Mean voting rule and strategical behavior: an experiment

Carla Marchese and Marcello Montefiori
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Carla Marchese\(^1\) and Marcello Montefiori\(^2\)

Abstract
This paper considers the problem of voting about the quantity of a public good. An experiment has been run in order to test the extent of the strategic bias that arises in the individual vote when the social choice rule is to select the mean of the quantities voted for; conflicting theoretical predictions are available in the literature on this purpose. The political implications of the mean rule and its effects upon efficiency are also discussed. The role of voters’ information is considered. A comparison is made with the working of the median rule.

Keywords: experiment, voting rule, public good

JEL Code: C91, D72

\(^1\) Carla Marchese, Department of Public Policy and Public Choice POLIS, University of Eastern Piedmont “Amedeo Avogadro”, Via Cavour 84, 15100 Alessandria, Italy. Phone: +39-0131-283744; fax: +39-0131-283704, e-mail: carla.marchese@sp.unipmn.it
\(^2\) Marcello Montefiori, Department of Public Economics (DISEFIN), University of Genoa, Via Vivaldi 5, 16126 Genova, Italy. Phone: +39-010-2095207; fax: +39-010-2095223, e-mail: mmontefori@economia.unige.it
1 Introduction

Many mechanisms that have been suggested for collective choice do not provide incentives for sincere disclosure of preferences; misrepresentation can arise, for example under majority voting or, with reference to choices pertaining to public goods, in procedures à la Wicksell and Lindhal.

Two recent studies by Ehlers et al. (2) and by Renault and Trannoy (4) have revived the discussion on strategic behavior in social choices by focussing upon the mean vote procedure. They describe the social choice process as aimed at locating a point within a bounded space, e.g. an interval of the real line, on which the amount of a public good is measured. Under the mean vote procedure society chooses the mean of the quantities voted for by the agents. The conclusions reached by the aforementioned papers about the working of mean vote are opposite, as, under conditions that will be stated in the following, the former predicts sincere disclosure of preferences, while the latter predicts widespread strategical behavior.

In this paper, after a discussion of the theoretical problems involved in mean voting, an experiment is used to test which predictions, if any, are supported by data.

The paper is organized as follows: Section 2 presents and expounds the “opposite” statements that can be drawn from the Ehlers et al. (§ 2.1) and the Renault and Trannoy (§ 2.2) paper, while § 2.3 illustrates the historical and the present-day role of the mean vote procedure respectively in ancient and modern society. Section 3 explains the experiment setting whereas section 4 provides a preliminary data analysis. In section 5 an econometric study is implemented in order to test the role of the variables considered in the model under examination in affecting individual voting behavior. Finally section 6 highlights the conclusions.
2 The mean vote procedure

Strategical voting behavior in social choice procedures can be ruled out only under specific conditions. Moulin, in a classical paper (3), analyses the working of a mechanism in which each participant directly announces his preferred point on the real line. The median point among those voted for represents the social choice. Restriction of preferences (single peakedness) secures in this case strategy-proofness, which consists of the stability of a non-cooperative Nash equilibrium as no agent has incentive to deviate from his bliss point in response to other agents announcing their bliss points\(^3\). This result, however, does not carry over to cases in which preferences have an unrestricted domain or the problem is multidimensional. Other approaches aimed at securing sincere revelation of preferences and specifically designed for the revelation of public goods demand (like the Groves and Clarke mechanisms, for example, which, in the most widely known versions, imply that truth telling is a dominant strategy) have other possible drawbacks, like budget imbalance.

2.1 The mean vote and the threshold strategy-proofness

Recently the discussion about strategy-proofness in voting has been revived from a non-standard point of view in a paper by Ehlers et al. (2) who adopt a kind of bounded rationality approach to the problem of collective choice. A basic assumption made by these authors is Lipschitz continuity of the voters’ utility function, a characteristic that broadly speaking means that utility does not change too fast when its arguments vary. Lipschitz continuity implies that a choice not aligned with what the agent prefers entails a utility loss not larger than \(L\) times the “distance” between the preferred point and the socially chosen one. This representation of preferences, while obviously restricting the permissible transformations of the utility

\(^3\)Strategy-proofness holds for coalitions as well.
function, is in line with the idea of a kind of limited ability of agents in perceiving the utility effects of decisions pertaining to public goods. This might be justified by the complexity which characterizes the collective action and the provision of public goods. Agents might simplify things by considering, for example, that no more than a given utility amount can ever be gained through a unit increase in the amount of a public good.

