus on whether individual votes are sensitive to: (i) the size of committee; (ii) different voting rules; and (iii) different costs of implementing an ethical alternative.

In each round, subjects were randomly assigned to be a member of a committee of size $n \in \{3, 9, 15\}$(a *within-subjects Committee Size Treatment*).[9] Each subject was endowed with $s = 10$ Experimental Tokens (ET, approximately 3.5 USD). Each individual had to vote Yes or No on whether they wanted a third-party recipient (in our case, the Red Cross Organization), to receive a donation of $B = 91$ ET. All committee members, regardless of their votes, had to pay an out-of-pocket cost $c \in \{4, 6\}$(exogenously determined at the beginning of the round) if the committee collectively chose to donate.[10]

Committees made collective decisions, without deliberation, via simultaneous voting in individual computers, maintaining complete anonymity in the interaction between members to reduce confounds with public image concerns. The experimental program was coded in Ztree (Fischbacher, 2007). Decisions were made according to two voting rules q (*Voting Rule Treatment, between subjects*): (i) Simple majority, $q = 1/2$ (198 subjects), and (ii) Unanimity, $q = 1$ (130 subjects). Each subject faced only one *Voting Rule Treatment* throughout the entire session. By combining these variations we have in total a $3 \times 2 \times 2$ design: Committee size $\times$ Cost $\times$ Voting Rule treatments. Tables 1 and 5 report the total number of observations and summary statistics of basic characteristics of our subjects across voting rule treatment.Column (5) presents the p-values from the pairwise null hypothesis that there is no significant differences in individual characteristics across voting rule treatments. Although subjects were randomly allocated to voting rule treatments, we note that there are significant differences at the 10% level in age, weekly expenses and willingness to donate out of 100 USD. In the most comprehensive statistical model we include these variables as controls.

Each session consisted of 33 subjects. For each (n, c) pair we let subjects take decisions for 10 rounds. In each round, a computer randomly assigned each subject to a committee, which was different from her committee in the previous round. All individuals started the experiment belonging to a committee of size $n = 3$. After taking decision over each cost $c \in \{4, 6\}$, always starting with the lower cost for 10 consecutive rounds, they were allocated to a different group size n - either $n = 9$ and then $n = 15$, or $n = 15$ first and then $n = 9$. This *Ordering treatment*, which was between subjects, was to guarantee that our results are not driven by potential order effects due to the order of committee size.[11]

The multiple-round design permits us to investigate whether some subjects followed mixed strategies. We did not provide feed-

[8] A sample of Spanish instructions is found in Appendix B.3 and a translated version in English in Appendix B.4. Individuals were recruited using ORSEE (Greiner, 2015). The show-up fee was 10,000 Colombian Peso (COP), and they were informed they could earn in addition up to 10,000 COP (for a total of approximately 7 USD). A session lasted for 1 h and 10 min: reading instructions (15 min), taking decisions (25 min), filling an exit questionnaire (15 min) and payment stage (15 min).

[9] We set the committee size as listed so as to allow for possible non-linear extrapolation of the predicted effect of larger size of voting body on voting behaviour.

[10] Our theoretical model sets an individual-specific altruistic payoff to be a from donating amount B USD as a group to the charity. It is an empirical challenge to tell what is $a = \beta \times B$, where β is the marginal altruistic payoff of a representative agent. Additionally, to satisfy the incentive compatibility according to the theoretical prediction, the parameters c and B must be set such that $c - \beta B > 0$. According to Ottoni-Wilhelm et al. (2017)'s estimates, the marginal rate of substitution between private consumption, $10 - c$, and the total amount given to a charity, B, is $\frac{0.0594}{0.385}\frac{10-c}{B}$. In our framework, such rate of substitution is equal to β. We set the maximum cost $\bar{c}$ such that $\bar{c} - \frac{0.0594}{0.385}\frac{10-\bar{c}}{B}B = 0$, which gives us $\bar{c} \approx 6$. We therefore set $B = 15 \times \bar{c} + 1 = 91$ ET (or 31.4 USD) so that it is always socially efficient to donate even when subjects belong to the largest committee where $n = 15$.

[11] All subjects in a committee of $n = 3$ decided for 10 rounds. When the committee size was $n = 9$ or $n = 15$, we randomly formed 3 or 2 committees, respectively, and grouped the remaining subjects in committees of size $n = 3$. To guarantee that all subjects take at least 10 decisions for any given (n, c) treatment, some subjects took voting decisions for 10, 11, or 13 rounds. Therefore, all subjects in a session were making decisions with the same group size and cost of donation, except for the excess subjects who were put into groups of 3. No excess subject in committee size 3 ever played for multiple consecutive rounds when the other subjects were in groups of 9 or 15. For the empirical analysis, we only take the first 10 rounds for each (n, c).

Table 1
Descriptive Statistics.

	(1) Mean	(2) Sd	(3) By Voting Rule	(4)	(5) p-value:
			Unanimity	Majority	(3)=(4)
Female	0.54	0.50	0.54	0.54	0.93
Age	20.45	2.68	20.83	20.21	0.05
SES stratum	3.57	1.14	3.67	3.51	0.23
Weekly expenses USD	44.78	36.33	51.99	40.15	0.01
Econ/Business	0.12	0.33	0.12	0.12	0.966
Donation of 100 USD	29.56	23.67	32.84	27.45	0.059
Red Cross	0.99	0.10	0.99	0.99	0.832
Observations	328		130	198	

Notes: Socioeconomic status (SES) stratum is 1 for poorest and 6 for richest households. Econ/Business is 1 if individuals studied Economics or Business Administration undergrad. Donation of 100 USD reports the hypothetical amount of dollars that would like to donate if they had 100 USD. Red Cross is 1 if individuals knew of the Red Cross.

back between rounds so as to mitigate the issue of learning, or of individuals following history dependent strategies. In total, each subject took 60 voting decisions per session. Final payoffs were determined by randomly choosing one round and subjects received feedback only from the paid round.

We conducted a total of 10 sessions - 4 sessions for the unanimity voting rule ($q = 1$); 6 sessions for the simple majority rule ($q = 1/2$). At the end of the incentivised experimental session, subjects were also required to give responses to a questionnaire. The questions include their family background and an additional module on their social and risk preferences (non-incentivised). On average individuals earned 6.8 USD,[12] and 533.5 USD were donated to the Red Cross.

5. Main empirical results

5.1. Stylised statistics

We begin by describing individual voting behaviour. Fig. 1 shows the percentage of instances, for each (n, c) treatment variation, in which individuals vote to donate. Panels (a) and (b) show decisions under simple majority and unanimity, respectively. In each panel we report the statistics by committee size ($n \in \{3, 9, 15\}$) and by cost of donation ($c \in \{4, 6\}$). Regardless of committee sizes and voting rules, our subjects' voting behaviour is cost sensitive. Subjects are substantially less likely to vote for the ethical alternative when the potential cost of doing so is high.

At the low cost treatment, we find that an increase in committee size makes subjects more likely to vote for costly donation. Under simple majority, subjects belonging to committees of size 3 vote in favour 45.8% of the time, while those belonging to committees of size 15 do so 53.3% of the time. The difference is statistically significant at 1 %. The same pattern is replicated in the unanimity voting rule (going from 59.5% when $n = 3$ to 63.7% when $n = 15$). When the cost is high, we find no evidence of a relationship between committee size and the probability of voting for the ethical option. Thus, as predicted by the theory, evidence of a positive relationship is stronger when the cost is sufficiently low.

Furthermore, comparing the percentage of subjects who vote to donate across Panels (a) and (b) shows that, keeping the cost of voting and committee size constant, subjects under the unanimity rule are more likely to vote to donate than those under simple majority. This is in line with the second main theoretical prediction. Under the unanimity rule, when $c = 4$, they vote to donate between 59.5% and 63.7% of the cases (when $c = 6$ the share of votes to donate varies between 42.6% and 45.7%). In comparison, under the simple majority rule, when $c = 4$, they vote to donate between 45.8% and 53.3% of the cases (when the cost is larger, $c = 6$, these proportions oscillate around 30%).

