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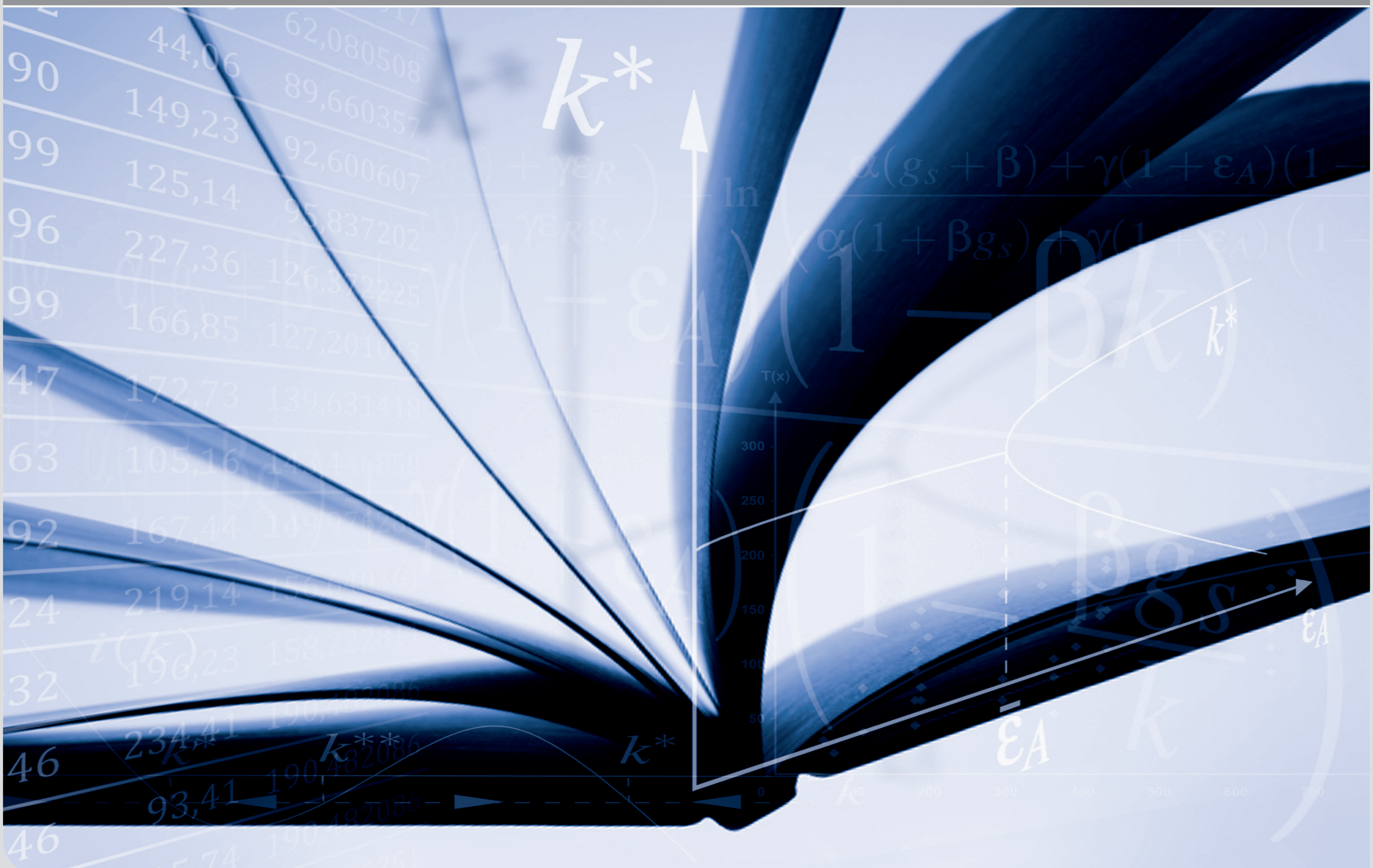
No. 155 | FEBRUARY 2022

WORKING PAPER SERIES IN ECONOMICS



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Impressum

Karlsruher Institut für Technologie (KIT)
Fakultät für Wirtschaftswissenschaften
Institut für Volkswirtschaftslehre (ECON)

Kaiserstraße 12
76131 Karlsruhe

KIT – Die Forschungsuniversität in der Helmholtz-Gemeinschaft

Working Paper Series in Economics
No. 155, February 2022

ISSN 2190-9806

econpapers.wiwi.kit.edu

Participation in Voting over Budget Allocations. A Field Experiment*

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February 2022

We study the effect on the participation rate of employing different voting rules in the context of the problem to allocate a fixed monetary budget to two different public projects. Specifically, we compare the mean rule according to which the average of the individually proposed allocations is implemented with the median rule which chooses the allocation proposed by the median voter as the social outcome. We report the results of a field experiment in which subjects (students of KIT) could allocate money to fund two different public projects, the student's bike shop and a campus garden project. The treatment variable was the collective decision rule employed. While the mean and median rules have very different properties in theory, we found no significant treatment effect on the participation rate. Our results nevertheless shed important light on the use of different voting rules in the context of budget allocation in practice.

*This work is based on Chapters 2 and 3 of the second author's Ph.D. dissertation; it has been presented at the ESA European Meeting 2017 in Vienna (Austria), at the the 13th HeiKaMaX Workshop 2018 in Mannheim (Germany), at the 14th Meeting of the Society for Social Choice and Welfare 2018 in Seoul (South Korea), at the Conference "Improving Public Debate and Political-Decision Making" 2019 at the New College of the Humanities in London (UK), at the International Summer School on "Pluridisciplinary Analysis of Collective Decision Making" 2019 at Université de Caen Normandie (France), and in Seminars at the University of Paderborn (2018), Université de Paris Dauphine (2019), Higher School of Economics, Perm Campus (2021). We are grateful to the participants for helpful comments and suggestions. Special thanks to Tobias Dittrich and Michael Müller for continuous discussions on the topic of the present paper and related topics throughout the years, and to Tim Cleffmann for technical support in the experiment. Needless to say that all errors are our own.

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1. Introduction

The problem of participation in elections is mostly either discussed in the context of large democratic elections (Downs, 1957; Tullock, 1967; Riker and Ordeshook, 1968), and/or assuming the election procedure to be simple majority voting among two alternatives, e.g. political candidates or parties (Palfrey and Rosenthal, 1983, 1985; Ledyard, 1984). By contrast, the present paper focuses on voters' participation decisions in (small) committees and under further assumptions about preferences. Specifically, we consider the collective decision on the level of a one-dimensional variable (spending on a public project) under the assumption of single-peaked preferences. This problem has been theoretically studied in Osborne et al. (2000); Müller and Puppe (2020); Müller (2022). These contributions show that the general game-theoretic analysis of the corresponding participation/voting games is complex. In particular, even under the (strong) assumption of complete information, the existence of pure Nash equilibria is not guaranteed, and in many cases in which existence can be proved the equilibria are not unique. The situation is even more intricate under incomplete information in which case there is little hope to successfully apply standard Bayesian analysis in order to arrive at behavioral predictions in real life situations. Indeed, in contrast to the case of two alternatives/candidates in which voters' beliefs can be parametrized by a single number (e.g. the proportion of the supporters of the first candidate), the relevant beliefs are high-dimensional when there is a large number of alternatives as in our context.

We therefore take a 'bounded rationality' approach in the present paper. Concretely, we hypothesize that a voter's participation decision is to a large part influenced by the *potential impact* that her or his vote can have on the outcome resulting from the collective decision procedure. In order to test this hypothesis we conducted a field experiment in which subjects could decide on the allocation of a fixed budget using two different aggregation rules. The first is the simple *mean rule* according to which the collective outcome is the average of the individual votes (here, a 'vote' is simply the amount of money allocated to one public project) (Renault and Trannoy, 2005). The second is the *median rule* that picks the median vote as the social outcome. Under the mean rule, the potential impact of a vote, i.e. the extent to which one's vote can change the social outcome, only depends on the number of other voters and not on the distribution of their votes. On the other hand, voting truthfully under the mean rule is clearly not optimal in general (because a rational voter would want to 'exaggerate' in expressing her or his preference whenever the true most preferred does not coincide with the social outcome). By contrast, the great advantage of the median rule is that sincere voting is a weakly dominant strategy (if the number of individuals is odd). Therefore, it has been widely employed and studied in the literature following the seminal work by Black (1948); Downs (1957); Moulin (1980). On the other hand, the potential impact under the median rule is uncertain or, more precisely, ambiguous. First, only one subject can change the outcome at all in the case of an odd number of participants (and maximally two subjects in the case of an even number of participants. Moreover, the extent to which pivotal median voter(s) can potentially change the outcome depends on the neighboring votes: if these are close, the potential impact is small. Summarizing then, the impact of one's vote is easy to understand and to assess under the mean rule, but it is uncertain and depends on the precise distribution of the votes of the other participants under the median rule.

Our main hypothesis was therefore that we would find a higher participation rate in our field experiment under the mean rule as compared to the median rule. While we do indeed observe effects in this direction, a closer examination reveals that the difference between the two rules is statistically not significant. We tested a number of other hypotheses as well and again found no significant treatment effects (with respect to the aggregation rule as main treatment variable). While our main hypotheses are not supported by our data, the results from our field experiment nevertheless have interesting and important implications. First, real subjects seem to be motivated by a number of factors different from pivotality in the voting process. Secondly, strategic behavior is much less prevalent in the field than one would expect by looking at corresponding data from lab experiments (Marchese and Montefiori, 2011; Block, 2014; Puppe and Rollmann, 2021).

The plan of the paper is as follows. After giving more background and an overview of the literature, we present a theoretical model of the role of the potential vote impact in Section 2. The field experiment and the hypotheses are described in Section 3, the results in Section 4. Section 5 concludes. An appendix contains further information, including the instructions, screenshots, and the questionnaire that we used during the experiment.

Background and Overview of the Literature

With their work on rational choice theory and the calculus of voting, Downs (1957), Tullock (1967) as well as Riker and Ordeshook (1968) provide a decision-theoretic model of participation in elections. The question that these models face is why a rational individual would vote if the return from voting is often outweighed by the costs that emerge in the voting process. Even if the cost to participate in an election is small, the probability that a single vote affects the outcome is almost zero in large electorates. As an example, Gelman et al. (1998) estimate the ex post probability of a single vote being decisive in the 1992 U.S. presidential election to be 1 in 10 million. Therefore, the rational choice model predicts turnout levels that are far below the actual participation rates in elections. This discrepancy is often referred to as the *paradox of voting*.

The calculus of voting has been tested empirically in a variety of studies in the 70s and 80s. Aldrich (1993) have pointed out that using aggregate data like Barzel and Silberberg (1973), Settle and Abrams (1976), as well as Silberman and Durden (1975) do, yields a correlation between pivotality and turnout while survey data as in the studies by Ferejohn and Fiorina (1975) or Foster (1984) do not. Enos and Fowler (2014) review some 70 articles on voter turnout and the relation between pivotality and participation rates. They find that in a majority of studies pivotality is an important driving force for turnout, and that most models on turnout in fact focus mainly on pivotality. In their own study, the authors describe a rare circumstance of an exact tie in electing a candidate for the Massachusetts State House in 2010, which led to a re-election and thus gave a unique opportunity for a field experiment to measure the effect of pivotality on turnout. They informed subjects about the closeness of the election but found a significant increase in turnout only for a subgroup of frequent voters. Thus, Enos and Fowler (2014) concluded that pivotality is not as relevant for turnout decisions as the 'calculus of voting' would predict.

Ferejohn and Fiorina (1974, 1975) argue that subjects often do not act as expected utility maximizers since the relevant probabilities of the model are unknown. Instead of basing their participation decisions upon pivotality, subjects are assumed to follow a strategy based on minimax regret. These authors argue that the minimax regret approach leads to a higher participation rates than the pivotality approach.

Palfrey and Rosenthal (1983, 1985) and Ledyard (1984) formulate the pivotal voter model using a game-theoretic approach. In the Palfrey-Rosenthal participation game, two groups of subjects prefer either one or another candidate. Each subject may vote for his or her preferred candidate (voting for the opponent is strictly dominated in the two-candidate case) or abstain. Participation is costly, while abstention is free. The candidate that gets the majority of votes wins. In their equilibrium analysis, Palfrey and Rosenthal (1983) show that there not only exist equilibria with low turnout levels but also equilibria with substantial turnout if participants face identical costs and complete information on the distribution of preferences. Ledyard (1984) endogenizes pivotality and highlights that the participation decision of all subjects is made simultaneously. His model implements uncertainty about preferences as well as costs, and turnout levels lie between zero and full participation in equilibrium. Building on Ledyard (1984), Palfrey and Rosenthal (1985) implement uncertainty about the individual voting costs and show that this lack of information causes individuals to abstain even when participation would be optimal under full information. Hence, in large electorates the unique Bayesian equilibrium displays low turnout under incomplete information.