The mechanism studied by Ehlers et al. (2) refers to a multidimensional decision problem: i.e. society must choose a point within a finite subset of a Euclidean space, whose dimensions refer to the issues at stake (i.e. in each dimension the amount of a given public good or the availability of a given political attribute in a decision is measured). The suggested procedure is the mean vote, i.e. society chooses the point whose coordinates are the mean of the coordinates of the points voted for by citizens. Every participant thus votes for a point, by supplying the vector describing his preferred choices in each dimension.

With reference to a large enough polity, the mean will become rather insensitive to the individual vote, thus implying only a small benefit of lying in preference reporting. By considering that Lipschitz continuity also sets a cap on the effects in utility terms, mean voting turns out to be “sharply threshold strategy proof”, as the gain from lying cannot exceed a given threshold. By considering that finding an advantageous strategy for misrepresentation of preferences is likely to be demanding in terms of information and calculus, threshold strategy-proofness implies a prediction of truth telling in mean voting procedures whenever the costs of strategical behavior exceed the threshold. The level of the threshold in turn depends positively on the Lipschitz constant $L$ (i.e. the parameter describing the maximum reactivity of the utility function), which is assumed to be the same for all the voters, and negatively upon the number of participants in the decision process. Note that threshold strategy-proofness occurs at the price of individual rationality in voting (why should
one vote if the effect on the collective choice is negligible?), a well-known problem that arises also with reference to the majority voting rule in large electoral bodies. Another problem arising from the Ehlers et al. (2) approach is that they consider a multidimensional decision in which only public goods or dimensions of a social choice are involved, i.e. in their model all individual utility functions are defined on the same domain. Hence, to apply their approach to a problem pertaining to public goods, it must be assumed that tax shares have already been set, in order to eliminate the private good from the utility function. This also means, as routinely happens in median voter models, that a change in the rule for sharing costs modifies the induced individual preferences and the result of voting. Even with these limitations the approach of Ehlers et al. (2) seems to offer quite a significant way out with respect to the problem of strategical behavior in collective choices.

2.2 Strategic behavior in mean voting

A somewhat more pessimistic message is conveyed by another recent paper that deals also with the mean voting mechanism and considers the voters’ optimal strategies in this case. The differences in the conclusions with respect to the paper by Ehlers et al. (2) that will be discussed subsequently are largely due to the fact that Renault and Trannoy (4) consider standard fully rational economic agents. In their setting voters have single peaked preferences defined on a segment of the real line (on which, for example, the quantity of a public good is measured), i.e. their problem is unidimensional. Like in the Moulin (3) paper, voters announce (either sincerely or not) their preferred quantities. Society, however, does not select the median but the mean, where the mean can be simple (i.e. one man one vote) or weighted. Building upon results available in the literature, the authors are able to show that there is a unique Nash equilibrium allocation for this game. The allocation represents a cut point that separates players into two groups, i.e. all the members of one group would like an
amount larger than the equilibrium one and thus vote for the maximum quantity of the public good (with reference to the interval in which the social choice must lie) whereas the members of the other group would like a quantity lower than the equilibrium amount and thus vote for the minimum quantity. The working of the model is illustrated in Figure ??.

Let us assume perfect information of voters about all the bliss points and the corresponding voters’ weights. Consider a continuum of voters indexed by $x$, uniformly distributed on the unit interval $[0,1]$. Consumers with a high $x$ have a low bliss point $y$, i.e. a low preferred quantity of the public good. In Figure ??, therefore, the negatively sloped curve represents bliss points as a function of $x$, while the positively sloped curve represents the cumulative weight in terms of votes. As an equal weight for all the voters has been assumed in the Figure, the latter curve is the $45^\circ$ line. Note that the cumulative weight curve also measures

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*Note that the cumulative weight curve also measures...*
the value progressively assumed by the mean if voters vote 1. The cut point is the abscissa of the point where the two curves intersect, while the equilibrium allocation is the ordinate of the same point. On the left-hand side with respect to the equilibrium point, as long as the bliss points curve lies above that of cumulative weights, by voting 1 the agent reduces as much as possible the gap between the social choice so far (i.e. the cumulative weight) and his bliss point. Note that such a voter does not fear that the vote of the next agent might push the mean above his bliss point, as the next agents less intensively want the public good. The opposite reasoning holds on the other side, where the curve of cumulative weights lies above the bliss points curve. Voters on this side vote 0. For the agent located at the cut point, the bliss point and the progressive mean coincide. On the other hand, because of the continuity assumption, this type is of measure zero. Thus the model predicts that virtually all the agents will hide their preferences and choose an extremist behavior. When there is a discrete number of agents, on the other hand, it might happen that one agent\footnote{If there are many voters in this position there might be multiple Nash equilibria, while, however, the equilibrium allocation is still unique.} exactly reaches his preferred quantity by fine tuning his vote within the interval, thus adopting a non-extremist behavior. Renault and Trannoy (5) also find that the strategic bias is independent of the information structure of the game, and thus occurs also when the assumptions pertaining to the participant’s information about the other people’s bliss points or weights in the vote are relaxed.