5.2. Reduced form estimation

We now investigate the robustness of our summary statistics findings with a linear probability model.[13] The dependent variable, $Donate_{i,r}$, is 1 if a member i votes for the ethical alternative in round r, and zero otherwise. A set of main treatment variables includes indicator variables on committee size that subject i faces in round r ($\mathbf{n}_{i,r} = \left(\mathbb{1}_{[n_{i,r}=9]}, \mathbb{1}_{[n_{i,r}=15]}\right)$), cost of voting for the ethical alternative in round r ($\mathbf{c}_{i,r} = \mathbb{1}_{[c_{i,r}=6]}$), voting rules ($\mathbf{q}_i = \mathbb{1}_{[q_i=1]}$), and the interaction of $\mathbf{n}_{i,r}$ and $\mathbf{c}_{i,r}$. In the full specification, we control for observable characteristics ($\mathbf{z}_i$), namely gender, socio-economic stratum (from 1 to 6), log of weekly expenditures, whether majoring in economics, standardised willingness to donate from a hypothetical transfer of 100 USD and a constant. We cluster robust standard errors at individual level.

$$Donate_{i,r} = \boldsymbol{\kappa}_1'\mathbf{n}_{i,r} + \kappa_2\mathbf{c}_{i,r} + \boldsymbol{\kappa}_3\mathbf{n}_{i,r} \times \mathbf{c}_{i,r} + \kappa_4\mathbf{q}_i + \boldsymbol{\kappa}_5'\mathbf{z}_i + \epsilon_{i,r} \qquad (4)$$

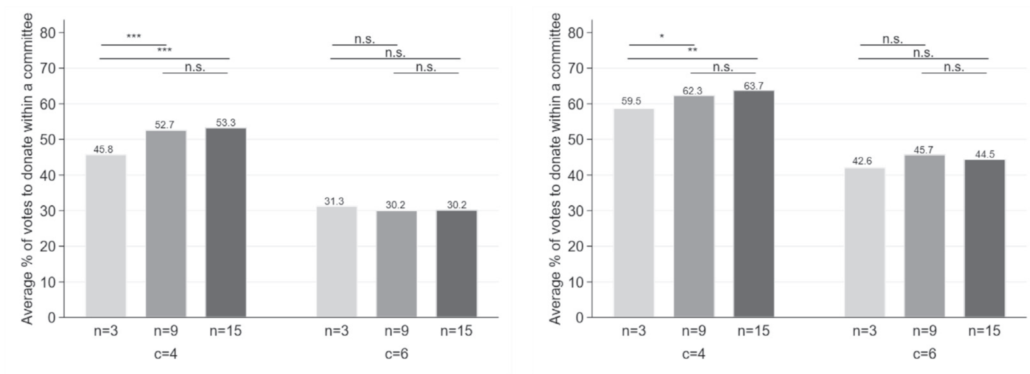
Table 2 reports the estimation results from Eq. 4. In the first three columns we sequentially add treatment variables. Note that individuals become more willing to vote to donate whenever they belong to larger committees, and are sensitive to changes in cost. Once we include the full set of controls (column 4),[14] subjects facing larger committees are more likely to vote to donate, in line with the first main theoretical prediction. Those belonging to committees of size $n = 15$ ($n = 9$) are approximately 6.2 *pp* (5.6 *pp*) more likely to vote to donate than those belonging to 3-members committees. Columns 5 and 6 confirm that the results are robust across different voting rule treatments (simple majority and unanimity, respectively) even after controlling for individual fixed effects. The estimation specifications account for issues of learning by controlling for the round subjects faced in each pair of (n, c) treatment variation.

The regressions also confirm the second main theoretical prediction that under the unanimity voting rule, members are more likely to vote to donate. Specifically, committee members are 13 *pp* more likely to vote for donating compared to simple majority treatments. We rule out possible framing or psychological carry over effects resulted from the order in which subjects face different

[12] Equivalent to approximately 15% of their average weekly expenses.

[13] Since the main explanatory variable is binary and the average is close to 0.5, marginal effects from a logit model should be equivalent to coefficients from a fully saturated linear probability model as the one we propose below. The advantage of the latter model is that coefficients are easier to interpret. Marginal effects from a logit model are actually very close to the coefficients from the linear probability model. These results are available upon request.

[14] Observations drop compared to column 3 because, due to a server error, we lost subjects' responses to the demographic questionnaire in one of the experimental sessions.



(a) Simple Majority (b) Unanimity

Fig. 1. Percentage of instances in which subjects voted to donate by voting rule, cost of donation and committee size. (*Note:* *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$, n.s.$p \geqslant 0.1$. Reported significance levels come from hypothesis testing from a fully saturated linear probability model where dependent variable indicates if an individual votes to donate and regressors are dummy variables associated with voting rule, cost of donation, and committee size. Given our within-subject design in terms of cost of donation and committee size, std errors are clustered at the individual level. Number of observations/clusters for Simple Majority: $11,850/198$, for Unanimity: $7,800/130$).

committee sizes.[15] The interacted variables of group size and high cost ($c = 6$) show negative signs. They are robust evidence that members tend to individually vote to donate more often when the cost of doing so is low.

5.3. Structural estimation

5.3.1. Likelihood function

So far, our reduced-form estimation presents evidence in line with the theoretical predictions. In this section we apply maximum likelihood estimation to recover three other components of the theoretical model: altruistic preferences, expressive preferences, and the distribution of depth of reasoning.

The likelihood function follows our theoretical model that allows for subjects of up to $\bar{k}$ levels of rationality. We follow Camerer et al. (2004) and approximate the distribution of subject types with a Poisson distribution, which characterises the fraction of each type as $\alpha_k = \frac{e^{-\tau}\tau^k}{k!}$, for $k \in \{0, 1, \ldots, \bar{k}\}$. The use of a Poisson distribution gives us two simplifying assumptions. First, it reduces the number of parameters describing the different levels of rationality to a single parameter τ. Second, it allows us to estimate the share of each type k for the overall subject pool. However, with this approach our estimation is not able to identify the type at the individual level.

For a chosen maximum depth of reasoning $\bar{k}$, which is a free parameter that we set at the beginning of the estimation, we recover the estimated mean and standard error of each α_k for $k \in \{0, 1, \ldots, \bar{k}\}$. In particular, the estimated means give us the share of each type while the standard errors allow us to test the hypothesis that a specific α_k is statistically different from zero. Therefore, for a given $\bar{k}$, we estimate the parameter τ such that our model (the Poisson distribution characterising $\alpha_1, \ldots, \alpha_{\bar{k}}$, as well as the voting behaviour prescribed by our theoretical model) best describes the behaviour observed in our data. Specifically, our model dictates that $\pi_{0,q,n}$ (the probability of voting to donate for type 0 subjects) is $\frac{1}{2}$. For a type $k > 0$, the probability of voting to donate is $\pi_{k,q,n}$, and her probability of being pivotal follows $\gamma_{k,q,n}$ from Section 3.2.

The expressive payoff of subject i in a given experimental round r is represented by $x^{i,r}$, about which each individual is privately informed. We assume that $x^{i,r} = \bar{x}^i + \epsilon^{i,r}$, where $\bar{x}^i$ measures individual-specific expressive preferences, and $\epsilon^{i,r}$ is an individual- and round-specific preference shock, drawn for each subject in each round from an i.i.d. logistic distribution with mean zero and scale parameter 1. Furthermore, we assume that $\bar{x}^i$ is a linear function of individual characteristics, defined as $\bar{x}^i = \boldsymbol{\theta}\prime\mathbf{z_i}$, where $\mathbf{z_i}$ the vector of individual characteristics plus a constant defined in the previous section.

Provided that subjects in our laboratory experiment do not observe characteristics of other members in the committee when making voting decision, our structural estimation makes an additional assumption that each subject i believes that every other member j of her committee has $\bar{x}^j = \bar{x}^i$. In other words, each subject chooses her vote assuming that all other members of her committee share the same round-invariant expressive preference parameter, with all uncertainty stemming from $\epsilon^{i,r}$.

Given voting rule q and pair (n, c), a subject with k depth of reasoning and an altruistic payoff a votes for the ethical alternative in round r if and only if $\bar{x}^i > (c - a)\gamma_{k,q,n}$, or, equivalently, if and only if $\epsilon^{i,r} > (c - a)\gamma_{k,q,n} - \bar{x}^i$.

The probability that she votes for the ethical alternative is given by

$$\pi^i_{k,q,n} = \frac{1}{1 + \exp(\gamma_{k,q,n}(c - a) - \bar{x}^i)}.$$

Consequently, if the maximum level of rationality among subjects is $\bar{k}$, the probability that subject i votes to donate, unconditional on i's depth of reasoning, is given by

$\Pi^i_{\bar{k},q,n} = \sum_{k=0}^{\bar{k}} \alpha_k \pi^i_{k,q,n}$.