Blais (2000) surveys numerous empirical studies and provides a review on rational choice models. He concludes that the rational choice model has limited explanatory power in order to explain empirical turnout rates. Dhillon and Peralta (2002) provide a complementary survey on the existing models and theoretical literature on participation.

The Palfrey-Rosenthal participation game is used widely in the literature that tests the pivotal voter model in experimental studies. A lab experiment conducted by Levine and Palfrey (2007) tests the voter turnout predictions of the Palfrey-Rosenthal model with asymmetric information, in which participation costs are private information. The authors find a 'size effect,' meaning that in large elections, participation rates are lower as compared to small electorates. The data also reveal a 'competition effect,' i.e. elections that are expected to be close are associated with a higher voter turnout. Another finding is the so-called 'underdog effect:' groups that support a less popular alternative have higher turnout rates as compared to the supporters of the popular alternative.

Duffy and Tavits (2008) perform a lab experiment of the complete information pivotal voter model and additionally elicit the subjects' beliefs about the probability of a close election. Therefore, the authors are able to directly test the pivotal voter model and focus on the correlation of beliefs about being pivotal and the participation decision. The study finds that a higher belief about the probability of being pivotal increases the likelihood of participation and that subjects tend to overestimate this probability of being pivotal. In another lab experiment, Agranov et al. (2017) test the effect of pre-election information on voter turnout. The study finds that pre-election polls influence participation, and the effects depend on the expectation on the closeness of the election. When a poll reveals that the election is expected to be close bandwagon effects appear (higher voter turnout among the majority), whereas when landslide victories are predicted, the authors find underdog effects. The authors also find that landslide elections occur more often in treatments with more information and that voter turnout is higher the more likely subjects expect the preferred alternative to win.

Grillo (2017) presents a game-theoretic model that takes risk aversion into account and by doing so, is able to explain bandwagon effects in cases in which the standard pivotal voter model would otherwise predict an underdog effect. Blais et al. (2014) study the rational choice model in the lab in the context of participation in elections, and compare different voting rules. Remarkably, they find that a large share of subjects (62%) make the 'wrong' decision, i.e. they vote when they should have abstained and vice versa. Even when controlling for beliefs of the opponents' behavior, the rational choice model fails to explain the decision of voting and abstaining, as subjects do not appear to maximize their payoff.

Börgers (2004) develops a costly voting model assuming that costs are private information. He compares compulsory to voluntary voting and finds that compulsory voting is Pareto-dominated by voluntary voting. In a related model, Krasa and Polborn (2009) find that paying subsidies to participants can prevent 'wrong' electoral decisions and increase social welfare by increasing the electorate. Another extension of the costly voting model is provided by Arzumanyan and Polborn (2017) who consider plurality rule among more than two candidates. The interesting new aspect is that strategic voting becomes possible, i.e. voting but not for the own top candidate (something that is never optimal in the two-candidate setting). However, the authors find that for three candidates all equilibria exhibit only sincere voting, a finding that hinges crucially on the fact that voting is costly.

2. Theoretical Framework

Consider a set of individuals $I = \{1, ..., n\}$ that have to collectively decide on the allocation of a fixed budget $Q \geq 0$ on m public projects $J = \{1, ..., m\}$. We assume that the entire budget has to be spent, and that no project can receive negative funding. The set of feasible allocations is thus given by

$$\mathcal{B} := \{x \in \mathbb{R}^m_{\geq 0} | \sum_{j \in J} x^j = Q\},$$

where x^j is the amount of money allocated to project j.

2.1. Aggregation Rules

Individuals decide whether or not to participate in the voting process; formally, each individual i faces a participation decision $\vartheta_i \in \{0,1\}$ that takes the value 1 for participation and 0 in case of abstention. An individual that decides to participate, i.e. $\vartheta_i = 1$, submits a vote that is taken into account in the calculation of the social outcome (such an individual is referred to as 'participant' in the following. The set of participants is denoted by $I^{-*} := \{i \in I | \vartheta_i = 1\}$, and the number of participants by $k = |I^{-*}|$. Each participant $i \in I^{-*}$ submits a vote $q_i = (q_i^1, \ldots, q_i^m) \in \mathcal{B}$. We refer to the vote of individual i also as voter i's *proposal*. The vector of all proposals/votes is given by $q = (q_1, \ldots, q_k) = (q_i)_{i \in I^{-*}}$ and will be accounted for in the aggregation process to determine the social outcome. If an individual abstains, i.e. $\vartheta_i = 0$, no vote is submitted and we define $q_i = *$. We define the set of abstainers by $A := \{i \in I | q_i = *\}$.

In our setting, the social outcome $x(q) = \big(x^1(q), \ldots, x^m(q)\big) \in \mathcal{B}$ is calculated either by the mean or by the median rule. Under the *mean rule*, all votes are added separately for each project and divided by the number of votes:

$$Mean(q) = \frac{1}{k} \sum_{i \in I^{-*}} q_i. \tag{2.1}$$

Obviously, the mean outcome is only well-defined if $k > 0$. Note also that the social outcome under the mean rule always satisfies the budget constraint, i.e. $Mean(q) \in \mathcal{B}$.

The median rule selects, for every project, the middle proposal if the number of participants is odd or the average of the two middle votes if it is even. Specifically, if we denote for each project j, by $q^j_{[1]}, ..., q^j_{[k]}$ the individual votes in ascending order, the *median rule* $Med(q)$ is defined by the m coordinate-by-coordinate median values:

$$Med^j(q) = \begin{cases} q^j_{[\frac{k+1}{2}]}, & \text{if } k \text{ is odd} \\ \frac{1}{2} \cdot (q^j_{[\frac{k}{2}]} + q^j_{[\frac{k}{2}+1]}), & \text{if } k \text{ is even.} \end{cases} \tag{2.2}$$

The median outcome can of course also only be calculated if $k > 0$. A problem of the median rule is that the coordinate-by-coordinate median values do not satisfy the total budget in multi-dimensional allocation problems in general even when the individual proposals do, i.e. it is well possible that $\sum_{j=1}^m Med^j(q) \neq Q$ if $m > 2$. There are several ways to respond to this problem in general, see Lindner (2011). For our purposes, however, this does not pose a difficulty because we will assume throughout that $m = 2$, i.e. that there are only two different public projects. As is easily verified, the median rule always satisfies the budget constraint in this case.

In fact, with two public projects, due to the budget restriction, it is sufficient to indicate both the vote or the social outcome only for one project – the value for the other project then follows directly from the budget equality: $x^1(q) + x^2(q) = Q$. We will therefore in the following omit superscripts referring to projects with the convention that the given value refers to the amount allocated to project $m = 1$, the value for project $m = 2$ is then given by the difference to the total budget Q.

2.2. Preferences

We assume that participation in the voting process is costly. Each participant faces a cost $c_i > 0$ if $\vartheta_i = 1$. By contrast, abstention ($\vartheta_i = 0$) is costless. Individuals are assumed to have single-peaked preferences over outcomes. More specifically, we assume *symmetric* single-peaked preferences (sometimes referred to as 'Euclidean' preferences): there is a unique most preferred outcome p_i (voter i's *peak*), and an outcome x is preferred to y if and only if x is closer than y to p_i in the standard Euclidean distance $d(\cdot, \cdot)$. Summarizing, voter i's preference can be represented by the following utility function:

$$u_i(x(q)) = \begin{cases} -d(p_i, x(q)) - c_i, & \text{if } \vartheta_i = 1 \text{ and } k > 0, \\ -d(p_i, x(q_{-i})), & \text{if } \vartheta_i = 0 \text{ and } k > 0, \\ -\infty, & \text{if } k = 0. \end{cases} \tag{2.3}$$

Observe that we set individual utility to $-\infty$ if no one participates in the voting process. Alternatively, we could have set that value to a large negative number. The idea is that if the group does not reach a decision via the voting process some external institution determines the social outcome, and that all involved individuals would prefer *any* collectively determined outcome to that exogenous outcome.

According to the pivotal voter model, an individual will participate in voting process if and only if the utility from doing so exceeds the utility of abstention, i.e. if and only if

$$-d(p_i, x(q_{-i}, q_i^*)) - c_i \geq -d(p_i, x(q_{-i})), \tag{2.4}$$

where q_i^* is the optimal vote of individual i given the votes q_{-i} of all other participants. In fact, the inequality (2.4) describes the participation decision in Nash equilibrium. Alas, the Nash equilibria of the corresponding voting game are very complex. Even under the (strong) assumption of complete information (i.e. each voter's preferences are common knowledge) and the restrictive assumption of symmetrically single-peaked ('Euclidean') preferences, there are multiple Nash equilibria for many parameter constellations; for other parameter constellations there do not exist pure Nash equilibria at all, see Müller (2022). Under the (in many applications more realistic) assumption of incomplete information, there is no hope of deriving general results on the structure and existence of Bayesian Nash equilibria even under restrictive assumptions (e.g. equal participation costs across individuals).

Thus, instead of concentrating on solutions that assume perfectly rational individuals (with a common prior and Bayesian updating under incomplete information), we explore in the following *boundedly* rational behavior and test various hypotheses by means of a field experiment. Concretely, we hypothesize that an important determinant of the participation decision is the potential *impact* that an individual's vote can have under the different voting rules.

2.3. Impact of a Vote

The *option set* of individual i, given the decisions of all other individuals is defined by[1]

$$\mathcal{OS}_i(q_{-i}) = \{\beta \in \mathcal{B} \mid \exists\ q_i \in \mathcal{B}, x(q_i, q_{-i}) = \beta\}\,.$$

The option set describes the set of all possible social outcomes that an individual i can induce given the decisions q_{-i} of all others. Since both the mean and median rule are monotonic and continuous in q_i given any fixed vector q_{-i}, we obtain

$$\mathcal{OS}_i = \big[x(0, q_{-i})\,,\, x(Q, q_{-i})\big] \ \subseteq [0, Q] \tag{2.5}$$

if $x(q)$ is determined either by the mean or by the median rule.

Observe that under the mean rule, $x(0, q_{-i}) = \sum_{j\neq i} q_j/k$ where k is the number of participants including voter i, and $x(Q, q_{-i}) = (Q + \sum_{j\neq i} q_j)/k$; in particular, the outcome from individual i abstaining, i.e. $\sum_{j\neq i} q_j/(k-1)$, can also be induced by individual i also voting for the $q_i = \sum_{j\neq i} q_j/(k-1)$. (Of course, with positive participation costs, individual i would never want to cast a vote that does not change the outcome as compared to abstention.)

Similarly, under the median rule we have $x(0, q_{-i}) = q_{[\frac{k-1}{2}]}$ and $x(Q, q_{-i}) = q_{[\frac{k+1}{2}]}$ if $k-1$ is even (and the $q_{[j]}$, $j = 1, ..., k-1$ or the other individuals' votes in ascending order); for $k-1$ odd, we obtain

$$x(0, q_{-i}) = \frac{1}{2}\cdot\Big(q_{[\frac{k-2}{2}]} + q_{[\frac{k}{2}]}\Big) \quad\text{and}\quad x(Q, q_{-i}) = \frac{1}{2}\cdot\Big(q_{[\frac{k}{2}]} + q_{[\frac{k+2}{2}]}\Big)\,.$$

We define the *potential impact* of individual i given the distribution q_{-i} of the other voters as the length of the option set and denote it by $imp_i(q_{-i})$; thus,

$$imp_i(q_{-i}) = d\Big(x(0, q_{-i})\,,\, x(Q, q_{-i})\Big). \tag{2.6}$$

When no confusion can arise, we will omit the argument, and simply write imp_i.

Clearly, the potential impact of a vote of individual i in general depends both on the rule and on the distribution of the other votes. But for the mean rule it in fact only depends on the total number of voters k. Since every vote under the mean rule has the same weight of $\frac{1}{k}$, the higher k the smaller is a voter's option set, and hence the smaller the potential impact. Indeed, it follows at once from the calculations of $Mean(0, q_{-i})$ and $Mean(Q, q_{-i})$ above that under the mean rule, for all q_{-i},

$$imp_i(q_{-i}) = \frac{Q}{k}. \tag{2.7}$$

As a simple example, take the mean rule and let $Q = 100$, $Mean(q_{-i}) = 20$ and $k = 4$. Individual i's option set is $\mathcal{OS}_i = [15, 40]$, resulting in a potential impact of $imp_i = 25$.