As far as the equilibrium allocation is concerned, it may or may not coincide with the mean of actual bliss points. Mean vote performs better than the median one in eliciting the actual mean of bliss points if the latter (once data have been normalized) is central in the interval \([0, 1]\).
2.3 The political relevance of the mean vote rule

To the best of our knowledge, there is no political tradition concerning the use of a mean rule in voting. Procedures that work more or less as if a mean rule were adopted can be found, however. Some interesting cases are reviewed by Renault and Trannoy (4). They focus particularly upon the “forced to pay free to choose” mechanisms, under which agents choose which share of the taxes they pay must go to specific uses, e.g. to the financing of their preferred school district or to a specific religious confession. The amount of money devoted by society to each of these uses can thus be seen as the mean of the shares chosen by taxpayers, weighted by the amount of taxes that each citizen pays. In fact the currently used mechanisms only allow discrete choices (e.g. in Italy taxpayers have to decide whether to allocate 0.8% of income tax to a religious confession or not), but if the prediction of extremist behavior holds, the only relevant alternatives are in fact discrete and extreme, and thus the idea of mean voting is tenable.

One might also rationalize in terms of mean vote the procedures based on rotation, under which the choice is made by a member of the relevant body that stays in charge for a given (short) period and then steps down while a second member takes charge. The policy that ensues over a period (e.g. one year) can then be described as the mean of the policy choices made by the members, where individual choices are weighted by the time span in which everyone is in charge and by the appropriate discount factor if relevant. Rotation has been widely used in the European institutions and is also provided for in the recently designed constitution, where it is mandated for the presidency of the EU’s sectorial Councils and for the members of the Commission, which must correspond to two thirds of the number of Member States.

Another approach that can be rationalized in terms of the mean rule is the random assignment of the right of deciding to a member of a social body who stays
in charge for a short period and is followed by another member chosen at random too, and so on. The method of drawing lots was widely used in classical Athens to select chairmen of political assemblies, members of the government, officials and judges; in fact drawing lots was the rule while other methods of selection were the exception. Drawing was often used jointly with rotation. Arisoteles\textsuperscript{6} for example refers that the epistate of the Pritaneon who, among other powers and duties, was in charge of guarding the Treasury of the State, was drawn to serve for one day and could hold that position only once in life.

The logic behind these approaches seems that of protecting against dictatorship and corruption, avoiding a too fierce political struggle for power and securing low transaction costs. When equal weights are adopted, participants in the decision process are endowed with equal power and are assumed to have equal ability to represent the whole body. Mean voting differs from the rotation and random selection procedures mainly because it avoids variance around the mean (and hence the risk) that the latter systems involve. Renault and Trannoy (4) also stress a potential role of the mean rule for protecting minorities. In the “forced to pay free to choose” model, for example, religious minorities can convey funds to their preferred schools, while a median voting procedure might disregard in full their preferences (i.e. the median voter might choose a zero amount for a good that is of vital interest for a minority). Thus mean voting might prevent social unrest or secessions in multiethnic or multireligious countries or federal states.

Unfortunately, the mean rule does not secure efficiency in the choice of the collective good amount, even in cases in which sincere revelation of preferences occurs. While Bowen (1), in a famous contribution, has shown that efficiency occurs when the mean of marginal rates of substitution equals marginal cost/number of agents (which is the equivalent of the Samuelson efficiency rule, i.e. the sum of marginal

\textsuperscript{6}in the Athenaion Politeia, 44, 1.
rates of substitution equals marginal cost), this is a condition referred to mean demand prices and not to mean quantities. From this point of view, the mean rule does not seem better than the median rule implied by majority voting, i.e. neither secure efficiency in collective choices.
3 The experiment

The aim of the experiment is to test whether the mean rule actually prompts sincere revelation of preferences or not, and in the latter case if extremist behavior prevails. It also aims to test the effects of the mean voting rule upon social welfare. The median vote rule is used in the experiment as a control treatment.