In our experimental data, subject i faced one of the voting rules $q \in \{\frac{1}{2}, 1\}$ and took decisions for 10 rounds ($r = 1, \ldots, 10$) per each (n, c) pair. Let $\mathbf{d}$ be the vector of all votes with typical element $d^{i,r}_{n,c}$, and let $\mathbf{Z}$ be the matrix of individual characteristics. Our log-likelihood function (LF) for each maximum level-k type ($\bar{k}$) is then given by

$$L_{N,\bar{k}}(\mathbf{d}|\mathbf{Z}; \boldsymbol{\alpha}, \boldsymbol{\theta}, \beta) = \frac{1}{N}\sum_q\sum_i\sum_n\sum_c\sum_r \log\left[\left(\Pi^i_{\bar{k},q,n}\right)^{d^{i,r}_{n,c}}\left(1 - \Pi^i_{\bar{k},q,n}\right)^{1-d^{i,r}_{n,c}}\right], \tag{5}$$

where N is the total number of observations, and $\boldsymbol{\alpha} = (\alpha_0, \ldots, \alpha_{\bar{k}})$. Given that the Red Cross receives the equivalent of 91 ET, we define the marginal altruistic payoff $\beta = \frac{a}{91}$.

[15] In columns 4–6 we include an indicator variable equal to 1 for sessions where individuals faced the $(3, 15, 9)$ order of committee sizes, and zero when the order was $(3, 9, 15)$.

Table 2
Linear estimation of individual donation decision.

Dependent: Individual vote to donate	(1)	(2)	(3)	(4)	(5) Majority	(6) Unanimity
Voting Rule Unanimity	0.125***	0.124***	0.124***	0.130**		
	(0.042)	(0.042)	(0.042)	(0.051)		
Group Size = 9	0.029***	0.029***	0.053***	0.056***	0.070***	0.028*
	(0.009)	(0.009)	(0.012)	(0.013)	(0.017)	(0.017)
Group Size = 15	0.031***	0.031***	0.062***	0.062***	0.075***	0.042**
	(0.011)	(0.011)	(0.014)	(0.016)	(0.020)	(0.020)
Cost = 6	−0.191***	−0.191***	−0.154***	−0.146***	−0.144***	−0.168***
	(0.016)	(0.016)	(0.016)	(0.018)	(0.021)	(0.027)
Group size = 9 × Cost = 6			−0.048***	−0.052***	−0.081***	0.002
			(0.015)	(0.017)	(0.019)	(0.024)
Group size = 15 × Cost = 6			−0.062***	−0.066***	−0.088***	−0.024
			(0.017)	(0.019)	(0.023)	(0.025)
Group Size Ordering = (3, 15, 9)		0.012	0.012	0.020		
		(0.048)	(0.048)	(0.061)		
Round within (n, c) pair		−0.001	−0.001	−0.001	−0.001	−0.002
		(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Constant	0.481***	0.486***	0.468***	0.229	0.308***	1.073***
	(0.027)	(0.028)	(0.028)	(0.406)	(0.015)	(0.018)
Controls†	No	No	No	Yes	No	No
Ind fixed effects	No	No	No	No	Yes	Yes
Observations	19,650	19,650	19,650	16,480	11,850	7,800
R-squared	0.052	0.053	0.053	0.060	0.555	0.620

Notes: *** p<0.01, ** p<0.05, * p<0.1. Robust standard errors clustered at individual level in parentheses. Coefficients come from an ordinary least squares regression. Columns (1) to (4) use the pooled data, while column (5) restricts the estimation to majority sub-sample and column (6) to the unanimity sub-sample. Dependent variable is 1 if a subject voted to donate. Controls include whether subject is female, socio-economic strata (from 1 to 6), log of weekly expenditures, whether studying an economics related major, and standardized willingness to donate from an hypothetical transfer of 100 USD. Observations when adding controls drop because we lost questionnaire's answers for: all subjects in session 2 (unanimity), and 10 subjects in sessions 10 (simple majority) and 11 (unanimity).

In the estimation, we allow β, the altruistic preference, to vary by gender. We do so for two main reasons. The first reason is that gender differences in social preferences are well documented in the literature, but with mixed evidence due to many findings that women's social preferences are malleable to cues to the experimental settings (see reviews in Croson and Gneezy, 2009; Azmat and Petrongolo, 2014). The second reason is more specific to our sample. In our data, we find significant differences (at 8.2 percentage points) in subjects' self-declared hypothetical willingness to donate across genders, but not across other observable dimensions (namely, socio-economic strata, weekly expenditures, college majors).[16] This suggests that gender does play a role in determining individual preferences for donating.

Finally, the estimation sequence begins with the selection of a maximum depth of reasoning $\bar{k} \in \{1, 2, \ldots\}$ and is followed by the maximisation of its corresponding log-likelihood function via Newton-Raphson method as described above - where the parameters of interest are estimated simultaneously. In this paper, we report the estimated parameters associated with the largest $\bar{k} \in \{1, 2, \ldots\}$ such that the $H_0 : \alpha_{\bar{k}} = 0$, at any standard significance level, is not rejected.

5.3.2. Estimated results

Let us briefly explain where the identification of our structural parameters comes from. Allowing subjects to take repeated decisions across rounds, given a pair (n, c), gives us identification of $\bar{x}_i$ whenever individuals vary their votes across rounds. Therefore, we can identify the expressive payoffs at the individual level. Identification of the altruistic preferences, a, comes from changes in the likelihood of voting to donate when c increases, which affects the opportunity cost of being altruistic with the Red Cross, which we subsequently allow for potential heterogeneity between our male and female subjects. Finally, as some individuals with the same characteristics faced different voting rules q, we have additional variation on the probability to vote in favour of donating for every (n, c) pair, which is needed to identify $\boldsymbol{\alpha}$.

In Fig. 2, we report graphically our estimated type k shares when $\bar{k} \in \{1, \ldots, 4\}$. We cannot reject that there are up to type 3 players in our sample. Our structural estimation suggests the following distribution of depth of reasoning, $(\alpha_0, \alpha_1, \alpha_2, \alpha_3) = (0.526, 0.340, 0.110, 0.024)$. While the majority of our subjects randomise their voting decision naively, a sizeable proportion of our subjects are strategically sophisticated ($\sum_{k>0} \alpha_k = 47.4\%$). Our committees consist mainly of members with depth of reasoning 0 and 1 which, according to Proposition 1, implies that an average member should be more likely to vote for donating when n or q is larger. While we can obtain the sample-level distribution of depth of reasons among our subjects, our estimation method - using the Poisson distribution - cannot identify their type at the individual level.

Table 3 reports additional structural parameters recovered for the $\bar{k} = 3$ model. The altruistic payoff from the act of donation is estimated at 2.304 for male and 1.645 for female subjects, respectively. Therefore, cost of donating net of altruistic gains, δ, equals 1.696 for male, 2.355 for female and 2.037 for full sample when $c = 4$ (3.696, 4.355 and 4.037 when $c = 6$). In sum, male committee members exhibit higher altruistic preferences than females in our experiment setting. This result is supported by a key conclusion in the literature that women are no more or less socially oriented than men, but their social preferences are more malleable and are more context-specific than those of men, being affected by, for example, the size of the payoffs, price of altruism, repetition of the game, anonymity, and framing (see for instance Croson and Gneezy, 2009; Cappelen et al., 2015; Carpenter et al., 2008; Kagel and Roth, 2020). Moreover, the calculated values of δ when $c = 4$ is equivalent to approximately 17 percent of the initial endowment for males, and 24 percent for females. The fact that δ

[16] In more detail, we run a linear regression with the hypothetical donation (0–100 USD) as the dependent variable, in which explanatory variables include gender, college major, socio-economic strata and log of weekly expenditures.