[1] We neglect the possibility that no individual participates in the election process. This is justified by the fact that the outcome from universal abstention is strictly worse than any other outcome for all individuals.

With an additional voter, the option set is $\mathcal{OS}_i = [16, 36]$, which reduces the potential impact to $imp_i = 20$. For $k = 100$, individual i's potential impact decreases to $imp_i = 1$.

If the median rule is used, the precise location of votes matters, more precisely the positions of the votes that are ranked next to the median as described above. Denote by q_{Med-} the vote that is ranked one position left of the median and by q_{Med+} the vote ranked one position right of the median. Consider the following example: $Q = 100$, $Med(q_{-i}) = 44$, $q_{Med-} = 18$, $q_{Med+} = 70$ and $(k-1)$ is even. Including individual i, there is an odd number of voters k and thus, the median outcome is the vote that is ranked at the middle position $[\frac{k+1}{2}]$. For any $q_i \leq 18$, the social outcome is $Med(q_i) = 18$, and for any $q_i \geq 70$, the social outcome is $Med(q_i) = 70$. Therefore, $imp_i = 52$. Take the same example but now let $(k-1)$ be odd, which means that there exists a median voter who votes for $q_{Med} = 44$. For any $q_i \leq 18$, the social outcome is $Med(q_i) = \frac{1}{2} \cdot \big(q_{Med-} + Med(q_{-i})\big) = 31$. For any $q_i \geq 70$, $Med(q_i) = \frac{1}{2} \cdot \big(Med(q_{-i}) + q_{Med+}\big) = 57$, resulting in $imp_i = 26$ or half the size of the potential impact in the even case.

Importantly, we hypothesize that the potential impact that an individual enjoys has a positive effect on this individual's participation decision. According to this hypothesis, a higher potential impact would thus induce a greater participation probability. However, as we have just seen, the potential impact generally depends on the distribution of the other participants' votes. This implies that, under incomplete information, the participation probability is affected by an individual's beliefs about the vote distribution of the other participants. How should we model this uncertainty? We will now briefly discuss two standard approaches to this problem: the 'complete ignorance' view and the 'Bayesian view.'

2.3.1. Minimal and Maximal Impact of Participation

According to the complete ignorance view, two important reference points are the *minimal* possible impact and the *maximal* possible impact (where the min and the max are taken over all distributions of the other particpants' votes). Indeed, the pessimistic 'maxmin' principle would focus exclusively on the minimal impact, the optimistic 'maxmax' principle would focus on the maximal impact, and the well-known 'Hurwicz-criterion' would consider a convex combination of both, see Luce and Raiffa (1957).

As observed above, the potential impact under the mean rule only depends on the number of voters and is given by $imp^{Mean} = \frac{Q}{k}$. Thus, for any given number of participants the minimal and maximal possible impacts coincides. Observe in particular that the potential impact is always positive under the mean rule, and for any given number of participants, a *sure thing.* Summarizing, we have for all i,

$$\min_{q_{-i}} imp_i^{Mean}(q_{-i}) \;=\; \max_{q_{-i}} imp_i^{Mean}(q_{-i}) \;=\; \frac{Q}{k} \;>\; 0. \tag{2.8}$$

By contrast, the minimal impact under the median rule can well by zero; for instance, if sufficiently many of the other participants cast the same vote, no single vote can change the location of the median. In other words,

$$\min_{q_{-i}} imp_i^{Med}(q_{-i}) \;=\; 0.$$

By contrast, the maximal impact under the median rule can be large. It depends on whether k is even or odd; specifically, we have

$$\max_{q_{-i}} imp_i^{Med}(q_{-i}) = \begin{cases} Q, & \text{if } k \text{ is odd} \\ \\ \frac{Q}{2}, & \text{if } k \text{ is even.} \end{cases} \tag{2.9}$$

To prove (2.9), consider for odd k a situation in which half of the other $k-1$ participants vote for 0, and the other half for Q; then evidently $\mathcal{OS}_i = [0, Q]$ resulting in a maximal impact of Q. Similarly, if k is even, $k/2$ of the other voters are at 0 and $k/2-1$ are at Q, we have $\mathcal{OS}_i = [0, Q/2]$ resulting in a maximal impact of $Q/2$; one also easily verifies that the impact for even k cannot be larger than $Q/2$.

Comparing the mean and the median rule, we thus find that the minimal impact is always larger under mean rule; the maximal impact is equal under both rules for $k = 2$, and strictly larger under the median rule for $k \geq 3$. While large impacts are possible under the median rule, they require quite special 'polarized' constellations of the votes of the other participants.

2.3.2. Expected Impact of Participation

We turn to the *expected (potential) impact* of an individuals' vote on the social outcome. In general, the expected impact depends on the belief about the distribution of the other votes. However, as already observed above, for the mean rule it only depends on the number of other participants (which is, of course, also uncertain in general). By contrast, for the median rule the expected impact does depend on the precise location of the other votes. It turns out that it can in fact be equal, larger, or smaller than the impact under the mean rule.

Let us consider different symmetric distributions with mean $\frac{Q}{2}$. Under a uniform distribution of $(k-1)$ votes the expected impact under the median rule is identical to that under the mean rule. Indeed,

$$E_{unif}(imp_i) = \frac{Q}{k}. \tag{2.10}$$

The reason is that under a uniform distribution of $(k-1)$ votes the expected distance of two adjacent votes is exactly $\frac{Q}{k}$, and as noted above it is this distance which is relevant for the potential impact under the median rule. To illustrate, consider the following example: $Q = 100$, $(k-1) = 3$, and a uniform distribution of votes at $q_1 = 25$, $q_2 = 50$, and $q_3 = 75$. Under either rule, we obtain the outcome $x(q_{-i}) = 50$. The expected impact of an additional vote q_i under the mean rule is identical to the one under the median rule and equal to $Q/k = 25$ as stated in (2.10); indeed, this is the length of the option set $\mathcal{OS}_i = [37.5, 62.5]$ under both rules.[2]

[2]Observe that by using an appropriate notion of 'uniform distribution' in the discrete case, we do not need to distinguish between even and odd numbers of voters. For instance, the 'uniform distribution' of four votes would correspond to $q_1 = 20$, $q_2 = 40$, $q_3 = 60$ and $q_4 = 80$. The resulting expected potential impact of an additional vote is easily calculated to be equal to $Q/k = 100/5 = 20$ for both rules.

If the other participants' votes are not uniformly distributed, the expected impact under the median rule may be smaller or larger than under the mean rule. For instance, if the other participants' votes are normally distributed around the mean $\frac{Q}{2}$, the expected impact under the median rule is smaller than the expected impact under the mean rule which remains at $\frac{Q}{k}$. The reason is that the *median interval*, i.e. the distance between the vote to the left and the vote to the right of the median is smaller than $\frac{Q}{k}$ in expectation under a normal distribution. By contrast, an analogous argument shows that the expected impact under the median rule is larger than $\frac{Q}{k}$ for a (symmetric) bi-modal distribution, see Figure 1 which shows the probability density functions for a uniform, normal and bimodal distribution, respectively. Observe that, while the mean and median outcomes are equal to $Q/2$ for all symmetric vote distributions, the expected impact of an additional vote under the median rule differs in general.

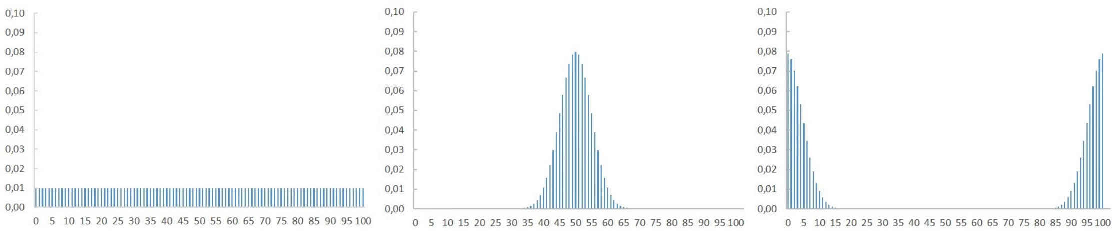
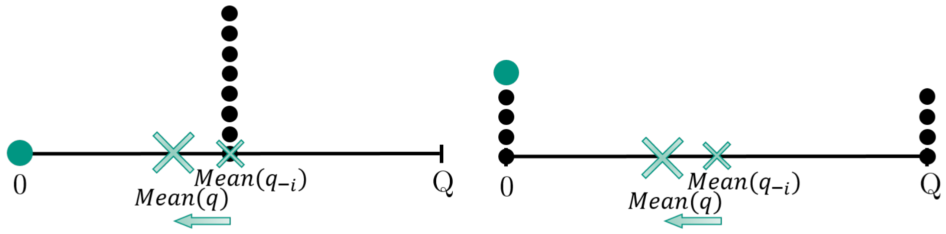


Figure 1: Probability density functions of votes (uniform, normal, bi-modal)

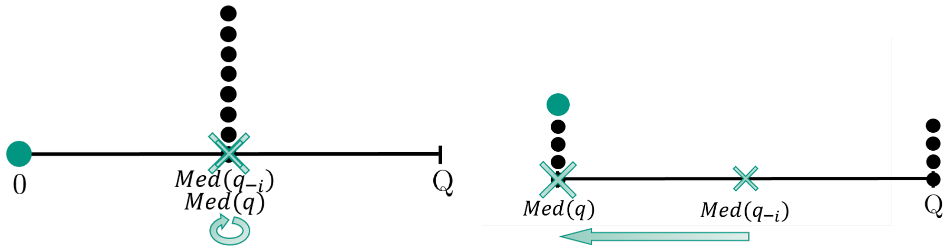
For further illustration, consider Figures 2 and 3 which show examples with $k = 9$ voters. Specifically, we have a set of eight voters, represented by the black circles, that either all vote for the allocation of $\frac{Q}{2}$ (Figures 2a and 3a), or they split equally between 0 and Q (Figures 2b and 3b). These examples can be understood as extreme cases of a normal distribution (with zero variance) and of a bi-modal distribution. Under both rules, the outcome is identical and denoted by $Mean(q_{-i})$ and $Med(q_{-i})$, respectively. The green circle displays the vote of participant i, which is $q_i = 0$ in all cases. (A vote $q_i = Q$ would yield symmetric results.) The mean outcome including voter i is denoted by $Mean(q)$, and according to our observations above the impact of i's vote under the mean rule does not depend on the distribution of the q_{-i}, see Figures 2a and 2b. By contrast, under the median rule the impact is zero in Figure 3a and equal to Q in Figure 3b.

Summarizing, the impact under the mean rule is small for large k but certain, while the (expected) impact under the median rule can be smaller, equal to, or larger than that of the mean rule. In any case, the variance of the (expected) impact under the median rule is larger than zero. We therefore hypothesized that risk averse, resp. ambiguity averse, individuals would tend to participate less under the median rule as compared to the mean rule. In order to test this and related hypotheses, we conducted the field experiment described in the remainder of this paper.



(a) Mean rule: impact (1) (b) Mean rule: impact (2)

Figure 2: Impact of vote q_i under the mean rule



(a) Median rule: no impact (b) Median rule: high impact

Figure 3: Impact of vote q_i under the median rule

3. The Field Experiment

The field experiment was conducted at the Karlsruhe Institute of Technology. We set up a vote over the allocation of a donation on two campus projects using either the mean or the median rule. Our main focus are the participation rate and the role of the impact of a vote under both voting rules. Subsequent to the vote, we implemented a survey in order to elicit beliefs about the allocation result, about the participation rate and about the impact on the social outcome. Additionally, we asked for strategic voting behavior and elicited risk preferences.

3.1. General Setup and Design

The field experiment went on for one week in July 2017 at the Karlsruhe Institute of Technology. We invited 510 subjects to participate in a vote over the allocation of a donation on two campus projects: the *bike workshop* (an assisted workshop which provides tools, help and space for students that would like to repair their bike) and the *campus garden* (the possibility to grow plants, cultivate and harvest fruits and vegetables). Both projects are on campus and accessible free of charge for all students. We assessed wide interest among the students for these projects and made sure that the implementation could be realized by the General Students' Committee (AStA) for every possible outcome. Pictures of the projects can be found in Appendix A.