The experiment was run in March 2005 at the ALEX laboratory of the University of Eastern Piedmont “A. Avogadro” in Alessandria (Italy). It was programmed by Marie-Edith Bissey and conducted with the software z-Tree (Fischbacher 1999(6)). Twenty-four undergraduate students from different years and faculties\(^7\) participated in it. The experiment took about an hour and the payment was around 10 euros per capita.

In order to keep the experiment simple, it was designed in just one dimension, by inviting the participants to vote for their preferred amount of a public good in the interval \([0 - 10]\). Participants receive payoffs based on quadratic utility functions, which are thus single peaked and are assumed to describe each participant’s net benefit\(^8\) as a function of the amount of the public good. As attention is restricted to the interval \([0, 10]\), the utility functions considered are Lipschitz continuous. However, it is obviously by no means taken for granted that when the payoff is evaluated by each participant on the basis of his actual individual utility function this characteristic still holds.

In the experiment payoffs are provided to the participants on paper instructions - in a table and via a graphic representation - and they can also digit an amount for the public good on their computer and check the result in terms of payoff on the

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\(^7\)The ALEX laboratory of the University of Eastern Piedmont maintains a list of students willing to participate in experiments. They are recruited through an announcement on the web site and alerted when an experiment is programmed.

\(^8\)It is thus assumed that the cost shares have been set, so that each agent’s utility only depends on the public good.
computer screen before voting. The actual payment to each participant is represented by his payoff in a randomly selected round out of the 15 actually played.9

8 types of preferences were assigned to the participants: hence some types appear more than once. The number of types was kept small in order to have round bliss points, to ease the perception. During the experiment, agents always kept the same utility (i.e. payoff) function. This should ease the learning during the experiment. Agents were always informed about the procedure used for making the collective choice (either the mean or the median). The information concerning the previous rounds’ results (up to five), in terms both of social choice and player’s payoff, was displayed on the screen.

Agents are assigned to groups of 3 people and receive 3 treatments in sequence as described in Table 1.

Groups are formed without repetition (i.e. each agent always meets other people having different bliss points) and with the aim of forming collectives in which the mean vote differs from the median one in the case of sincere revelation. Half of the participants start with full information about bliss points of the other two members of their group, while the remaining participants have no information about either the bliss points or the number of members in their group. After five rounds of mean vote the scenario is reversed, i.e. those who had information are told that they are now part of a group with an undefined number of possibly new partners (and the composition of their group is in fact changed), while those who had no information beforehand now receive it. This design aims at verifying if there are effects arising from the sequence in which the treatments are administered. In the final five rounds every agent keeps his previous status in terms of information about the other people’s bliss points and about the composition of the group, while the median voting rule is

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9 In the appendix are provided the instructions given to the participants at the beginning of the experiment: the complete instructions are available from the authors upon request.
The main variable that varies during the experiment is the information supplied to the participants. The design is in a sense prone to elicit strategical behavior as, even according to the Ehlers et al. (2) approach, the smaller the group of voters the larger the threshold for strategy-proofness. Even in a small group, however, a more widespread sincere revelation of preferences should be seen under lack of information than with information, as in the former case it is more cumbersome to design efficient strategies. Sincere disclosure of preferences is expected under median voting.

Table 1: the experiment design

<table>
<thead>
<tr>
<th>Voting rule</th>
<th>Mean</th>
<th>Median</th>
</tr>
</thead>
<tbody>
<tr>
<td>Round</td>
<td>1...,5</td>
<td>6...,10</td>
</tr>
</tbody>
</table>

Sequence of the treatments for:

<table>
<thead>
<tr>
<th>12 people in groups of 3</th>
<th>$i$</th>
<th>$ni$</th>
<th>$ni$</th>
</tr>
</thead>
<tbody>
<tr>
<td>12 people in groups of 3</td>
<td>$ni$</td>
<td>$i$</td>
<td>$i$</td>
</tr>
</tbody>
</table>

Total number of observations

- 120
- 120
- 120

$i$: players have information about other people’s bliss point

$ni$: players do not have information about other people’s bliss point
4 Data Analysis

In Table 2 agents are classified according to whether they vote strategically or they reveal their preferences. We term as strategic the votes close to the Renault and Trannoy’s predictions (±0.5 along the 0-10 voting line), as a small deviation might represent a sketchiness error. Similarly, it is assumed that revelation occurs if the vote is close to the bliss point, i.e. ±0.5 along the 0-10 voting line. Table 2 shows also the incidence (on the total number of participants) of extremist - a term with which we refer to those who exactly match the Renault and Trannoy predictions - and the incidence of the fully sincere voters. The chosen definitions for strategic behavior and for revelation imply that some overlapping occur, i.e. some votes satisfy both definitions. This happens when the Renault and Trannoy deviation with respect to the participant bliss is small enough, i.e., not larger than 1.