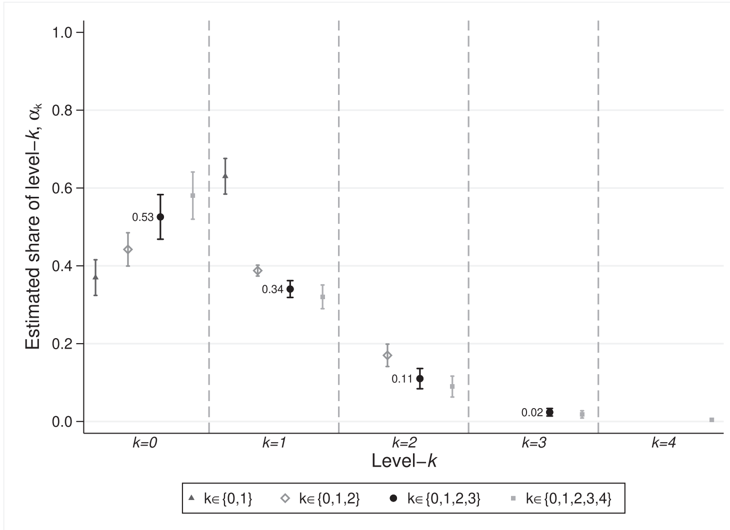


Fig. 2. Estimated share of level-k types, α_k, for models with different maximum levels of rationality. *Note:* Depicted center points are mean estimates of α_k for a given $\bar{k}$, and vertical bars correspond to 95% robust confidence intervals from model in Eq. 5 using maximum likelihood estimation method. Number of observations: 16,480.

is low suggests that the sufficient condition for the result in Proposition 2 to hold is satisfied.

Next, our structural estimation recovers the distribution of individual-specific expressive payoffs. In Table 3, we observe a statistically significant relationship between gender, wealth (measured by socio-economic stratum) and expressive preferences. Fig. 3 plots the histograms of expressive payoffs for the whole sample, and separately for female and male participants. The median values of the estimated expressive payoffs are 1.65, 1.28 and 3.85 for full sample, female, and male, respectively. Therefore, on average females have lower expressive payoffs than their male counterparts. A small fraction of our subjects display negative expressive payoffs, with the majority being female. This indicates that some subjects did not think that donating to the Red Cross was an ethical decision. Subjects from poorer households tend to have lower expressive payoffs. The estimated expressive payoffs are positively correlated with the self-reported amount that individuals are willing to donate if they receive an endowment of USD 100.

Table 3
Estimates of shares of level-k members (α_k), altruistic payoffs (total, a and marginal, β), and expressive payoffs ($\bar{x}^i$).

	(1)
α_k: share of level-k	
α_0: share of level-0	0.526***
	(0.030)
α_1: share of level-1	0.340***
	(0.011)
α_2: share of level-2	0.110***
	(0.013)
α_3: share of level-3	0.024***
	(0.005)
***a*: total altruistic payoff; β: marginal altruistic payoff**	
Female	1.645***; 0.018***
	(0.077); (0.001)
Male	2.304***; 0.025***
	(0.073); (0.001)
$\bar{x}^i$: expressive payoff	
Female	−2.775***
	(0.252)
Socioeconomic stratum	0.419***
	(0.074)
Log weekly expenses	−0.155
	(0.175)
Econ/Business	−0.133
	(0.305)
Donation 100USD	0.517***
	(0.088)
Constant	4.381**
	(2.037)
Log-pseudolikelihood	−10946.50
Observations	16,480

Notes: The estimations follow Eq. 5 using Maximum Likelihood Estimation. Robust standard errors in parentheses.

Our estimates of altruistic and expressive payoffs also show that under simple majority and when cost is low ($c = 4$), the second sufficient condition for the result in Proposition 2 to hold is also satisfied. The median value of the distribution of expressive payoffs (1.65) is larger than $\frac{\delta}{2}$ which, according to our theoretical model, implies a positive relationship between committee size and the probability of voting for the ethical alternative, as we observe in the data. However, the statement is not satisfied in the case of high cost treatment. This is suggestive explanation for why we do not observe the positive relationship under high cost treatments in our regression results.[17]

6. Discussion

6.1. Mechanism: belief about being pivotal

The main channel, advanced by our theory, on how voting institutions affect individual incentives to vote for the ethical alternative is through the perceived probability of being pivotal. Our model suggests that larger committee size, as well as more stringent voting rules, should reduce the probability of a committee member being pivotal, thus increasing the likelihood that she will vote to donate.

In the last 3 experimental sessions (2 with simple majority and 1 with unanimity treatments, and total of 99 subjects),[18] we

[17] Figure 9 in the Online Appendix shows the individual probabilities of voting for the proposal across treatments, using the estimated values of expressive payoffs, altruistic payoff, and the shares of each depth of reasoning that base on the theoretical model.

[18] Due to Covid-19 lockdown in Colombia, we had to cancel the second planned session with unanimity rule treatment, which is why our treatment variations are unbalanced. We decided not to implement an online experiment because it would not have been comparable to the rest of sessions.

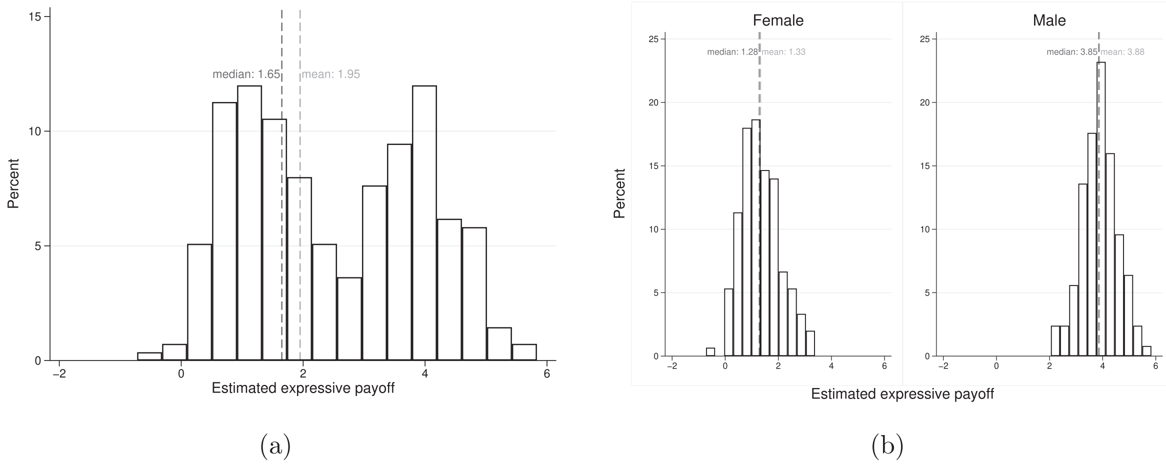


Fig. 3. Histogram of predicted expressive payoffs $\hat{x}_i$, by gender. (*Note:* Panel (a) plots the histogram of predicted expressive payoffs for the whole sample, and panel (b) shows separate histograms for female and male participants. The median values of the estimated expressive payoffs are 1.65, 1.28 and 3.85 for full sample, female, and male, respectively.)

included a supplementary incentivised question for each subject about her perceived probability that exactly $q(n-1)$ other members would vote for donating. We recovered this belief for each (n, c) pair.[19] This question is directly associated with the probability of being pivotal, and was asked at the end of the experiment without telling subjects from the beginning, which guarantees that voting decisions from these 3 sessions are still comparable to the ones made in the previous sessions.

In Fig. 4 (right-hand column) we depict the average of what subjects report as their expected probability that exactly $q(n-1)$ members vote in favour of donating - by committee size, cost of voting for the ethical alternative, and voting rule. Note that, for any given n, a more stringent voting rule is associated with a decrease in the perceived probability of being pivotal. Similarly, for any given q, a larger committee size is associated with a lower perceived probability of being pivotal. Specifically, for $n = 3$ and low (high) cost, the probability of being pivotal associated with $q = 1/2$ is 0.671 (0.422) while it drops to 0.522 (0.348) for $q = 1$; for $n = 9$ it goes from 0.570 (0.367) under simple majority to 0.358 (0.262) under unanimity; and for $n = 15$ this probability for low (high) cost is 0.536 (0.316) under simple majority; and 0.285 (0.238) under unanimity. These results suggest that individual's perceived probability of being pivotal changes with voting institutions in the direction predicted by the theory.

To test the robustness of this graphic inspection we run an ordinary least squares regression where the dependent variable is individual's perceived probability of being pivotal. As right-hand side variables we include indicator variables for committee sizes, unanimity voting rule and high cost, plus individual characteristics.