We randomized subjects using the HROOT subject pool (Bock et al., 2014) of the KD2Lab at Karlsruhe Institute of Technology. Our randomly selected pool consists of 510 subjects which were divided into 30 groups of 17 members each. The subjects received an invitation to participate in the voting process via e-mail on July 11th, 2017. Each group voted over the allocation of 100 Euros on the two projects. We use a between-subjects design with the treatment variable voting rule: 255 subjects were randomly assigned to the mean rule, and 255 to the median rule. In the e-mail subjects were informed that they belonged to a group with 16 other persons who were also invited to vote over the allocation of 100 Euros on the bike workshop and the campus garden. We explained the voting rule (mean or median) and the requirements for a valid vote. Subjects were also informed that other groups would vote in a similar fashion over the allocation of another 100 Euros, and that for an implementation of the group outcome at least one vote within the group is necessary. Together with the remark that no individual payments to the voters will be made followed the link to submit one's vote.

The vote for an allocation on the two projects was accompanied with a short questionnaire. The questionnaire asked for information on the individual beliefs regarding the allocation result, the number of participants in each group and the degree of the impact of their vote. We further asked if the voting rule was well understood, and if the participants revealed their true preferred allocation. Besides, we asked for demographic data and elicited risk preferences. In Appendix B, we provide the e-mail that subjects received under both treatments. Screenshots of the voting process and the questionnaire can also be found in the appendix (see C and D).

3.2. Eliciting Impact Beliefs and Risk Preferences

When comparing the mean and median rule for relatively small groups, we hypothesize that differences in participation rates be driven by different beliefs about how participation affects the social outcome. We capture these beliefs in various ways.

We asked the participants directly to assess the impact of their vote. For this, we asked them to choose one out of six qualitatively described impact categories, ranging from 'my vote does not have any impact' to 'my vote is decisive for the outcome'. These categories are certainly open to individual interpretation but arguably this represents a suitable way to elicit impact beliefs directly.

The indirect way of eliciting beliefs on the impact of one's vote is to ask participants about their belief on the social outcome and the number of participants in their respective group. When a subject gives an estimation on the social outcome, we may calculate the distance between this allocation and the individual vote. However, it is not clear how to interpret the distance between the belief about the social outcome and the own vote. Consider a case in which both values are identical. It might mean that this voter believes that his or her vote is decisive, and thus the impact belief of his or her vote is large since the vote determines the outcome. Thus, the closer the outcome belief and the own vote, the higher might a participant's belief on the impact her or his vote has on the outcome. But it is also possible that an equality of vote and outcome belief comes from the belief that the subject's vote would not change the outcome at all. In this case, the belief about the own impact would be minimal.

Another indirect indication of the belief about the impact of one's own vote is the belief about the number of participants in the group. For the mean rule, the impact strictly decreases with the number of voters, and also under the median rule the possibilities for affecting the outcome are higher if the number of participating voters is low.

Since we expected that differences in participation rates can be traced back to risk attitudes via impact beliefs, we also elicited risk preferences. Charness et al. (2013) present and evaluate several methods for eliciting risk preferences in experiments. The authors argue that simple methods are especially suitable for capturing treatment effects, which is the aim of our study. We elicit risk preferences using the Eckel and Grossman (2002) method, where subjects have to choose one out of a series of lotteries. We adapt the values of the original gambles as suggested by Dave et al. (2010). Dave et al. (2010) let participants choose between six lotteries, each involving a high and a low payoff with equal probability of 50%. Table 1 presents the lottery choices. Lottery 1 represents a secure option as subjects receive a payoff of 28$ for sure.[3] Expected payoffs increase together with the risk level from lottery 1 to lottery 5. Lottery 5 represents risk-neutrality as it comes with the highest expected return combined with a lower standard deviation as compared to lottery 6, which implies risk-seeking behavior.

	Low Payoff	**High Payoff**	**Exp. Return**	**S.D.**
Lottery 1	28	28	28	0
Lottery 2	24	36	30	6
Lottery 3	20	44	32	12
Lottery 4	16	52	34	18
Lottery 5	12	60	36	24
Lottery 6	2	70	36	34

Table 1: Lottery choices from Dave et al. (2010)

Reynaud and Couture (2012) perform a field experiment and compare the Eckel and Grossman method to the well-known elicitation method of Holt and Laury (2002). They perform a non-incentivized field experiment and find that while there exist differences among elicitation methods, the risk attitudes are significantly correlated across the different lottery tasks. The main advantage of the Eckel and Grossman method for our purposes is that by letting individuals choose only one lottery, we exclude inconsistent decisions like subjects switching lotteries in the Holt and Laury method. Moreover, the Eckel and Grossman task is simpler and the explanation can be done faster. One should keep in mind that subjects participated in the vote on a voluntary basis and we wanted to keep the questionnaire as short as possible.

3.3. Hypotheses

While we have shown above that the (expected) potential impact on the social outcome can be larger under the median rule than under the mean rule, its quantification is much

[3] We adapt the currency from $ to Euros in our experiment but otherwise stick to the same values.

more involved under the median rule. By contrast, the impact under the mean rule is easy to understand; moreover, it only depends on the number of participants and not on the distribution of the other participants' votes. Therefore, we expected that subjects overestimate the impact their vote would have under the mean rule as compared to the median rule.

Hypothesis (H1). ***The belief about the real impact is higher under the mean rule as compared to the median rule.***

Hypothesis H1 is further backed up by the following consideration. Ex-post, every voter's vote is pivotal for the outcome under the mean rule; by contrast, under the median rule no participant is pivotal except one (the median voter if the number of participants is odd), or possibly two (the two middle voters if the number of participants is even). Thus, also from the perspective of *how many* participants are pivotal (ex-post), the mean rule fares better than the median rule.

In light of the greater variance of the expected potential impact under the median rule, we also expected that there is a *selection effect* in the set of participants under the two rules. Indeed, for risk-averse individuals the probability of participation under the median rule might be lower precisely because the impact of one's vote is 'more uncertain' under the median rule than under the mean rule. We therefore hypothesized:

Hypothesis (H2). ***Participants are more risk averse in mean voting as compared to median voting.***

Based on H1 and H2, together with standard assumptions about individual preferences, in particular about the widespread trait of risk aversion (e.g. Holt and Laury, 2002), we expect that the voter turnout under the mean rule is higher as compared to the median rule.

Hypothesis (H3). ***The actual number of participants is higher under the mean rule as compared to the median rule.***

Our last hypothesis does not address voter turnout but the structure of the actual votes. It is well-known that under the mean rule (in a complete information setting) the unique Nash equilibrium of the voting game with a fixed number of participants prescribes all but possibly one participant to vote for one of the extreme options, i.e. 0 or Q (Renault and Trannoy, 2005; Block, 2014). By contrast, as is also well-known, truth-telling is a weakly dominant strategy under the median rule. The 'game' that our subjects played is of course different in two important respects: first, it took place under conditions of incomplete information, and secondly it involved not only a voting but also a participation decision. Nevertheless, the qualitative difference of the equilibria of the corresponding voting games (under complete information and a fixed number of participants) made us hypothesize:

Hypothesis (H4). ***The variance of the participants' votes is higher under the mean rule as compared to the median rule.***

The field experiment allows us to test all four hypotheses. The data for H3 and H4 are the direct observations of the voter turnout and the votes of all participants. The data used for H1 and H2 are collected via the subsequent survey filled out by participants.

4. Results

Our main focus in the following is whether there is a difference in the participation rates under the two voting rules, and if so, whether our data on impact beliefs and risk preferences are able to explain it. We also study if subjects voteed optimally given their beliefs.

4.1. Real Impact versus Assessed Impact

For the analysis of the experimental results, we define the *real impact* of a participant's vote as the difference of the actual social outcome and the hypothetical outcome without this voter's participation given the actual distribution of votes for each group, i.e. the absolute difference between $x(q_{-i})$ and $x(q)$. This can be always be calculated because in all groups there were at least two participants. The real impact range over all individuals, i.e. the interval from the lowest to the highest real impact, is $[0, 30]$ under the median rule, the range under the mean rule is $[0.08, 18.33]$, see the box plot in Figure 4. Our observations align well with the theoretical considerations above: the real impact under the mean rule is small but always strictly positive; by contrast, it can be zero under the median rule and has higher variance. The average individual real impact is 4.48 Euros under the mean rule, and the real impact values are significantly lower as compared to the median rule with an average individual real impact of 7.90 Euros (Mann-Whitney U test, $p = 0.018$).

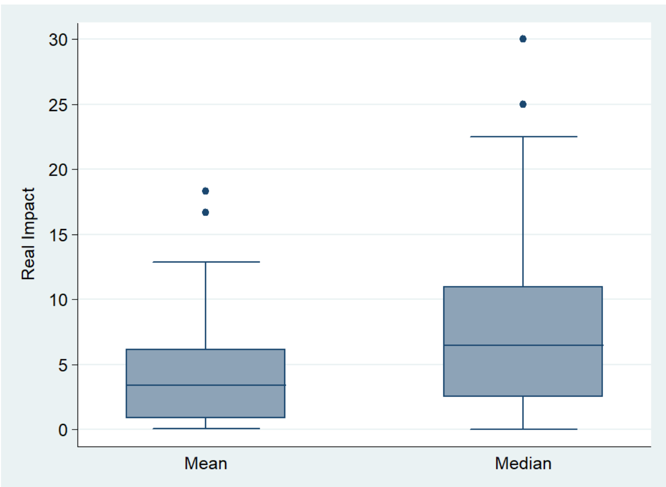


Figure 4: Real impact

Is this significant difference in the real impact, as one could have expected from the theoretical analysis, also reflected in the beliefs of the subjects? We elicited the belief about the impact by letting the participants evaluate their impact in six qualitative categories. The categories range from ‘my vote has no impact on the social outcome’ to ‘my vote is decisive’. The share of participants that chose the respective categories is displayed in Figure 5.

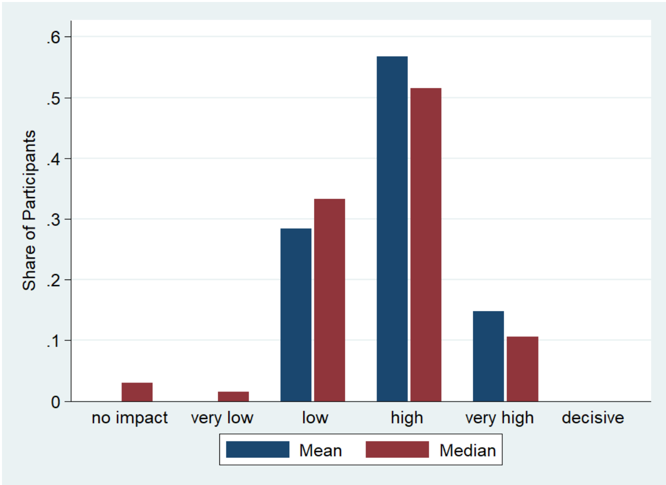


Figure 5: Belief about impact

Figure 5 indicates a slightly higher belief about the impact for mean rule participants, but the difference is in fact not statistically significant; in particular, our data do not support Hypothesis H1 (Mann-Whitney U test, $p = 0.159$).

Figure 6 plots the belief about the impact against the real impact for each participant. Each participant is represented by a bubble, larger bubbles represent several subjects. We classify the real impact values into six categories, indicated by the blue frames in Fig. 6: ‘No impact’ corresponds to an impact of 0 Euros, ‘very low’ is classified as an alteration of the outcome by more than 0 and up to 5 Euros, and so on; ‘decisive’ is classified as an alteration by more than 20 Euros (recall that the highest value of the real impact was 30). Participants whose belief matched their real impact (given our classification) are situated within the blue areas and make for 12.16% of mean and 18.18% of median rule participants. Very few subjects underestimated their real impact under the mean rule (6.76%), a somewhat higher share did so under the median rule (18.18%) (these are represented by the bubbles to the top-left of the blue areas). An overestimation occurs for 81.08% of the participants under the mean and for 63.64% under median rule (the bubbles below the blue areas). We find that the differences in proportions of over- and underestimation are significant (two-sample test of proportions, $p = 0.019$ for underestimation, $p = 0.010$ for overestimation); but clearly, these figures depend on the chosen classification.