Strategical behavior (as previously defined) and sincere revelation are able to describe the conduct of around 65% of the participants. Sincere revelation is larger under median voting than under mean voting. Sincerity is expected under median voting: as the problem is unidimensional and single peaked, no misrepresentation of preferences should occur (see Moulin, (3)). On the other hand, fully sincere revelation occurs quite often also under mean voting and extremist behavior is neither widespread nor specially linked to mean voting, two facts that cast some doubts on the predictions based upon the Renault and Trannoy approach.

Repetition of the voting game under the mean rule seems to induce the participants to increase their resort to alternatives to the sincere revelation of preferences (Table 3). On the other hand, under the median voting rule (to which the 15th round refers) people seem to learn that sincerity pays.

A point of interest in this study concerns the role of information in affecting the voters’ behavior. According to the Renault and Trannoy paper, the unique
<table>
<thead>
<tr>
<th>Voting rule</th>
<th>Strategic behavior</th>
<th>Revelation</th>
<th>Overlapping of strategical behavior with revelation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>of which: extremist</td>
<td>of which: sincere</td>
<td></td>
</tr>
<tr>
<td>Mean (total)</td>
<td>20.83%</td>
<td>14.17%</td>
<td>50.4%</td>
</tr>
<tr>
<td>Mean (without information)</td>
<td>23.33%</td>
<td>15.83%</td>
<td>50%</td>
</tr>
<tr>
<td>Mean (with information)</td>
<td>18.33%</td>
<td>12.5%</td>
<td>50.8%</td>
</tr>
<tr>
<td>Median (total)</td>
<td>20%</td>
<td>13.33%</td>
<td>54.2%</td>
</tr>
<tr>
<td>Median (without information)</td>
<td>31.67%</td>
<td>21.67%</td>
<td>51.67%</td>
</tr>
<tr>
<td>Median (with information)</td>
<td>8.33%</td>
<td>5%</td>
<td>56.67%</td>
</tr>
</tbody>
</table>

Table 2: Modes of behavior under different treatments
Nash equilibrium which originates from the game is predicted independent from the informational structure. Actually we have found empirical evidence of this assertion: using the non parametric chi-square test, the null hypothesis that the sincere disclosure of preferences is independent from the information provided cannot be rejected. To note that this result holds whether the informational structure is tested with reference to the mean or the median vote.

To further investigate the voter’s behavior in comparison with the predictions of the Ehlers et al. (2) and the Renault and Trannoy (4) papers respectively, let’s consider the sequence of treatments. The chi-square test shows that under the mean voting rule with full information there are differences in behavior according to whether the treatment is administered at the beginning of the experiment or after five rounds of mean voting without information (Table 4). Experienced subjects resort more often to extremist voting, while the overall incidence of this mode remains small.

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<table>
<thead>
<tr>
<th></th>
<th>With Information</th>
<th>Without Information</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st round</td>
<td>50%</td>
<td>41.67%</td>
<td>45.83%</td>
</tr>
<tr>
<td>5th round</td>
<td>33.33%</td>
<td>33.33%</td>
<td>33.33%</td>
</tr>
<tr>
<td>10th round</td>
<td>25%</td>
<td>33.33%</td>
<td>29.17%</td>
</tr>
<tr>
<td>15th round</td>
<td>58%</td>
<td>50%</td>
<td>54.17%</td>
</tr>
</tbody>
</table>

Table 3: percentage of sincere disclosures in rounds

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10 Both at 5% and 10% level of significance.
11 $\chi^2 = 12.42$, df=2, critical value=9.21, significant at $\alpha = 0.01$. The null hypothesis is rejected ($\chi^2 > \text{Critical Value}$). The null hypothesis states that the player’s experience does not affect his behaviour (i.e., sincere disclosure of preferences, Renault and Trannoy strategical behaviour, other).
12 Partitioning Table 4 in two tablets, it turns out that the only significative Chi-square refers to the modalities “sincere+extremist” versus “other”.