Table 4 shows the estimation results. The first two columns report the estimated coefficients for the pooled sample (in the second column we add our controls), and columns (3) and (4) show estimates for simple majority and unanimity sub-samples, respectively. Due to small sample concerns, we report in parenthesis bootstrapped standard errors clustered at the individual level. Our results confirm that perceived probability of being pivotal decreases with more restrictive voting institutions (that is, larger committee size, or unanimity voting rule). Overall, this is evidence in favour of the theoretical mechanism proposed in Section 3.

6.2. Alternative channels

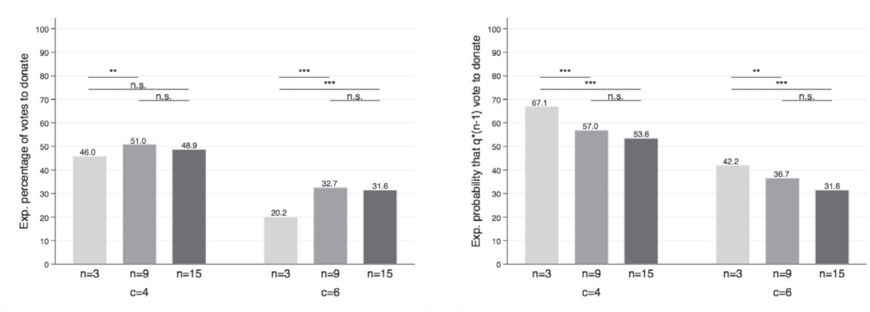
In addition to the theoretical mechanism proposed by our model, there are several alternative channels that can affect the interpretation of the experimental results.

Diffusion of responsibility. First, the perceived probability of being pivotal may also affect the expressive payoff. Recent research points to the existence of "bystander effect" or "diffusion of responsibility": individuals may feel less inclined to take ethical actions when they think that their action is less likely to be decisive for the outcome (see Latane and Darley, 1968, as well as Falk et al., 2020 for a recent experimental study). If this effect is present, it would, in the language of our model, imply that the expressive payoff x_i is an increasing function of the probability of being pivotal $\gamma_{k,q,n}$. As a result, a reduction of $\gamma_{k,q,n}$ would make individuals less willing to vote for the ethical alternative. Hence, this effect works against the mechanism proposed by our model. Since experimental results go in line with our proposed mechanism, this suggests that the mechanism is sufficiently strong to overcome the potential effect of diffusion of responsibility.

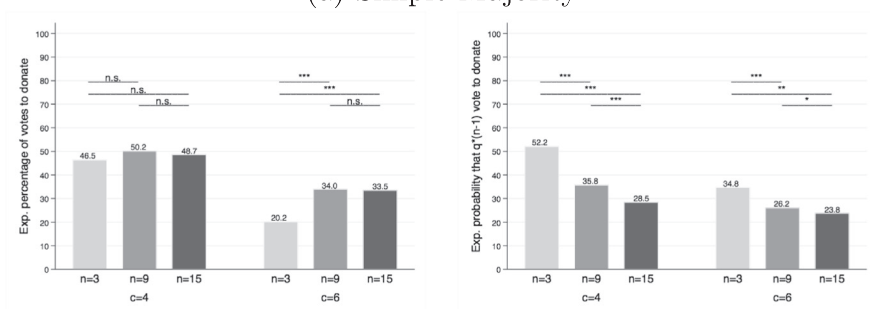
Efficiency considerations. Second, note that an increase in committee size n makes donating costlier for the committee as a whole. Recall that in our experimental design a collective decision to donate imposes a cost c on each committee member. Hence, an increase in n raises the aggregate cost of donating, making it a less efficient choice. It may be possible that subjects care about the overall efficiency of the collective decision. In the language of our model, this would mean that the individual altruistic payoff a is decreasing in n. Hence, an increase in n would increase the net individual cost of donating δ, and thus, following Eq. 2 in Section 3, would reduce the probability that an individual member votes to donate. Similarly to the diffusion of responsibility discussed above, this effect works against the mechanism of our model, again suggesting that our mechanism is strong enough to overcome this alternative channel.

Social image. In many real-world committees, votes are publicly observed. When this is the case, committee members' votes may be affected by potential social image concerns – that is, by the willingness of members to be perceived as ethical individuals. This would give them an additional incentive to vote for the ethical

[19] Specifically, prior to giving subjects feedback, we asked them: *"What do you think, in what percentage of rounds when you faced (n, c), exactly $q(n-1)$ group members have chosen to donate to charity?"*. The computer then chose one (n, c) pair for each question and we paid them 2 ET if their answer matched the true value of the event. Notice that, because no feedback between rounds was ever given to the individual, we can use this answer as their prior expectation of the probability that exactly $q(n-1)$ other members vote to donate. See the Appendix B.3 for the supplementary instruction of the belief elicitation stage.



(a) Simple Majority



(b) Unanimity

Fig. 4. Elicited beliefs about percentage of votes (left) and probability that exactly $q(n-1)$ members (right) vote for donation by voting rule, cost, and committee size. *Note:* *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$, n.s.$p \geqslant 0.1$. Reported significance levels come from means hypothesis testing from a fully saturated linear model, where dependent variables are elicited beliefs about percentage of votes (left) and probability that exactly $q(n-1)$ members vote for donation (right), and regressors are dummy variables associated with voting rule, cost of donation, and committee size. Given a voting rule, individuals answer a question for each cost of donation and committee size, therefore std errors are clustered at the individual level. Number of observations/clusters for Simple Majority: 396/66; for Unanimity: 198/33.

Table 4
Mechanism: Expected probability of being pivotal.

Dependent Var: Expected probability of being pivotal	(1)	(2)	(3) Majority	(4) Unanimity
Voting Rule Unanimity	-0.145^{**}	-0.119^{*}		
	(0.055)	(0.069)		
Group Size = 9	-0.122^{***}	-0.116^{***}	-0.104^{***}	-0.147^{***}
	(0.020)	(0.025)	(0.027)	(0.046)
Group Size = 15	-0.169^{***}	-0.164^{***}	-0.148^{***}	-0.209^{***}
	(0.026)	(0.027)	(0.036)	(0.053)
Cost = 6	-0.224^{***}	-0.235^{***}	-0.261^{***}	-0.164^{***}
	(0.026)	(0.029)	(0.037)	(0.036)
Group size = 9 × Cost = 6	0.057^{***}	0.048^{*}	0.046	0.054
	(0.021)	(0.025)	(0.029)	(0.036)
Group size = 15 × Cost = 6	0.062^{**}	0.064^{**}	0.044	0.120^{***}
	(0.027)	(0.029)	(0.035)	(0.038)
Constant	0.670^{***}	0.659	0.277	0.992
	(0.031)	(0.535)	(0.549)	(1.764)
Controls†	No	Yes	Yes	Yes
Observations	594	528	390	138
R-squared	0.179	0.182	0.235	0.178

Notes: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$ based on bootstrapped robust standard errors clustered at individual level in parenthesis. Coefficients come from an ordinary least squares regression. Columns (1) and (2) use the pooled data while columns (3) and (4) restrict the estimation to majority and unanimity sub-samples, respectively. Dependent variable is Expected probability of being pivotal which stands for the incentivised answer to the question: "In what percentage of rounds in each of (n, c) cases, did exactly $q * (n-1)$ group members voted to donate". † Controls include whether subject is female, socio-economic strata (from 1 to 6), log of weekly expenditures, whether majoring in economics, and standardised willingness to donate from a hypothetical transfer of 100 USD. Observations drop when adding controls because we lost answers for: 10 subjects in sessions 10 (simple majority) and 11 (unanimity).

alternative – in the language of our model, an additional payoff from better social image would add to the intrinsic expressive payoff x_i. In our experiment, this mechanism was excluded, since subjects' votes were not revealed to others. Hence, in real-world committees, the incentives to vote for ethical alternatives may be higher. In this sense, our results are conservative, and provide a lower bound for the actual individual payoffs from the act of voting for the ethical alternative.

Conformism. A fourth potential alternative channel is conformity (see, for example, Bernheim, 1994). In our context, this would mean that subjects would tend to align their votes with their expectations about the votes of others. Since other members' voting decisions are affected by q and n, this may confound our results. To test this additional channel, in the last three sessions we elicited (in an incentivised way) subjects' beliefs about the exact number of other committee members who voted for the ethical alternative.[20] The left-hand column of Fig. 4 illustrates subjects' beliefs about the expected percentage of other members voting to donate. Under high cost, the committee size has an effect on the expected share of votes in favour of donating. Under low cost, however, we do not observe an effect of committee size, except under simple majority rule for committee size 9. Fig. 4 also suggests that the voting rule has no effect on the expected share of votes in favour of donating (see Table 6 for a statistical test of this statement). Recall, however, that our main results suggest that voting rules do affect voting behaviour, and that the committee size affects voting behaviour specifically when the cost is low. Hence, the observed changes in the voting behaviour driven by variations in voting institutions are not associated with changes in members' beliefs about the share of other members voting to donate. Therefore, conformity is unlikely to explain the observed effect of voting institutions on votes.