We elicited beliefs about the impact also indirectly by asking the participants about their belief about the allocation result. Figure 7 plots this against the impact beliefs. The horizontal axis shows the classification of the impact belief, while the vertical axis notes

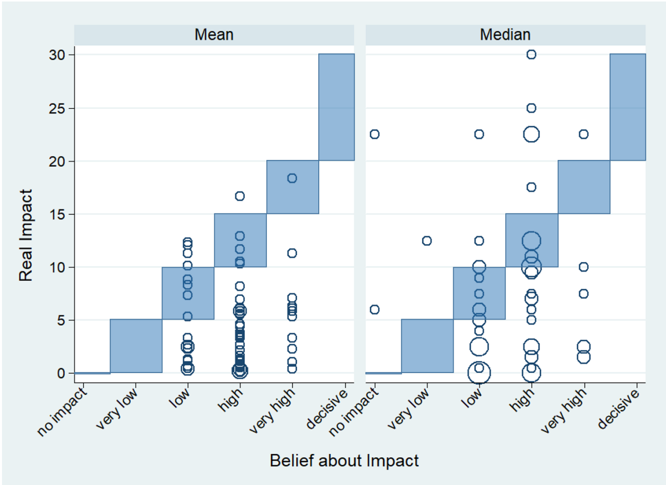


Figure 6: Belief about impact vs. real impact

the distance between the actual vote and the belief about the result of the respective participant (again represented by a bubble). We additionally draw the regression line and find that there is no correlation. It is remarkable that some subjects believe to have had a very high impact when asked directly, and at the same time indicate that they believe the group result will differ from their own vote by more than 30 Euros.

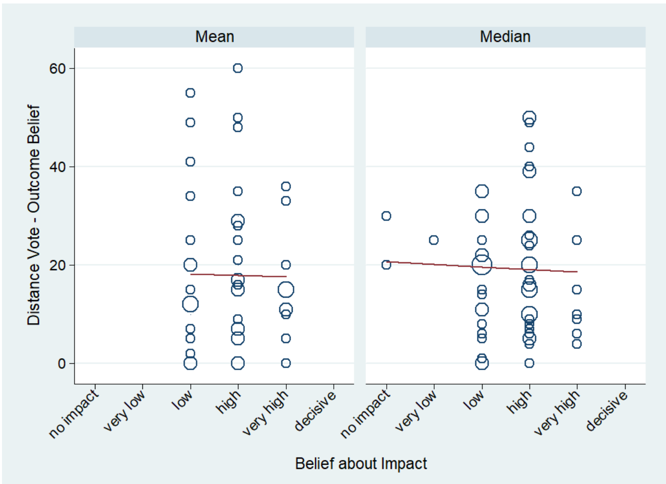


Figure 7: Measures of impact belief

We also examine gender differences in impact beliefs by performing a Mann-Whitney U test on the impact belief depending on gender.[4] We are able to reject the H_0 hypothesis that male and female participants have an equal belief about their impact with $p = 0.034$ in support of the H_1 that the impact belief of men is on average higher as compared to

[4]Two participants did not state their sex, therefore we exclude these observations.

women. Since female participants have on average a lower belief about their impact, we tested in a second step if women also overestimate their impact less frequently. Out of the 102 participants that overestimated their impact, 63 were male and 37 were female. Therefore, the share of male participants that overestimated their impact is 68.48% (63 out of 92), while the share for women was 80.43% (37 out of 46). However, we do not find a significant correlation between overestimation and gender (chi-squared test, $p = 0.138$).

When analyzing the votes separately for male and female participants, we find some interesting differences. While 24 male participants, i.e. 26.09% of all men, voteed for an extreme allocation of either 0, 1, 99 or 100 Euros, the share of female participants that voted extreme is only 8.70% or four women. Building on these differences in the voting behavior, we performed another Mann-Whitney U test to compare the real impact dependent on gender, and find indeed that the real impact of male participants is on average significantly higher as compared to the real impact of women ($p = 0.026$).

Considering the high shares of overestimation of the real impact, the question arises if these high beliefs are driven by an underestimation of the number of participants (which is negatively correlated with impact for both rules). In both treatments subjects believed on average that the number of participants per group is 8.8 (no difference, two-sample t-test, $p = 0.966$). This means that the share of participants that overestimated the number of participants as compared to the real number of participants is 84.85% in the median (with a true group average participation rate of 4.4), and 74.32% in the mean groups (with a true average of 4.9 participants).

If one measures the belief about impact indirectly by the belief about the number of participants, most subjects underestimate this impact, since the belief about the number of participants is higher than the actual number of participants. Therefore, participants overestimate their real impact directly (as inferred from Fig 6) and at the same time overestimate the number of participants. Figure 8 gives an insight of the indicated beliefs about the impact in combination with the beliefs about the number of other participants per group. Remarkably, the red regression line has a positive slope in the mean treatment; the correlation between the belief about the number of participants and the belief about one's own vote impact is 0.188 (Spearman correlation, $p = 0.109$). Since the actual impact of participation under the mean rule is negatively correlated with the number of participants, subjects display inconsistent beliefs under the mean rule. Under the median rule, the correlation is slightly negative (-0.072) so that we do not find the same inconsistency in beliefs for the median rule (Spearman correlation, $p = 0.566$).

4.2. Risk Preferences

Since we only have the survey data for the subjects who completed the questionnaire, the following analysis refers to these subjects only. We elicited risk preferences using the Eckel and Grossman (2002) method with the values shown in Table 1 above. Figure 9a displays for each of the six lotteries the share of participants by voting rule. The average lottery number per individual is 3.64 under the mean rule and slightly higher under the

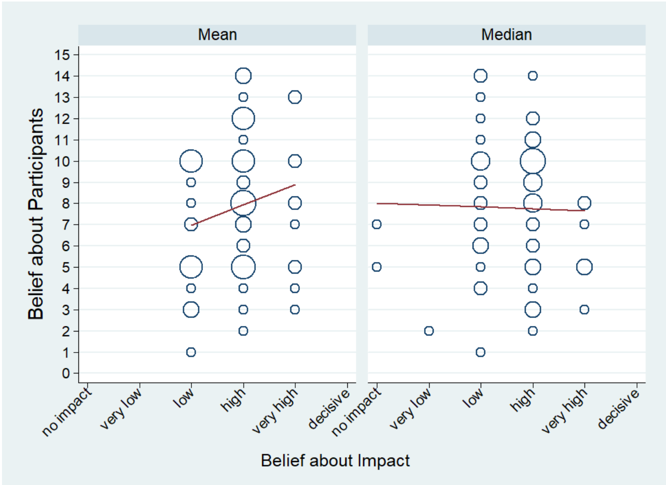
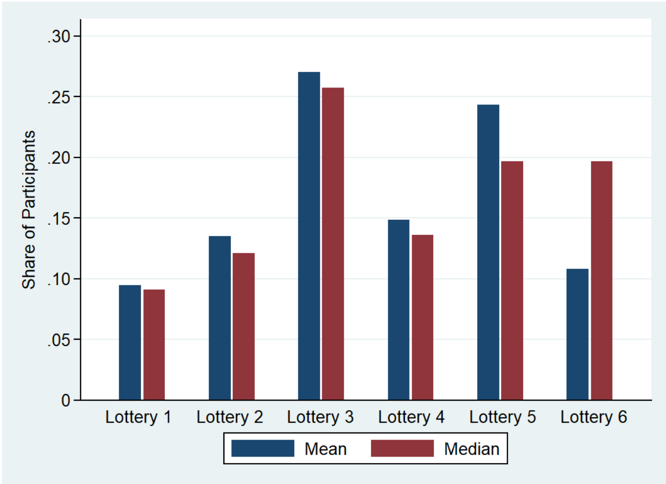


Figure 8: Belief about impact vs. belief about participants

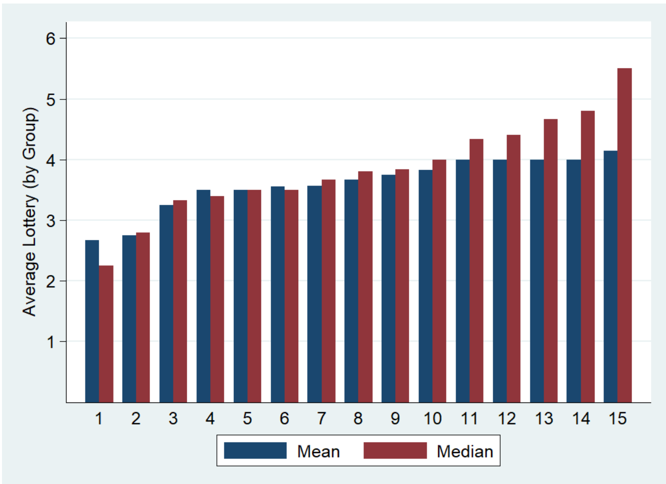
median rule, where the average lottery is 3.82. Both values indicate risk aversion at the individual level, since the average is below lottery 4, which among the risk averse lotteries is the one with the highest expected return and the highest standard deviation. At the individual level, we however do not find a significant difference between the two rules (two-sample t-test, $p = 0.485$). Thus, our individual data do not support Hypothesis H2.

We label the six lotteries by corresponding values from 1 to 6 and run a regression of the chosen lottery on a set of independent variables. The results are displayed in Table 2, and again we see that the voting rule (the relevant coefficient is 'rulemean', which takes the value 1 for the mean rule and 0 for the median rule) is negative but not significantly so. Interestingly, we find a highly significant and positive coefficient for the dummy variable 'gendermale', which takes the value 1 if the participant is male and 0 for female participants.

In order to further analyze gender differences, we perform a two-sample t-test for the individual risk attitudes of male vs. female participants. We are able to reject the H_0 hypothesis that there is no difference in the risk preference between men and women (independent of the voting rule) at a p-value below 1%, and find support for the H_1: the average risk preference level is lower under female as compared to male participants (on average 2.98 vs. 4.09). Since we do find a gender difference regarding the risk preferences, our next question is if the share of female participants under the two voting rules is different. As argued above, risk averse subjects could be assumed to prefer the sure impact under the mean rule, and the higher degree of risk aversion by women would therefore predict a higher female participation rate in mean voting as compared to median voting. The overall share of female participants was 33.33% and splits up into 35.14% under the mean rule and 31.25% under the median rule. Our overall subject pool (participants and non-participants) consisted of 91 women under the mean and 92 under the median rule. The adjusted share of female participants out of all female subjects is therefore 28.57% for the mean rule and 21.74% for the median rule, which makes an



(a) Shares by lottery



(b) Average lottery, by group (increasing)

Figure 9: Risk preferences

even higher difference. Nevertheless, we do not find that the difference in participation rates by gender is statistically significant (chi-squared test, $p = 0.381$).

VARIABLES	lottery
rulemean	-0.0985
	(0.256)
extremevote	0.0138
	(0.336)
partbelief	0.0135
	(0.0403)
man	0.574
	(0.494)
impactbelief	-0.127
	(0.176)
gendermale	1.113***
	(0.275)
Constant	3.230***
	(0.580)
Observations	138
R-squared	0.130

Standard errors in parentheses
*** p <0.01, ** p <0.05, * p <0.1

Table 2: Regression results risk preferences

4.3. Voter Turnout

Out of the $n = 510$ subjects that were invited, $k = 140$ participated and completed the entire voting process. Further 21 subjects visited the survey platform but did not complete the form. The 140 participants split up into the two treatments: 74 subjects participated under the mean rule and 66 under the median rule. The overall participation rate was quite high with 29.0% and 25.9%, yielding 4.9 participants on average per group under the mean and 4.4 under the median rule. There were at least two participants in each group and a maximum number of nine participants, which occurred under the mean rule. Figure 10a presents a boxplot containing the number of participants per group. The median number of participants per group is four under the mean and five under the median rule. The detailed number of participants by voting rule and groups is displayed in Figure 10b, ordered by increasing number of participants. As one can see in the two figures, the spread of participation rates is higher under the mean rule. In six of the ordered groups, the number of participants under the mean rule exceeds the one under the median rule; the opposite is true for only two groups. We do find support for the hypothesis that the variance of mean rule participation is higher as compared to participation under the median rule groups (variance ratio test, $p = 0.046$).