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16
Table 4: modes of behavior under mean voting rule with information

<table>
<thead>
<tr>
<th></th>
<th>Without experience</th>
<th>With experience</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sincere</td>
<td>43.33%</td>
<td>6.67%</td>
</tr>
<tr>
<td>Extremist</td>
<td>18.33%</td>
<td>23.73%</td>
</tr>
<tr>
<td>Other</td>
<td>38.33%</td>
<td>70.00%</td>
</tr>
</tbody>
</table>

Table 5: standard deviation with respect to predicted values

Table 5 reports the standard deviation\textsuperscript{13} of the actual voters’ choice with respect to the two predictions. The prediction which exhibits a smaller deviation is the one which exhibits more predictive accuracy. Table 5 suggests that there is a general better fit of the Ehlers et al. predictions.

The location of the player’s bliss point on the \([0 – 10]\) voting interval may affect the individual behavior. On the one hand participants located towards the extremes of the interval might realize more quickly which is their optimal strategy (i.e. voting extremistically); on the other hand they might have less room for manoeuvre as they are near the border. The opposite reasoning holds for those who have a central position. To analyze this issue, the \([0 – 10]\) line has been split in three intervals: \([0, 3]\), \([3 – 7]\) and \([7, 10]\). A chi-square non parametric test has been run. Under mean

\[
\sigma = \sqrt{\frac{1}{N-1} \sum_{i=1}^{N} (x_i - \mu)^2},
\]

where \(\mu\) is the predicted value under consideration, \(x_i\) is the individual choice and \(N\) is the total number of votes in the relevant rounds.

\textsuperscript{13}The standard deviation has been calculated as:
voting, the null hypothesis that the voter’s position along the voting line does not affect behavior (in terms of either sincerely disclosing preferences or not), is amply rejected both at 5 and 10% level of significance. On the opposite, with the median vote, the player’s location doesn’t seem to play any role in influencing choices (the null hypothesis is accepted at 5%).

To further investigate the role of voter’s location, Table 6 reports the standard deviation of the middle and side players respectively with reference to the Renault et al.(4) and Ehlers et al. (2) predictions. When voters have no information, the predictions of strategical behavior of Renault and Trannoy (4) tend to better fit side players rather than middle ones. The predictions of Ehlers et al. (2) are instead very accurate for voters in a central position, in particular in the scenario with median vote and full information. Hence one can infer that a location close to the extremes renders more easy for the voter to find a suitable strategy under mean voting, while a central location eases the perception that sincerity pays under median voting.

<table>
<thead>
<tr>
<th>Voting Rule</th>
<th>Mean</th>
<th>Median</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Voter’s location</td>
<td>No Inf</td>
</tr>
<tr>
<td>Renault et al.</td>
<td>Side</td>
<td>2.96</td>
</tr>
<tr>
<td>Renault et al.</td>
<td>Middle</td>
<td>4.11</td>
</tr>
<tr>
<td>Ehlers et al.</td>
<td>Side</td>
<td>2.13</td>
</tr>
<tr>
<td>Ehlers et al.</td>
<td>Middle</td>
<td>1.99</td>
</tr>
</tbody>
</table>

Table 6: side and middle players standard deviation with respect to predicted values.

An issue which deserves attention concerns the social welfare first best outcome, and in particular the voting mechanism that gets closer to the social optimum. To cope with this point, firstly the objective social welfare function must be defined. For this purpose a standard Bergson-Samuelson social welfare function, given by the sum of individuals’ utility functions, is set. Each electoral group is associated with a
Table 7: welfare gap with respect to social optimum

<table>
<thead>
<tr>
<th></th>
<th>Welfare loss</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean vote</td>
<td>-1.89%</td>
</tr>
<tr>
<td>Median vote</td>
<td>-4.01%</td>
</tr>
<tr>
<td>Predicted: Renault et al.</td>
<td>-0.90%</td>
</tr>
<tr>
<td>Predicted: Ehlers et al.</td>
<td>-0.53%</td>
</tr>
<tr>
<td>Predicted: Moulin</td>
<td>-2.19%</td>
</tr>
</tbody>
</table>

Thus the standard deviation $^{14}$ of the actual choice with respect to the social optimum is computed and reported in Table 8. It is compared to the standard deviation predicted in the light of the Ehlers et al. (2) and Renault and Trannoy (4) articles (Table 8). The deviations of actual choices from efficiency are larger than both the predicted$^{15}$ ones. On the other hand, mean voting does not seem worse than median voting from this point of view.

