Voter Motivation and the Quality of Democratic Choice

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Abstract

The efficiency of committee voting and referenda with common-interest issues critically depends on voter motivation, i.e., on voters' willingness to cast an informed vote. If voters are motivated, voting may result in smart choices because of information aggregation but if voters remain ignorant, delegating decision making to an expert may yield better outcomes. We experimentally study a common-interest situation in which we vary voters' information cost and the competence of the expert. We find that voters are more motivated to collect information than predicted by standard theory and that voter motivation is higher when subjects demand to make choices by voting than when voting is imposed on subjects.

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1 Introduction

1.1 Motivation

Committees often make collective choices by voting. When they do, the issue at stake is in many cases one of common interest. Consider, for instance, a faculty meeting with the purpose to decide on changing the rules for the admission of students. Assume that all faculty members have the same interest, namely to uphold the high quality of their program. Then, a majority vote on this issue held at the faculty meeting serves as a device to aggregate dispersed private information on how the envisaged change of regulations will affect program quality. In the spirit of Condorcet's jury theorem, a vote might be the best way to solve this issue if the faculty has private and conditionally uncorrelated (imperfect) information on the issue at hand. However, getting the relevant private information in the first place is costly; faculty members would have to spend time pondering about an administrative issue instead of their research. Thus, each faculty member has an incentive to free-ride on information acquisition or to skip the meeting altogether. As a consequence, there is little information to aggregate and it would be better to delegate the entire decision to an expert, e.g., the dean. Hence, the question arises under which conditions a majority vote is more efficient (in terms of information aggregation and the efficiency of the choice made) than expert delegation when private information is costly.

This question is of interest not only in the organizational but also in the political context. For instance, in Germany referenda are held on the city level on issues like whether or not the city should host the next Olympic Games. The trade-off to be solved by the citizens is then mostly of a cost-benefit type: Will the benefits of the additional jobs and infrastructure created by the next Olympic Games outweigh the costs? Thus, it is reasonable to model at least some of these referenda as votes in a common-interest setting.[2] Similarly, referenda in Switzerland are often on issues that can be viewed as common interest rather than private interest, e.g., on whether commercial banks, in addition to the national bank, should

[2] Common-interest situations prevail when voters agree on the overall goal but are uncertain about the best way to reach that goal. For example, voters agree that financial crises should be prevented, crime and pollution reduced and economic prosperity promoted, but they are uncertain about which particular policy is more effective in reaching each goal. Based on the private information each voter has, he or she would prefer one policy or the other and the overall vote will be split, despite the common interest they all share.

be allowed to create money, or on whether the radio and television license fees should be abolished.

Referenda on common-interest issues are structurally similar to the example of the faculty meeting above: It might be efficient to have the vote if many voters make an effort to be informed; but the individual voter has an incentive to free-ride and to stay uninformed.[3]

This paper investigates voter motivation in a common-interest setting in which the predictions of standard theory for participation and information are known and can therefore be tested. We show that voter ignorance is less pronounced than predicted by standard economic theory and that, as a consequence, the efficiency of voting outcomes is not as poor as predicted. We also show that voters systematically respond to changes in information costs. This finding indicates that the high level of information acquisition and participation we observe is not simply due to confusion but to a motivation to contribute which is not absolute but traded off against material motives. We then show that a majority vote aggregates more information when players demand to make choices by voting (by signing a petition) compared to when voting is imposed on them. [4]

In our experiment, a successful petition makes voters optimistic that others will acquire information, which, in turn, motivates voters to acquire information themselves. We argue that the effect of a successful petition is causal (i.e., not due to selection) and that it is stronger than cutting the cost of information from a high to an intermediate level.

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[3] Standard economics assumes that voters are exclusively motivated by material self-interest. From this perspective, voter ignorance is individually rational if the private costs of being informed outweigh its private benefits (Downs 1957). But voter motivation may also be driven by factors beyond strict self-interest. Voters may feel that it is their duty to turn out and to be well informed. In fact, voters often do turn out and some are reasonably well-informed. The extent to which voters make an effort has been shown to depend on many factors, including education and socio-economic status (Delli Carpini and Keeter 1996, Lijphart 1997).

[4] Referenda of both types – government-initiated and citizen-initiated – are common elements of direct democracy in Europe. Citizen-initiated referenda are mainly held in German-speaking European countries, both at the federal and the local level. They are most common in Switzerland. Citizen-initiated referenda require a successful petition. In organizations, committees (like a faculty meeting) can often decide whether to hold a majority vote on a specific issue or to delegate the decision to an (internal or external) expert.