In order to test our Hypothesis H3, we run a regression of the dichotomous variable 'participation' on a dummy variable for the voting rule and gender. These are the only independent variables that we have for participants and abstainers, as the subject pool contains information on gender and the voting rule was assigned by us. The regression results are displayed in Table 3. The coefficient for 'rulemean', which takes the value 1 for the mean rule and 0 for the median rule, is $\beta_1 = 0.0370$; the positive value indicates that the voter turnout is higher for the mean rule. However, we cannot reject the null hypothesis that the deviation is significantly different from zero. The same is true for the coefficient of the gender dummy variable, indicating that male subjects have a higher participation rate, yet the difference is not significant.

VARIABLES	participation
rulemean	0.0370
	(0.0395)
gendermale	0.0314
	(0.0412)
Constant	0.233***
	(0.0384)
Observations	508
R-squared	0.003

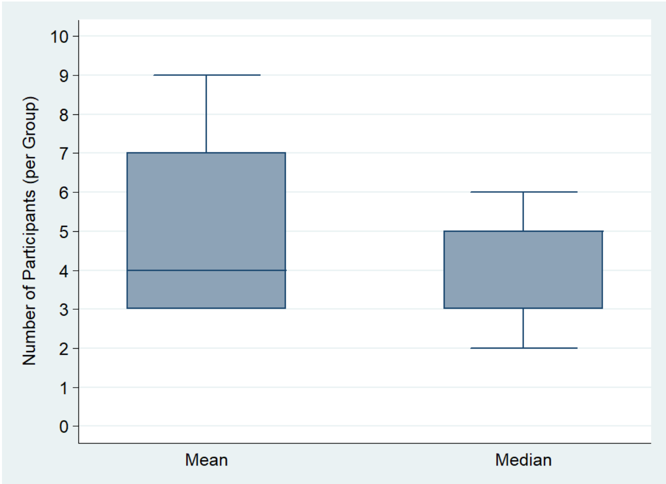
Standard errors in parentheses
*** p <0.01, ** p <0.05, * p <0.1

Table 3: Regression results participation

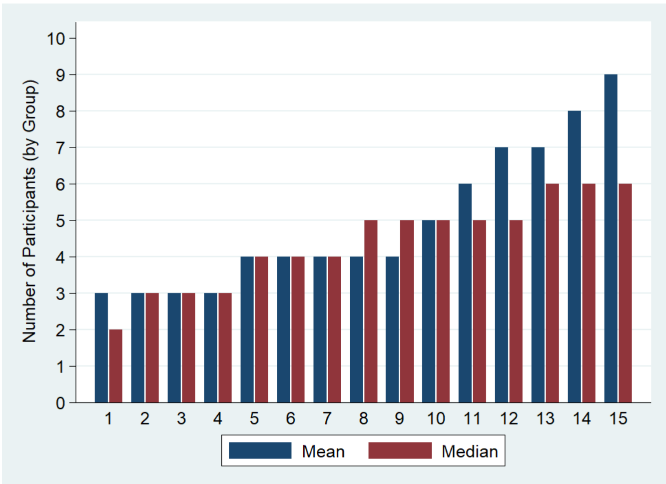
We additionally consider the aggregated group values for participation and perform a Mann-Whitney U test. The rank sum of the average group participation rate is higher under the mean rule, but the difference is also not statistically significant ($p = 0.735$). Our data thus do not support our Hypothesis H3; indeed, we do not find evidence for different numbers of participants among the two rules. This result has to be considered with some cautioun, however. The number of groups that we compare is limited to fifteen and the average participation rates per group differ in only eight cases.

4.4. Distribution of Votes

The factual distribution of votes is displayed in Figure 11a. The horizontal axis shows the votes for the bike workshop in Euros. The vertical axis ('share of votes') represents the percentage of participants that voted for the respective amount. The overall distribution shows the highest percentage at 100 Euros, indicating the preference to allocate all the money on the bike workshop. Further remarkable values are those close to a $(70, 30)$ split as well as the symmetric $(30, 70)$, indicating the existence of reference points besides the



(a) Boxplot of participants



(b) Participants by group (increasing)

Figure 10: Average number of participants

extreme allocations or the equal split, which only two participants under the median rule and three under the mean rule voted for. We do not find a significant difference across the rules in the votes themselves (Mann-Whitney U test, $p = 0.680$), in the distribution of votes (two-sample Kolmogorov-Smirnov test, $p = 0.830$), nor in the variance of votes (variance ratio test, $p = 0.553$). A boxplot of the votes for the bike workshop by rules is shown in Figure 11b.

These results imply that Hypothesis H4 is not supported either; in fact, we do not find that the variance of votes is higher under the mean rule. This is an indication that participants did not vote strategically under the mean rule, for which extreme voting (i.e. $q_i = 0$ or $q_i = Q$) is almost always optimal.[5] In the light of the lab experiments of Block (2014); Rollmann (2020); Puppe and Rollmann (2021) this is a particularly remarkable finding; indeed, in the lab situation we consistently find strategic behavior under the mean rule even in situations of incomplete information. Our present results thus suggest that in a voting context the natural environment of field experiments plays an important role and is crucial for the behavior of subjects. To identify the confounding effects in the field as compared to the more tightly controlled lab situation seems an important task for future research.

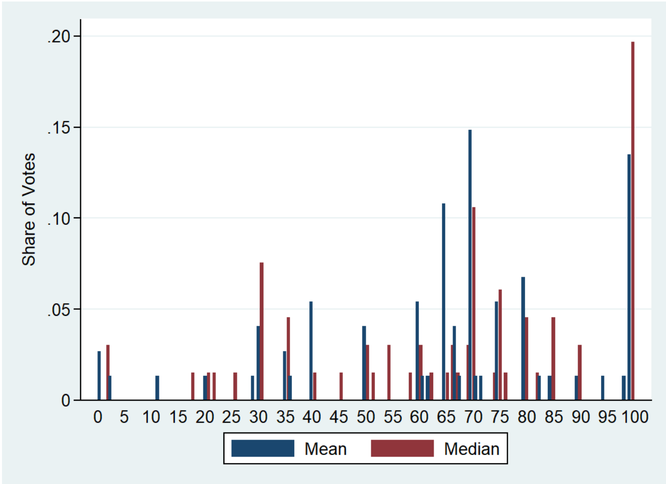
Also observe that since the distribution of votes did not differ significantly among the voting rules, we can also conclude that the difference that we found in the real impact is not driven by differences in the distribution of votes.

4.5. Allocation Outcomes

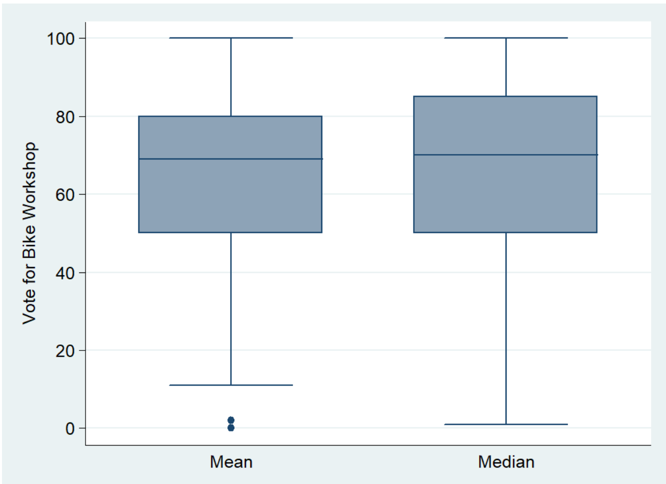
We also do not find a significant difference in the group allocation results across the two voting rules (two-sample t test, $p = 0.227$). The allocation result (*bike*, *garden*) is on average (64.97,35.03) under the mean rule and (70.47,29.53) under the median rule. Figure 12a shows a boxplot of the allocation results by rule. Though the group results are not significantly different, we do observe a greater spread in the group results under the median rule, where one group result was to donate the total budget of 100 Euros to the bike workshop project. In this group, three subjects participated and the vector of votes was $q = (85, 100, 100)$. Also, only under the median rule the social outcome was once below 50 Euros for the bike workshop. The greater variance in the group allocation results under median voting is statistically significant (variance ratio test, $p = 0.021$). The total donation for the bike workshop adds up to 2,031.60 Euros and for the campus garden to 968.40 Euros.

We also asked for the belief about the allocation result, which is slightly more balanced as compared to the actual result: $(62.10, 37.90)$ is the average belief under the mean and $(62.87, 37.13)$ under the median rule. We do not find a significant difference in the belief about the allocation result across voting rules (two-sample t-test, $p = 0.786$). Interestingly, we do find a significant difference in the correct belief about the result (two-sample t-test, $p = 0.019$). Specifically, we calculated the difference between the

[5] Observe that the optimality of extreme voting for almost all voters under the mean rule carries over to an incomplete information setting for all Bayesian rational players. This is because an interior vote $\tilde{q}_i \in (0, Q)$ can only be optimal under the mean rule if the social outcome is exactly at $\tilde{q}_i$.

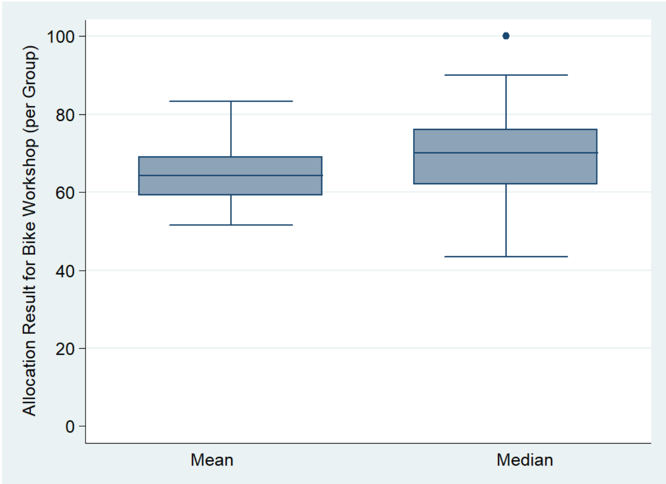


(a) Distribution of votes

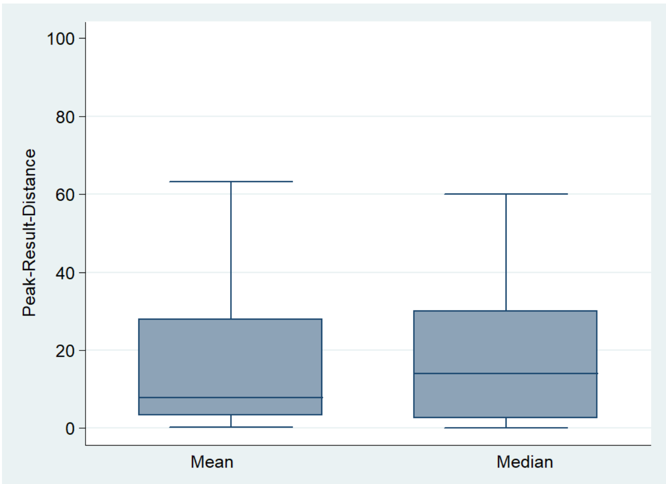


(b) Boxplot of votes

Figure 11: Votes for bike workshop



(a) Allocation results for bike workshop



(b) Distance between peak and result

Figure 12: Allocation results and distance to peaks

Figure 13: Belief about result vs. real result

belief about the result and the real result and find that the average difference under the mean rule is -2.08, as compared to -7.08 under the median rule. The negative sign indicates that participants under both rules believed that the result for the bike workshop is lower than it really was, i.e. on average they underestimated the share for the bike workshop, or in other words, they believed that the result was more balanced among the projects. We find that the average value for correct estimation is significantly higher under the mean rule, which means that the average of the participants' beliefs is only 2.08 Euros lower as the real result. Under the median rule, the average deviation from the real result is 7.08 Euros. Figure 13 plots the belief about the result versus the real result. The correlation is positive for both rules (0.061 for the mean rule and 0.467 for the median rule), however the coefficient is significant only for the median rule (Spearman correlation, $p = 0.608$ and $p < 0.001$). We find that the difference between the rules is significant (two sample Fisher's z-test, $p = 0.037$).

In order to (roughly) assess welfare under both voting rules, we assume that the votes correspond to the true preference peaks of the participants (which seems well justified in the absence of strategic voting) and calculate for each subject the distance between the peak (vote) and the aggregated group results. Implicitly, we thus also assume that the true underlying preferences are symmetrically single-peaked, and that the costs of participation are identical across subjects. Figure 12b displays the boxplots for the distance between peak and result for both voting rules. We do not find a significant difference in the average distance (two-sample t-test, $p = 0.534$) nor in the variance between both rules (variance ratio test, $p = 0.837$).