$^{14}$The standard deviation has been calculated this way: $\sqrt{\frac{\sum_{i=1}^{N}(x-x^*)^2}{N-1}}$, where $x^*$ is the social optimum for the group, while $x$ is the social choice (either actual, or predicted respectively by Ehlers et al. (2) or by Renault and Trannoy (4) an $N$ is the number of groups which receive the specified treatment.

$^{15}$The prediction of sincere revelation of preferences under median voting was made by Moulin (3)
<table>
<thead>
<tr>
<th>Voting Rule</th>
<th>Mean</th>
<th>Median</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Yes</td>
<td>No (b)</td>
</tr>
<tr>
<td>Inform.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(a)</td>
<td>1.26</td>
<td>1.19</td>
</tr>
<tr>
<td>Actual choice</td>
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<td>0.91</td>
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<td>1.03</td>
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<td>Ehlers et al.</td>
<td>0.65</td>
<td>0.74</td>
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Table 8: standard deviation with respect to social optimum

5 Econometric analysis

Econometric analysis has been applied to a panel consisting of cross-sections of individuals observed for a 15 round time series. The total number of observations is 360.

Thus a regression is set where strategy represents the regression’s dependent variable. It measures the player’s strategic behavior and it is expressed by the absolute deviation of the player’s actual choice with respect to his individual optimum. The larger this distance, the more the player behaves strategically, i.e. the more he deviates from his true preferences.

The following explanatory variables were considered:

period is a sort of trend variable useful to capture the players’ experience. It varies from 1 (first period) to 15 (last period). The use of a lagged variable (ruleofthumb: see below) reduces the time series to 14 time observations (the first period has been lost);

inf is equal to 1 when full information is provided to the player, 0 otherwise;
votingrule is equal to 0 when a mean voting rule is implemented, 1 when the median voting rule is implemented;
ruleofthumb explanatory variable is obtained by the difference between the indi-
individual bliss point with respect to the actual amount of the public good chosen inside each group (on the basis of the actual individuals’ votes) at time t-1. The goal of this variable is to capture a behavior based on *ex post* systematic adjustment to the previous round result which conveys information about the other players vote.

`mgvar` is an indicator of the curvature of the utility function. The utility function associated to each participant is:

\[ U(x) = -ax^2 + bx + c; \quad a, b, c > 0 \]

`mgvar` is given by the `a` parameter;

`deltapref` represents the distance in absolute value of the individual preferred amount of public good with respect to the group specific mean value, i.e. the public good amount which would be chosen by the group when all the members truly reveal their preferences;

`delta_rt_pref` is a variable intended to catch the predictive accuracy of the Renault and Trannoy expectations. The value of this variable represents the distance, in absolute terms, between the Renault and Trannoy voting prediction and the individual’s true preferences;

`constant` is the constant term.

The presence of heteroskedasticity across panels was assessed by the likelihood ratio test and the modified Wald test for groupwise heteroskedasticity in fixed effects regression model. A cross-sectional correlation (in fixed effect model) was detected by the Breusch-Pagan statistic for cross-sectional independence in the residuals of a fixed effect regression model.

Finally the Wooldridge test for serial correlation in panel data models rejects the null hypothesis of no first order serial correlation.

To take all of these problems into account, a feasible generalized least square model which considers heteroskedastic panels with cross-sectional correlation and
panel specific correlation was implemented.

Table 9 reports the results of a feasible generalized least square estimate which allows consideration of heteroskedasticity with cross-sectional correlation and panel-specific AR(1).

| Dependent variable: strategy | Coef. | \( P > |z| \) |
|------------------------------|-------|------------|
| period                       | 0.0574587* | 0.007 |
| inf                          | 0.1564729 | 0.188 |
| votingrule                   | -0.709308* | 0.000 |
| ruleofthumb                  | 0.1133996* | 0.000 |
| mgvar                        | 10.50003* | 0.000 |
| deltapref                    | 0.019639 | 0.689 |
| delta_rt_pref                | 0.955562 | 0.152 |
| Constant                     | -0.3032722 | 0.292 |

cross-sectional time series FLGS
Panels: heterosk. with cross-sectional corr. No. of groups: 24
Correlation: panel-specific AR(1) No. of obs. 336
Wald Chi2(7)=38.05 Prob>chi2=0.0000