False consensus. Another potential confounding mechanism is the "false consensus effect" – a tendency of individuals to overestimate the prevalence of their own beliefs or attitudes among members of their group (see, for example, Ross et al., 1977; Engelmann and Strobel, 2000; Hadar and Fischer, 2008; Roth and Voskort, 2014). In particular, Bischoff and Egbert, 2013 show that false consensus effect can impact voting.

In our setting, the false consensus effect might induce an individual to believe that other committee members tend to share her expressive preferences. In the language of our model, this would mean that each committee member i with depth of reasoning $k \geqslant 1$ would play a best response to other members whose expressive payoffs are drawn not from the true distribution F, but from a distribution F_i whose shape depends on i's expressive payoff x_i.

Note that such an extension of the model does not change the behaviour of members with depth of reasoning $k = 0$ and $k = 1$, since the former are not playing best responses, while the latter best respond to individuals whose actions do not depend on their expressive preferences. Hence, the result of Proposition 1 remains unchanged.

For members with depth of reasoning $k > 1$, the false consensus effect can have an impact on voting choices, since their perceived probability of being pivotal depends on the distribution of other members' expressive payoffs. At the same time, one can show that the effects of committee size n and voting rule q, as described in Propositions 2 and 3, remain qualitatively unchanged. Specifically, under any $q \geqslant \frac{1}{2}$, an increase in n increases the probability that a member votes for the proposal, as long as δ is sufficiently small, or as long as $F_i(\frac{\delta}{2}) \leq 1 - q$ for all i. Similarly, for any n, an increase in q increases the probability that a member votes for the proposal as long as δ is sufficiently small and $F_i(0) \geqslant 1 - q$ for all i. The proofs of these results are similar to the proofs of Propositions 2 and 3, respectively, replacing F with F_i where appropriate.

Moral licensing. The final alternative channel we explore is "moral licensing" (see Blanken et al., 2015 for an overview) – that is, the carryover effect from the initial voting experience in committee of size 3. Specifically, subjects who initially voted unethically may have an additional incentive to act ethically later on because of guilt. Conversely, subjects who initially voted for donating may be less inclined than others to vote for donating in subsequent rounds, having established their moral credentials. This can potentially confound our results on the effect of increasing committee size.

If this psychological effect is present, there should be a difference between the behaviour of subjects who face committee size 9 before committee size 15, and the behaviour of subjects who face size 15 before size 9. However, as we show in Table 2 above, the group size ordering – that is, facing committee size 9 or 15 in different orders – does not significantly affect voting behaviour.

To further study this potential channel, we split our subject pool into two sub-samples depending on the subjects' initial voting behaviour when belonging to committee size 3: (i) those less likely than the median subject to vote for donating, and (ii) those more likely to vote for it. If our results are explained by moral licensing, moving from committee size 3 to a larger committee size should increase the likelihood of voting in favour of donating for the former group, and decrease it for the latter group. However, this is not the case. As we show in Figure 8 of the Online Appendix, neither group becomes less likely to vote for donating. Instead, we observe that both groups are more likely to vote for donating in a larger committee, although the effect is not always statistically significant. The only exception, in which the latter group becomes less likely to vote for donating when n becomes greater than 3, is the case under simple majority and high cost. Taken together, this data suggests that, if present, moral licensing is not sufficiently strong to explain our experimental results.

6.3. Committee-level outcomes

How do individual votes translate into collective choices? As seen in Fig. 5, committees are more likely to approve the ethical option under the simple majority rule, and under the low cost treatment. Under simple majority rule, the effect of the committee size on the probability of the ethical alternative to be chosen: the effect is positive when the cost is low, but negative when it is high. Under unanimity rule, committees consisting of more than 3 members almost never approve the ethical alternative despite a high fraction of individual members voting for it. This is in line with our previous result that a substantial fraction of subjects are strategically naive, which implies that in a large committee there is a high probability of some member voting against donating.[21]

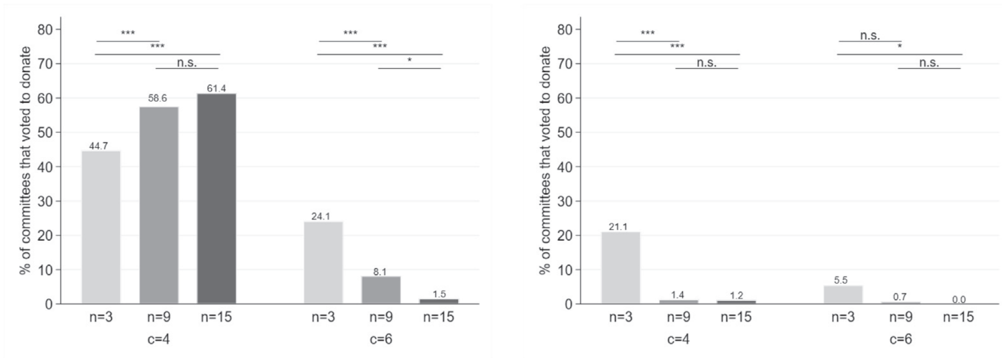
Thus, while an increase in committee size makes members more likely to vote for the costly ethical alternative, this only translates into increased frequency of the ethical alternative winning the vote under simple majority rule and when the cost is low.

6.4. Supermajority voting rule

As a robustness check to tell whether our theoretical predictions also hold for other voting rules, we ran 2 additional sessions (with 65 subjects) under a supermajority voting rule, $q = \frac{2}{3}$. Table 8 in the Online Appendix reports the supplementary regression results on the determinants of voting for costly ethical alternative. Column 1 reports the estimates from the full sample (all voting rules $q \in \{1, \frac{2}{3}, \frac{1}{2}\}$), and column 2 restricts the sample to supermajority rule. The regression shows that subjects are more likely to vote for the ethical alternative under supermajority rule than under simple majority rule, although the coefficient is not statistically significant. On the one hand, for subjects facing this supermajority voting rule, an increase in committee size also induces a higher probability of voting ethically, even after accounting for individual level fixed effects.

[20] We ask them "*What do you think, in the majority of rounds when you faced (n, c), how many of the other $n-1$ group members have chosen to donate to charity?*". (See B.3 for details)

[21] Table 7 in the Online Appendix presents regression results associated with this figure.



(a) Simple Majority (b) Unanimity

Fig. 5. Percentage of instances in which committees voted to donate (by committee size, individual cost to donate and voting rule). *Note:* *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$, n.s.$p \geqslant 0.1$. Reported significance levels come from means hypothesis testing from a fully saturated linear probability model, where dependent variable indicates if a committee votes to donate and regressors are dummy variables associated with voting rule, cost of donation, and committee size. Given that individuals belonging to a given session were randomly matched together across different decision rounds, std errors are clustered at the session level. Number of observations/clusters for Simple Majority: $2,024/6$; for Unanimity: $1,344/4$.

6.5. Comparison with the Nash equilibrium

Our theoretical analysis uses level-k best responses as a solution concept. Consider instead the Nash equilibrium. Let λ be the probability that a given member votes for the proposal. Then the probability is given analogously to Eq. 2 as $\lambda = 1 - F\left[\delta\gamma_{k,q,n}\right]$.Under Nash equilibrium, $\gamma_{k,q,n}$ is given as in Section 3, replacing $\pi_{k-1,q,n}$ with λ. Hence, any Nash equilibrium is given by

$$\lambda = 1 - F\left[\delta\binom{n-1}{q(n-1)}\lambda^{q(n-1)}(1-\lambda)^{n-1-q(n-1)}\right] \tag{6}$$

Note that the right-hand side of Eq. 6 is non-monotone in λ, and thus Eq. 6 can hold for more than one value of λ, which correspond to multiple Nash equilibria. This presents problems for structural estimation of behavioural parameters, especially because comparative statics move in different directions in different equilibria. Nevertheless, under unanimity rule, Nash equilibrium is unique and tractable. Specifically, when $q = 1$, Eq. 6 can be rewritten as

$$\lambda + F\left[\delta\lambda^{n-1}\right] = 1 \tag{7}$$

The left-hand side of Eq. 7 is monotone in λ, and is strictly smaller (larger) than the right-hand side when λ approaches zero (one). Hence, there exists a unique equilibrium strategy $\lambda \in (0,1)$ at which Eq. 7 holds. Furthermore, when n increases, the left-hand side of Eq. 7 decreases. To restore equality, λ must increase. Hence, under unanimity, the probability that a given member votes for the proposal is increasing in committee size. Thus, under unanimity rule, a result similar to those found in Section 3 holds in a Nash equilibrium as well.