4.6. Non-Truthful and Strategic Voting

Clearly, in our field experiment we cannot know the underlying preferences and hence cannot infer if subjects voted truthfully or strategically purely from the observation of their votes. Nevertheless, one can ask them about the motives for their behavior, and that is what we did. Specifically, we asked them if they casted their vote truthfully, and if not about their true peak p_i.

As already noted, under the mean rule the belief about the social outcome is sufficient for deciding where to place one's vote. For instance, if the belief about the social outcome is $Mean(q_{-i}) = 70$ and the most preferred outcome of i $p_i < 70$, submitting a vote $q_i < p_i$ is optimal but of course non-truthful. (Recall that we only list the expenditure for the first project, which is the bike workshop in the present context.) Table 4 lists all participants under the mean rule, that stated to have voted non-truthfully. The share of all votes that are non-truthful (as per the statements of the participants) is 6.76% and rather low (five subjects). Based on the reported true peaks p_i, the beliefs about the social outcome $b_i^{x(q)}$ and about the number of participants $b_i^{(k-1)}$, we calculate a theoretical best response $q_i(b_i^{x(q)}, b_i^{(k-1)})^{(*)}$ for each of the five individuals. After correcting for allocations that are feasible (only natural numbers between zero and 100), we are able to compare the theoretical belief-based best responses $q_i(b_i^{x(q)}, b_i^{(k-1)})^*$ to the actual votes q_i. Two individuals submited a vote that corresponds to the best response ($q_i = q_i(b_i^{x(q)}, b_i^{(k-1)})^*$), which implies that these votes are not only strategic but also optimal given the beliefs. Two further votes were very close to the best response and therefore strategic, as they deviate from the true peak and decrease the distance to the social outcome belief. The one individual that places a 'non-strategic' vote according to the beliefs argued that he could not find a reason why his peak should be different from the equal split ("I don't find an argument why one project should be better for the community than the other"). Nevertheless, he voted for more budget on the project that seemed more useful personally ("I will probably never use the campus garden").[6] This argumentation puts the vote into perspective and makes it in some way strategic as well, as it seems that the indicated peak was based on the benefit for the community.

p_i	$b_i^{x(q)}$	$b_i^{(k-1)}$	$b_i^{x(q_{-i})}$	$q_i(b_i^{x(q)}, b_i^{(k-1)})^{(*)}$	$q_i(b_i^{x(q)}, b_i^{(k-1)})^*$	q_i
85	51	10	46.10	435.10	100	100
80	64	5	56.80	172.80	100	100
60	60	10	58.00	78.00	78	80
50	50	8	56.20	6.25	6	0
50	70	8	68.75	-81.25	0	80

Table 4: Non-truthful voting, mean rule

Table 5 summarizes the corresponding data for the six participants that stated to have cast a non-truthful vote under the median rule. The share of non-truthful votes is 9.10% and, surprisingly, higher than under the mean rule. Beneficial strategic voting under the median rule (and single-peaked preferences) is possible only for an even number of participants and only if the corresponding peak is one of the two in the middle. With the beliefs about the social outcome and the true peak, we get a hint on whether participants

[6]The original statements are in German.

vote strategically according to their beliefs. As strategic voting is not possible for an odd number of voters, the best response given that $b_i^{(k-1)}$ is even is a vote that is at least as high as the belief about the median outcome $b_i^{x(q)}$ if $p_i > b_i^{x(q)}$, or at most as high as $b_i^{x(q)}$ if $p_i < b_i^{x(q)}$. The three individuals that believe $(k-1)$ to be even play a best response given their beliefs, but the belief-based distance between their peak and the social outcome is not reduced. If a voter believes that the social outcome is identical to the peak, then the best response according to this belief is not necessarily distinct. It depends on the belief about the distribution of votes, more precisely, on whether or not the voter believes to be the unique median voter. Voting for the true most preferred allocation is optimal given the belief to be the unique median voter. Otherwise, deviation from the true peak might not change the social outcome because the median vote is chosen also by other voters and thus the optimal vote regarding this belief might be any feasible allocation. Nevertheless, truth-telling is still a weakly dominant strategy if the (belief about the) total number of voters is odd. As can be inferred from Table 5, none of the voters that voted non-truthfully and had the belief that $(k-1)$ is even in addition believed that the social outcome corresponds to the own peak.

p_i	$b_i^{x(q)}$	$b_i^{(k-1)}$	$q_i(b_i^{x(q)}, b_i^{(k-1)})^*$	q_i
85	75	10	≥ 75	100
78	61	11	?	62
70	60	8	≥ 60	85
50	50	3	?	35
30	40	14	≤ 40	1
26	66	9	?	17

Table 5: Non-truthful voting, median rule

If $(k-1)$ is odd, the median is determined by the mean of the two middle votes and strategic voting may be possible. However, the optimal votes can also be calculated under information about the precise distribution of votes. Since we did not elicit beliefs about the distribution, a closer look into the statements of the participants is useful. One individual stated that his vote should not be suppressed by the other votes, which hints on a willingness to give up the possibility of strategic voting and thereby casting the winning vote. By submitting a vote that allocated little money to the bike workshop, one participant argued that he wanted to give the garden supporters the possibility that their votes influenced the social outcome: "Only few participants will vote for the extremes to make sure that the median is centered. My extreme position will give the garden supporters the necessary room for a high median." In order to evaluate if these votes are to be classified as 'strategic,' a more detailed elicitation of beliefs would have been necessary. For instance, one participant submitted a non-truthful vote and believed that the social outcome will be equal to her peak ($p_i = b_i^{x(q)} = 50$). This might suggest that the submitted vote was strategic given her beliefs, but we cannot be sure.

5. Conclusion

Instead of providing a comprehensive summary, let us conclude by highlight the following two findings. First, it appears that voting over a one-dimensional variable is governed by very different principles in the field than in the lab. Secondly, we find much less strategic behavior (under the mean rule) then one could have expected from the results of corresponding lab experiments. We are only at the beginning of understanding the motivations underlying participation and voting decisions in our context, and there is certainly more work to be done. We believe that (controlled) field experiments can contribute significantly to our understanding of voting and participation in elections, and we hope that the present paper might stimulate further work in this direction.

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Appendix

A. The Projects

Figure 14: Bike Workshop and Campus Garden (https://www.asta-kit.de)

B. Voting over Donation Projects at KIT

Mean Treatment

Hello,

The Chair of Economic Theory at KIT would like to invite you to participate in an election. Besides you, **16 other people** have been invited to participate in this election. Your group votes on the allocation of **100 Euro** on two campus projects. For this purpose, each group member can make an individual proposal for the allocation. The result of the election is calculated by the **average** of all allocation proposals, i.e. the sum of the allocation proposals divided by the number of votes cast.
The two projects are a **Bike Workshop** (supervised self-help workshop) and the **Campus Garden** (opportunity to grow and harvest fruits and vegetables). Your allocation proposal therefore consists of two amounts of money: the amount to be donated to the Bike Workshop and the amount to be donated to the Campus Garden. Both amounts must add up to 100 Euro.
There will be no individual payment. The total amount of 100 Euro will be donated to the two projects according to the voting results. The election is held online and takes about 5 minutes. If you would like to participate in the election, please click here:
`https://www.survio.com/survey/d/d1`
In addition to your group, there are other groups that will vote on the allocation of 100 Euro on the two projects. Every group consists of 17 participants and votes on the usage of 100 Euro each. For the realization of the allocation proposal of each group, at least

one vote per group is required.
The election will run until 17.07.2017. If you are interested in the result of the election, please enter your e-mail address after the election. Your answers will be treated anonymously and cannot be assigned to the e-mail address. Once again, this is the link to the election: `https://www.survio.com/survey/d/d1`

Best regards,

the Chair of Economic Theory of KIT

Median Treatment

The result of the election is calculated by the **median** of all allocation proposals, i.e. the vote that is in the middle position after sorting all votes in ascending order is elected. If the number of votes cast is even, the median is calculated from the mean value of the two middle allocation proposals.

C. The Voting Process

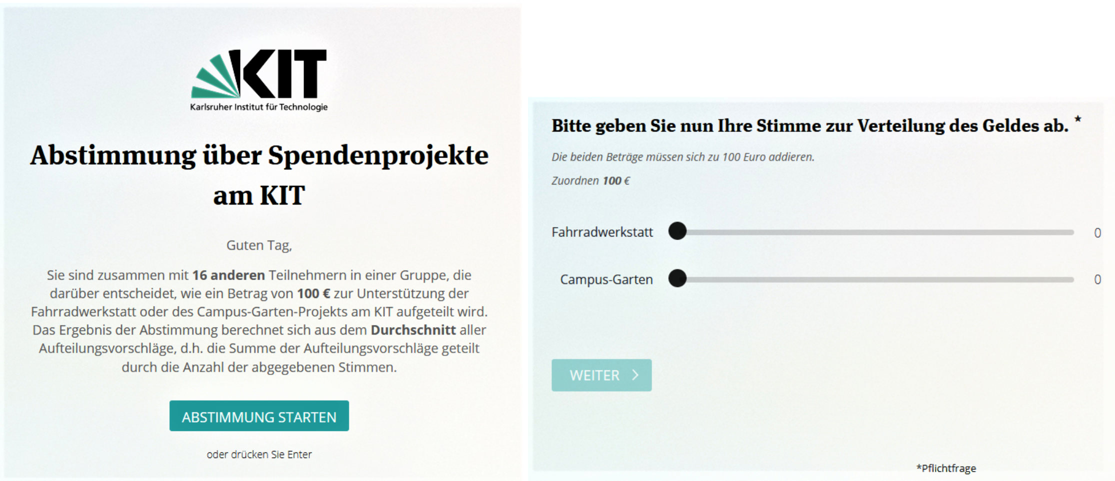
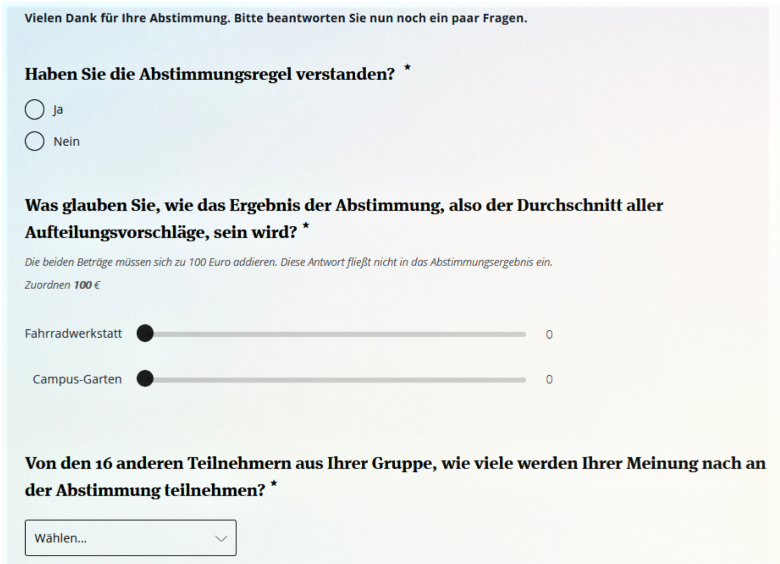


Figure 15: The vote

D. The Questionnaire



Vielen Dank für Ihre Abstimmung. Bitte beantworten Sie nun noch ein paar Fragen.

Haben Sie die Abstimmungsregel verstanden? *

- Ja
- Nein

Was glauben Sie, wie das Ergebnis der Abstimmung, also der Durchschnitt aller Aufteilungsvorschläge, sein wird? *

Die beiden Beträge müssen sich zu 100 Euro addieren. Diese Antwort fließt nicht in das Abstimmungsergebnis ein.