* = Significant at 5% level of significance

Table 9: FGLS estimate

The two explanatory variables period and votingrule, which refer to the agent’s experience and to the voting rule, have the correct sign and they are significant. This result confirms what was found in the previous non-parametric analysis: the player’s strategic behavior increases with experience but decreases when the median voting rule takes the place of the mean voting rule. The inf (information) variable does not significantly affect the dependent variable, nevertheless it assumes the expected sign: information boosts the strategic deviation from truth.
The rule of thumb is highly significant. Under this rule, the agent increases his reported amount if the collective choice in the previous round was under his bliss point, and decreases it in the opposite case. Together with the autoregressive nature of the model (which probably captures also some effects of incremental experience and information), this suggests that subjects reacted through partial adjustments in each round and this conduct was rewarding for them.

Also $mgvar$ is significant at 5% level of significance. This result suggests that strategic behavior is deeply affected by potential loss/gain inherent to the individual specific utility.

The variable $deltapref$ measures the opportunity for lying available to the player, in terms of distance of his bliss point from the group mean. The positive sign associated with the $deltapref$ coefficient (even if the variable is not significant) gives some support to the interpretation that this opportunity was mainly exploited by voters who were far from the group mean. Such an inference accords also with the results discussed in § 4 with reference to the relevance of the agent’s location as a factor that influences the propensity to behave strategically.

The last variable which deserves attention is $delta_{rt\_pref}$. The fact that this variable is not significant may suggest that the Renault and Trannoy predictions are unable to explain the player’s strategic behavior, but the positive sign suggests that at least they are able to catch their "strategy trend".
6 Conclusions

The experiment was designed in order to have a reference treatment in which people are likely to cheat in voting, as they are put in small groups and have information about other people’s bliss points, while mean voting is used. Besides this case, in the further treatments it was expected that, under lack of information and under median voting, more sincere revelation of preferences would occur. In fact the experiment in a sense belied these expectations: it turned out that about one third of the votes were fully sincere also in the reference case, thus suggesting that even in small groups and with full information, the difficulties of finding suitable strategies are considerable. One might also imagine that some people always prefer to tell the truth, but just one agent chose this conduct in all the rounds, thus this interpretation is not supported by our results.

Since even in the reference case sincere revelation was chosen to some extent, the behavioral predictions made by Ehlers et al. (2), based on a kind of bounded rationality approach, receive some support from this experiment and seem likely to work in large groups. While experimental tests with larger groups remain to be done, we expect in real life a social choice systems based on the ”forced to pay free to choose” mechanism, in which people vote once in a while in very large collectives, to offer small incentives for widespread strategical misrepresentation.

On the other hand it emerges that strategical conducts tend to increase when conditions become more favorable, thanks for example to repeated participation in the experiment. Hence it also seems reasonable to expect strategical behavior to arise in committees consisting of experienced professionals and extremist strategies to represent a relevant limit result for these cases.
Appendix

Hello. First of all we would like to thank you for participating in this experiment. Everything you will have to do is simple and straightforward. There are no tricks. Just follow the instructions on your screen. The answers are anonymous so nobody will know who gave the answers.

This experiment represents a regional decision making process concerning public expenditure on a public good. The regional expenditure ranges between 0 and 10 million euros.

Cost and benefit vary according to the regional expenditure level.

The citizens’ net benefit, which originates from the regional decision concerning a public good, is increasing in the amount of public good provided until costs prevail over benefits.

Net benefit varies between the participants in the experiment. It is even possible that the net benefit associated with a zero expenditure level could be positive. For instance, when your private business might be more profitable when public intervention is absent.

Before the experiment starts, you will be informed about the regional expenditure which provides you with the maximum net benefit, i.e., your maximum earning.

The actual regional expenditure level is given by the mean of the “values” voted by citizens, i.e., the values chosen by the participants in the experiment.

Each of you must indicate your preferred expenditure level, choosing a value in the interval 0-10 (referring to millions of euros). You can also choose non integer values – for example, 4.13 – but full stop rather than comma has to be used.

Afterwards, the computer will compute the mean. For instance, the mean of the following:

2; 2.5; 4; 6.5; 10
5.

The outcome (which reflects the final regional choice) is provided jointly with your personal earning.

Your personal earning is directly correlated to the regional expenditure, which in turn depends on your choice and that of the other participants in the experiment.

Only one experiment out of the 15 rounds played in this experiment will be randomly selected. You will be paid with what you earned in the selected round, at a rate of 1 real euro per each experimental million euros.
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# Working Papers

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