7. Conclusions

In this paper, we have explored the role of expressive voting in committees. A key feature of committees is that their size is relatively small, which implies that an individual voter can be pivotal with a substantial probability. Our theoretical model predicted that institutions that reduce the individual probability of being pivotal - namely, larger committee size, and a more restrictive majority rule - make members more likely to vote expressively, that is, to vote for a costly alternative that is considered ethical. A laboratory experiment produced results consistent with this prediction.

The belief elicitation component of our experiment plays a crucial role in our analysis. With it, we are able to obtain evidence which suggests that the perceived probability of being pivotal is indeed a channel through which voting institutions affect individual votes. Hence, the approach whereby subjects are asked, in an incentivised way, to state their beliefs about the behaviour of others provides a better understanding of collective decision making.

Our structural estimation results confirm the presence of expressive voting in committee decision-making. In particular, we found that expressive payoffs are positively correlated with self-reported social preferences. Also, we found that females and subjects from lower socioeconomic background exhibit lower expressive payoffs. In addition, we estimated the distribution of individual depth of reasoning. This estimation shows that just over half of voters are strategically naive, around a third have depth of reasoning 1, and the rest have types 2 or 3.

Importantly, our results can be seen as conservative. The experimental results suggest that our theoretical mechanism is strong enough to overcome the potential opposing effects from diffusion of responsibility and social efficiency concerns. Furthermore, in real-life committees votes are sometimes publicly observed, and hence social image concerns are likely to amplify the effect that we found. Subsequent research can aim at isolating these confounding factors, and determining their effects on expressive voting. On the other hand, in real-life committees, members are often able to communicate. This may reduce uncertainty about the probability of being pivotal. While existing empirical evidence (Dressler, 2020) supports the predictions of our model, further research would be useful for investigating whether the results hold in a field setting.

Appendix A. Proofs

For the subsequent proofs, the following technical result will be useful:

Lemma 1. *Suppose $q < 1$. Consider any n and n' such that qn and qn' are integers. If $n' > n$, then*

$$\frac{\binom{n}{qn}}{\binom{n'}{qn'}} > \left[q^q(1-q)^{1-q}\right]^{n'-n}.$$

Proof. Let $r := n' - n$. Denote $A_r(n) := \frac{\binom{n}{qn}}{\binom{n+r}{q(n+r)}} = \frac{\binom{n}{qn}}{\binom{n'}{qn'}}$. We have

$$A_r(n) = \tfrac{n!(q[n+r])!([1-q][n+r])!}{(n+r)!(qn)!([1-q]n)!}$$
$$= \frac{\left[\prod_{i=1}^{qr}(qn+i)\right]\left[\prod_{i=1}^{(1-q)r}(n-qn+i)\right]}{\prod_{i=1}^{r}(n+i)}$$
$$= \left(\prod_{i=1}^{qr}\tfrac{qn+i}{n+i}\right)\left(\prod_{i=1}^{r-qr}\tfrac{(1-q)n+i}{n+qr+i}\right).$$

Note that both $\frac{qn+i}{n+i}$ and $\frac{(1-q)n+i}{n+qr+i}$ are strictly decreasing in n for all $i > 0$. Hence, $A_r(n)$ is decreasing in n for all values of r. Furthermore,

$$\lim_{n\to\infty} A_r(n) = \left(\prod_{i=1}^{qr} q\right)\left(\prod_{i=1}^{r-qr}(1-q)\right) = \left[q^q(1-q)^{1-q}\right]^r,$$

which together with the strict monotonicity of $A_r(n)$ implies that for any n and any $r = n' - n$, we have

$$\frac{\binom{n}{qn}}{\binom{n'}{qn'}} = A_r(n) > \left[q^q(1-q)^{1-q}\right]^r = \left[q^q(1-q)^{1-q}\right]^{n'-n}. \qquad \square$$

Proof of Proposition 1.

To simplify notation, let $\hat{n} \equiv n-1$. The model focuses on values of $\hat{n}$ such that $q\hat{n}$ is an integer. For a member with $k = 1, \pi_{k-1,q,n} = \frac{1}{2}$. Hence, her perceived probability of being pivotal is

$$\gamma_{1,q,n} = \binom{\hat{n}}{q\hat{n}}\frac{1}{2^{\hat{n}}}.$$

From (2) it follows that $\pi_{1,q,n}$ increases whenever $\gamma_{1,q,n}$ decreases.

To prove the first statement, we need to show that $\gamma_{1,q,n}$ decreases in $\hat{n}$. Under unanimity rule, that is, when $q = 1$, we have $\gamma_{1,1,n} = \frac{1}{2^{\hat{n}}}$, which decreases in $\hat{n}$.

Now consider the case when $q < 1$. Take any $\hat{n}' > \hat{n}$ such that $q\hat{n}' > \hat{n}$ is an integer. Note that

$$\frac{\binom{\hat{n}}{q\hat{n}}\frac{1}{2^{\hat{n}}}}{\binom{\hat{n}'}{q\hat{n}'}\frac{1}{2^{\hat{n}'}}} = \frac{\binom{\hat{n}}{q\hat{n}}}{\binom{\hat{n}'}{q\hat{n}'}}2^{\hat{n}'-\hat{n}} > \left[q^q(1-q)^{1-q}\right]^{\hat{n}'-\hat{n}}2^{\hat{n}'-\hat{n}} \geqslant 1,$$

where the first inequality follows from Lemma 1, and the second – from the fact that that $q^q(1-q)^{1-q} \geqslant \frac{1}{2}$ for all $q \in \left[\frac{1}{2}, 1\right]$.To prove the second statement, we need to show that $\gamma_{1,q,n}$ decreases in q. For this, it is sufficient to show that for each q, the smallest increase in q under which $q\hat{n}$ remains an integer decreases $\gamma_{1,q,n}$. That smallest increase is a change from q to $\tilde{q} > q$ such that $\tilde{q}\hat{n} = q\hat{n}+1$. Note that $\gamma_{1,\tilde{q},n} < \gamma_{1,q,n}$ if and only if $\binom{\hat{n}}{q\hat{n}+1}\frac{1}{2^{\hat{n}}} < \binom{\hat{n}}{q\hat{n}}\frac{1}{2^{\hat{n}}}$, or, equivalently, if and only if

$$\tfrac{(q\hat{n})!(\hat{n}-q\hat{n})!}{(q\hat{n}+1)!(\hat{n}-q\hat{n}-1)!} < 1$$
$$\iff \tfrac{\hat{n}-q\hat{n}}{q\hat{n}+1} < 1.$$

This holds because $\frac{\hat{n}-q\hat{n}}{q\hat{n}+1} < \frac{\hat{n}-q\hat{n}}{q\hat{n}} = \frac{1-q}{q} \leq 1$. $\square$

Proof of Proposition 2.

To simplify notation, let $\hat{n} \equiv n-1$. The model focuses on values of $\hat{n}$ such that $q\hat{n}$ is an integer. As before, (2) implies that for any $\delta > 0, \pi_{k,q,n}$ increases whenever $\gamma_{k,q,n}$ decreases. We will prove the result in two steps. First, we will prove the result in the case when $q = 1$, and then for the case when $q < 1$.

Since the condition $F\left(\frac{\delta}{2}\right) \leq 1-q$ never holds when $q = 1$, for that case we only need to prove the first statement. For $k = 1$ the result holds by Proposition 1. For $k > 1$, we have $\gamma_{k,1,n} = \pi_{k-1,1,n}^{\hat{n}} = \left(1 - F\left[\delta\pi_{k-2,1,n}^{\hat{n}}\right]\right)^{\hat{n}}$. Hence, $\lim_{\delta\to 0}\gamma_{k,1,n} = (1-F[0])^{\hat{n}}$, which is strictly decreasing in $\hat{n}$, and hence also in n. By continuity, there exists a range of sufficiently small but positive values of δ for which $\gamma_{k,1,n} > \gamma_{k,1,n+1}$, and hence $\pi_{k,1,n+1} > \pi_{k,1,n}$.