Zuordnen ***100 €***

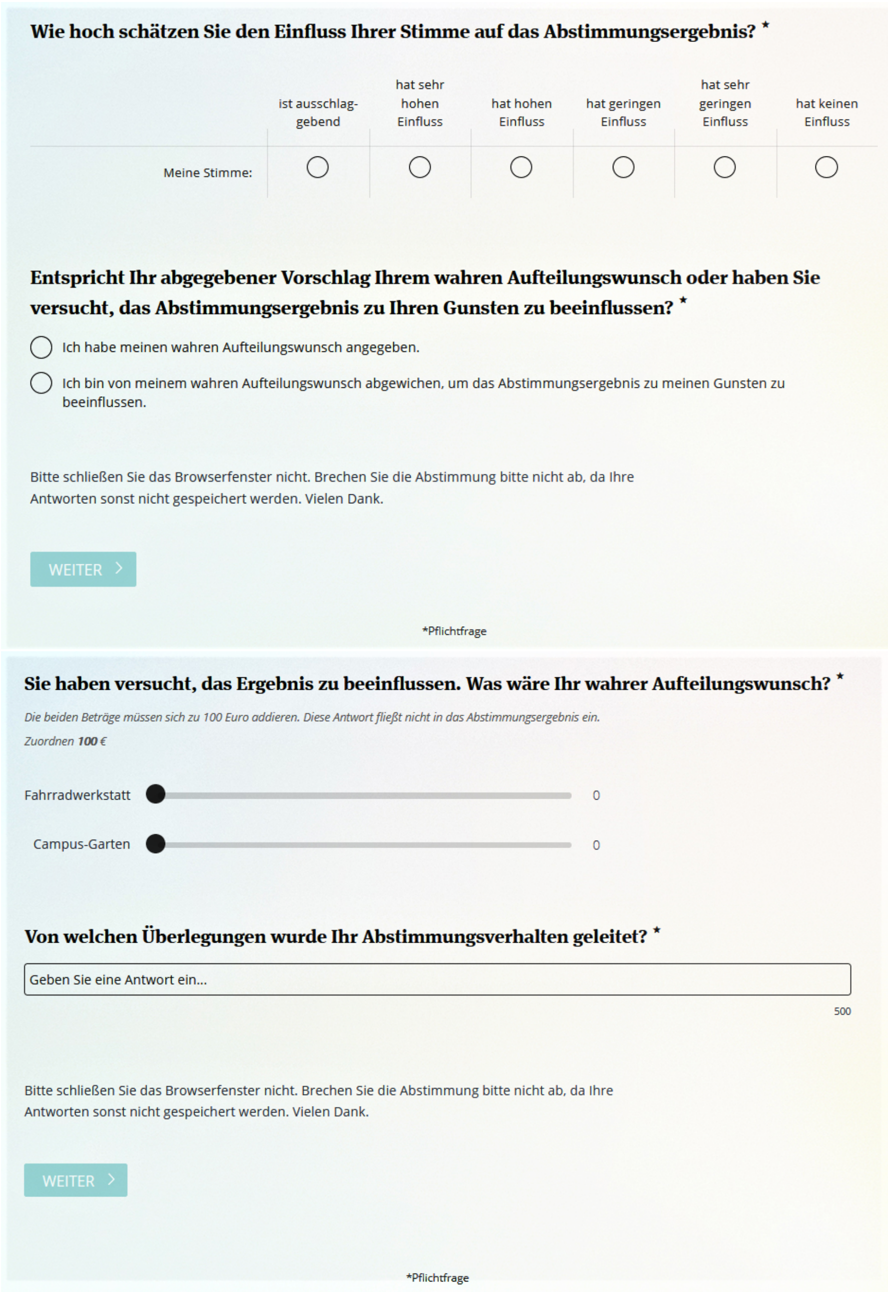
Fahrradwerkstatt 0

Campus-Garten 0

Von den 16 anderen Teilnehmern aus Ihrer Gruppe, wie viele werden Ihrer Meinung nach an der Abstimmung teilnehmen? *

Wählen...

Figure 16: Questions on the vote I



Wie hoch schätzen Sie den Einfluss Ihrer Stimme auf das Abstimmungsergebnis? *

	ist ausschlag-gebend	hat sehr hohen Einfluss	hat hohen Einfluss	hat geringen Einfluss	hat sehr geringen Einfluss	hat keinen Einfluss
Meine Stimme:	○	○	○	○	○	○

Entspricht Ihr abgegebener Vorschlag Ihrem wahren Aufteilungswunsch oder haben Sie versucht, das Abstimmungsergebnis zu Ihren Gunsten zu beeinflussen? *

- ○ Ich habe meinen wahren Aufteilungswunsch angegeben.
- ○ Ich bin von meinem wahren Aufteilungswunsch abgewichen, um das Abstimmungsergebnis zu meinen Gunsten zu beeinflussen.

Bitte schließen Sie das Browserfenster nicht. Brechen Sie die Abstimmung bitte nicht ab, da Ihre Antworten sonst nicht gespeichert werden. Vielen Dank.

WEITER >

*Pflichtfrage

Sie haben versucht, das Ergebnis zu beeinflussen. Was wäre Ihr wahrer Aufteilungswunsch? *

Die beiden Beträge müssen sich zu 100 Euro addieren. Diese Antwort fließt nicht in das Abstimmungsergebnis ein.

*Zuordnen **100 €***

Fahrradwerkstatt 0

Campus-Garten 0

Von welchen Überlegungen wurde Ihr Abstimmungsverhalten geleitet? *

Geben Sie eine Antwort ein...

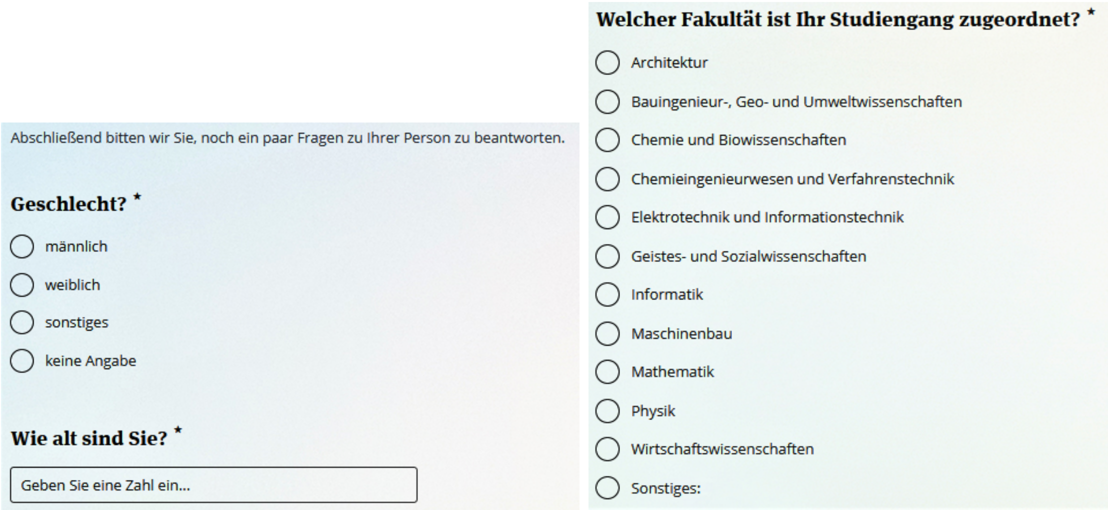
500

Bitte schließen Sie das Browserfenster nicht. Brechen Sie die Abstimmung bitte nicht ab, da Ihre Antworten sonst nicht gespeichert werden. Vielen Dank.

WEITER >

*Pflichtfrage

Figure 17: Questions on the vote II



Abschließend bitten wir Sie, noch ein paar Fragen zu Ihrer Person zu beantworten.

Geschlecht? *

- männlich
- weiblich
- sonstiges
- keine Angabe

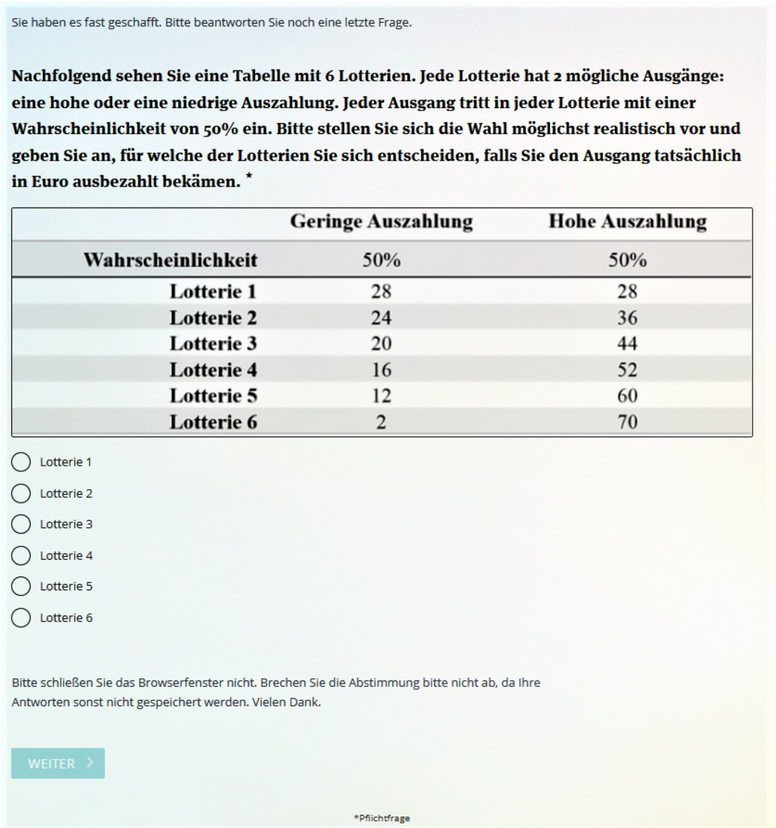
Wie alt sind Sie? *

Geben Sie eine Zahl ein...

Welcher Fakultät ist Ihr Studiengang zugeordnet? *

- Architektur
- Bauingenieur-, Geo- und Umweltwissenschaften
- Chemie und Biowissenschaften
- Chemieingenieurwesen und Verfahrenstechnik
- Elektrotechnik und Informationstechnik
- Geistes- und Sozialwissenschaften
- Informatik
- Maschinenbau
- Mathematik
- Physik
- Wirtschaftswissenschaften
- Sonstiges:

Figure 18: Demographic questions



Sie haben es fast geschafft. Bitte beantworten Sie noch eine letzte Frage.

Nachfolgend sehen Sie eine Tabelle mit 6 Lotterien. Jede Lotterie hat 2 mögliche Ausgänge: eine hohe oder eine niedrige Auszahlung. Jeder Ausgang tritt in jeder Lotterie mit einer Wahrscheinlichkeit von 50% ein. Bitte stellen Sie sich die Wahl möglichst realistisch vor und geben Sie an, für welche der Lotterien Sie sich entscheiden, falls Sie den Ausgang tatsächlich in Euro ausbezahlt bekämen. *

	Geringe Auszahlung	Hohe Auszahlung
Wahrscheinlichkeit	50%	50%
Lotterie 1	28	28
Lotterie 2	24	36
Lotterie 3	20	44
Lotterie 4	16	52
Lotterie 5	12	60
Lotterie 6	2	70

- Lotterie 1
- Lotterie 2
- Lotterie 3
- Lotterie 4
- Lotterie 5
- Lotterie 6

Bitte schließen Sie das Browserfenster nicht. Brechen Sie die Abstimmung bitte nicht ab, da Ihre Antworten sonst nicht gespeichert werden. Vielen Dank.

WEITER >

*Pflichtfrage

Figure 19: Risk preferences

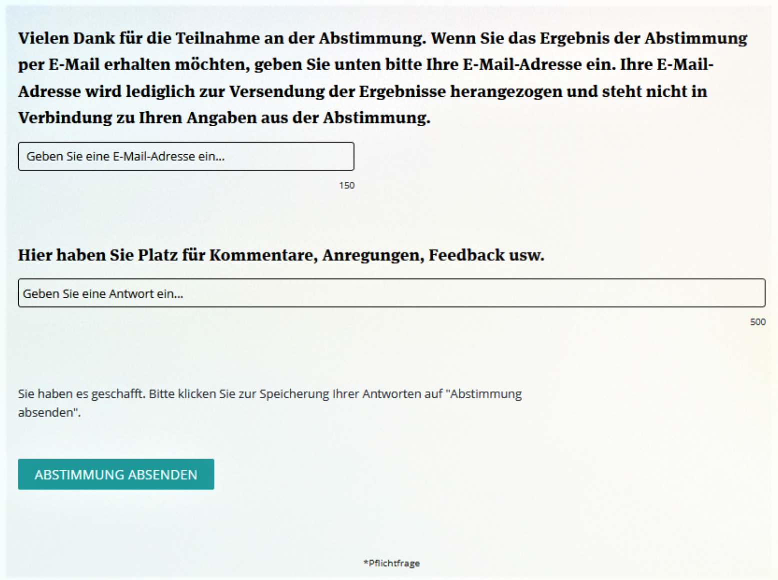


Figure 20: Concluding remarks

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