We will now prove the result for all $q < 1$. For $k = 1$ the result holds by Proposition 1. Now consider $k > 1$. Let r be the smallest positive number such that $q(\hat{n}+r)$ is an integer. To show that $\gamma_{k,q,n}$ is monotone decreasing in $\hat{n}$, it is sufficient to show that increasing the size of the committee by r decreases $\gamma_{k,q,n}$. Hence, it is sufficient to show that when either of the two conditions in the proposition holds, we have $\gamma_{k,q,n+r} < \gamma_{k,q,n}$, or, equivalently,

$$\binom{\hat{n}+r}{q\hat{n}+qr}\pi_{k-1,q,n+r}^{q\hat{n}+qr}\left(1-\pi_{k-1,q,n+r}\right)^{\hat{n}+r-q\hat{n}-qr} < \binom{\hat{n}}{q\hat{n}}\pi_{k-1,q,n}^{q\hat{n}}\left(1-\pi_{k-1,q,n}\right)^{\hat{n}-q\hat{n}},$$

which is in turn equivalent to

$$\frac{\binom{\hat{n}}{q\hat{n}}}{\binom{\hat{n}+r}{q\hat{n}+qr}}\frac{1}{\left[\pi_{k-1,q,n+r}^{q}\left(1-\pi_{k-1,q,n+r}\right)^{1-q}\right]^r} > \left[\frac{\pi_{k-1,q,n+r}^{q}\left(1-\pi_{k-1,q,n+r}\right)^{1-q}}{\pi_{k-1,q,n}^{q}\left(1-\pi_{k-1,q,n}\right)^{1-q}}\right]^{\hat{n}}. \tag{8}$$

Note that

$$\frac{\binom{\hat{n}}{q\hat{n}}}{\binom{\hat{n}+r}{q\hat{n}+qr}} > \left[q^q(1-q)^{1-q}\right]^r$$

by Lemma 1. Furthermore, note that

$$\pi_{k-1,q,n+r}^{q}\left(1-\pi_{k-1,q,n+r}\right)^{1-q} \leqslant q^q(1-q)^{1-q},$$

which follows from the fact that for all $y \in (0,1)$ the function $y^q(1-y)^{1-q}$ has a unique maximum at $y = q$. Hence, the left-hand side of (8) is strictly greater than one.

To prove the first statement, note that (2) implies that $\lim_{\delta\to 0}\pi_{k-1,q,n} = \lim_{\delta\to 0}\pi_{k-1,q,n+r} = 1 - F[0]$. Hence, as $\delta \to 0$, the right-hand side of (8) converges to one. Therefore, as $\delta \to 0$, (8) holds. By continuity, there exists a range of sufficiently small but positive values of δ for which (8) holds, and hence $\pi_{k,q,n}$ is increasing in n.

To prove the second statement, we will use induction. Suppose that $F\left(\frac{\delta}{2}\right) \leq 1-q$. When $k = 1$, Proposition 1 implies that an increase in n raises $\pi_{k,q,n}$. Now we will prove that if $\pi_{k,q,n}$ increases in n for depth of reasoning $1,\ldots k-1$, then it also increases in n for depth of reasoning k. We have

$$\pi_{k-1,q,n+r} > \pi_{k-1,q,n} \geqslant 1 - F\left(\frac{\delta}{2}\right) \geqslant q,$$

where the first inequality follows from the induction statement; the second comes from the fact that $\pi_{k-1,q,n} = 1 - F\left[\delta\gamma_{k-1,q,n}\right]$ and $\gamma_{k-1,q,n} \leqslant \frac{1}{2}$; and the third is from the condition $F\left(\frac{\delta}{2}\right) \leq 1-q$. Because the function $y^q(1-y)^{1-q}$ is decreasing in y for $y \geqslant q$, this implies that $\pi_{k-1,q,n+r}^{q}\left(1-\pi_{k-1,q,n+r}\right)^{1-q} < \pi_{k-1,q,n}^{q}\left(1-\pi_{k-1,q,n}\right)^{1-q}$. Hence, the right-hand side of (8) is strictly smaller than one. Therefore, (8) holds, and hence $\pi_{k,q,n}$ is increasing in n. □

Proof of Proposition 3.

To simplify notation, let $\hat{n} \equiv n - 1$, as before. The model focuses on values of $\hat{n}$ such that $q\hat{n}$ is an integer. As before, (2) implies that for any $\delta > 0, \pi_{1,q,n}$ increases whenever $\gamma_{k,q,n}$ decreases.

For $k = 1$ the result holds by Proposition 1. Now suppose $k > 1$. Consider a change in the voting rule from q to $\tilde{q} > q$ such that $\tilde{q}\hat{n}$ is an integer. Let $b \equiv \tilde{q}\hat{n} - q\hat{n}$. We need to show that

$$\gamma_{k,\tilde{q},n} < \gamma_{k,q,n} \iff \binom{\hat{n}}{q\hat{n}+b}\pi_{k-1,\tilde{q},n}^{q\hat{n}+b}\left(1-\pi_{k-1,\tilde{q},n}\right)^{\hat{n}-q\hat{n}-b}$$

$$< \binom{\hat{n}}{q\hat{n}}\pi_{k-1,q,n}^{q\hat{n}}\left(1-\pi_{k-1,q,n}\right)^{\hat{n}-q\hat{n}}$$

$$\iff \frac{(q\hat{n})!(\hat{n}-q\hat{n})!}{(q\hat{n}+b)!(\hat{n}-q\hat{n}-b)!} < \left(\frac{\pi_{k-1,q,n}}{\pi_{k-1,\tilde{q},n}}\right)^{q\hat{n}}\left(\frac{1-\pi_{k-1,q,n}}{1-\pi_{k-1,\tilde{q},n}}\right)^{\hat{n}-q\hat{n}}\left(\frac{1-\pi_{k-1,\tilde{q},n}}{\pi_{k-1,\tilde{q},n}}\right)^{b}$$

$$\iff \prod_{j=1}^{b}\frac{\hat{n}-q\hat{n}-b+j}{q\hat{n}+j} < \left(\frac{\pi_{k-1,q,n}}{\pi_{k-1,\tilde{q},n}}\right)^{q\hat{n}}\left(\frac{1-\pi_{k-1,q,n}}{1-\pi_{k-1,\tilde{q},n}}\right)^{\hat{n}-q\hat{n}}\left(\frac{1-\pi_{k-1,\tilde{q},n}}{\pi_{k-1,\tilde{q},n}}\right)^{b}.$$

Note that (2) implies that $\lim_{\delta\to 0}\pi_{k-1,q,n} = \lim_{\delta\to 0}\pi_{k-1,\tilde{q},n} = 1 - F[0]$. Hence, as $\delta \to 0$, the above inequality converges to

$$\prod_{j=1}^{b}\frac{\hat{n}-q\hat{n}-b+j}{q\hat{n}+j} < \left(\frac{F[0]}{1-F[0]}\right)^{b}. \tag{9}$$

At the same time, note that

$$\prod_{j=1}^{b}\frac{\hat{n}-q\hat{n}-b+j}{q\hat{n}+j} = \prod_{j=1}^{b}\frac{1-q-\frac{b-j}{\hat{n}}}{q+\frac{j}{\hat{n}}} < \prod_{j=1}^{b}\frac{1-q}{q} = \left(\frac{1-q}{q}\right)^{b}.$$

Hence, for (9) to hold, it is sufficient to have $\left(\frac{1-q}{q}\right)^{b} \leqslant \left(\frac{F[0]}{1-F[0]}\right)^{b}$, or, equivalently, $F[0] \geqslant 1 - q$. Therefore, as $\delta \to 0, F[0] \geqslant 1 - q$ is a sufficient condition for $\pi_{k,\tilde{q},n} > \pi_{k,q,n}$. By continuity, there exists a range of sufficiently small but positive values of δ for which $F[0] \geqslant 1 - q$ is a sufficient condition for $\pi_{k,\tilde{q},n} > \pi_{k,q,n}$. □

Appendix B. Supplementary material

Supplementary data associated with this article can be found, in the online version, at https://doi.org/10.1016/j.jpubeco.2021.104555.

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