1.2 General description of experimental design

Our experimental design is as follows. Subjects are assigned to groups and are in the role of citizens who face a choice between two policies, A and B. In the main treatment (*Endo*), they first decide about how to make that choice. The choice between A and B is made by majority voting if sufficiently many citizens demand to hold a vote by signing a petition, where signing is costless. However, the choice is delegated to an expert of known competence if too few sign. The subjects are called "citizens", the expert is called "mayor" and the policy choice is which of two companies to hire for a construction project (e.g. bridge, stadium, hospital) in a city.[5] Citizens know that one of the two companies is more qualified for the job, and all citizens equally benefit if the "right" company is chosen. At the end of the petition stage, subjects learned whether the petition was successful but not how many had signed. In case the petition succeeds, citizens individually decide whether to acquire costly information and whether to participate in the majority vote. If they do acquire information, they obtain a noisy but informative private signal about whether policy A or B is best. The signals are conditionally uncorrelated. When subjects have made their decision whether to buy information at a cost, they decide whether and how to vote. Voting is not compulsory (abstentions are allowed) and participation is costless. If the majority of votes is for the right policy, all citizens get the same positive payoff. That is, the individual voter's payoff is independent of whether or how a particular citizen voted. Improving the chances to make the right group choice by acquiring information is thus like contributing to a public good and therefore subject to free-rider incentives. Treatment *Exo* is the same as *Endo*, except that there is no petition. Instead, how the decision is made – by voting or by the expert – is exogenously imposed on the group. This treatment comparison serves to isolate the motivational effect of demanding vs. imposing a vote on citizens. The treatment comparison is tightly controlled for experience by holding the sequence of decision situations constant across treatments.

We ran the *Endo* sessions (where citizens choose how to choose) first and the *Exo* sessions (where the mode of choice between the policies is imposed) later. This sequence allows

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[5] We chose to frame the experiment in order to facilitate understanding. Obviously, there is a trade-off: On the one hand, framing helps subjects to make sense of an otherwise rather complex game. In particular, our framing makes clear that the game is about voting rather than guessing the correct policy. This might have contributed to depress uninformed voting, which is in line with our purpose to minimize errors in order to be able to concentrate on the motivational effect of our treatment variation, rather than on irrational behavior. On the other hand, framing activates associations to situations outside the lab, including normative associations. Hence, our subjects might have adapted their behavior to what they believe citizens should do rather than what they would do themselves (as pointed out by an anonymous referee.) We believe that the fact that no citizen-initiated referenda exist in Austria, where the experiment was conducted, mitigates this potential problem.

us to match a particular group *g'* in *Exo* with group *g* in *Endo* such that the choices that were endogenously chosen in *g* are imposed on *g'*. We thus hold the sequence of parameters and decision situations at any point constant across matched groups.

In our experimental environment, information aggregation is depressed when informed voters abstain or when uninformed voters participate. The benefit of casting an informed vote falls as turnout of informed voters goes up, but information costs are independent of turnout in our experiment. Thus, given a sufficiently high turnout by others, incentives are stacked against casting an informed vote. Self-interested citizens therefore rationally prefer to remain ignorant if sufficiently many others do acquire information (e.g. Persico 2004). Clearly, delegating the choice to the expert is the more attractive the more competent the expert, the less informed other voters are, and the higher the cost of acquiring information. We experimentally vary these parameters and find that voter behavior and efficiency respond in line with standard theory predictions. But in contrast to standard predictions, we find that citizens' willingness to be informed is high and can be further improved by providing social information indicating that other citizens are willing to be informed.

1.3 Related literature

Our treatment variation *Endo* vs. *Exo* is inspired by field experiments on voter motivation (Gerber et al. 2008, Gerber and Rogers 2009, Nickerson and Rogers 2010, Bryan et al. 2011, Bond et al. 2012).[6] Nickerson and Rogers (2010) show that helping voters to elucidate a specific voting plan (e.g. what time they would vote, what they would be doing beforehand) increases turnout in U.S. presidential elections. In our treatment *Endo*, signing a petition may have similar effects as those observed when voters make a plan to vote. Bond et al. (2012) use Facebook to divulgate advertisements to "get out the vote!" along with a clickable "I voted" button. The treatment group, which in addition sees which of their friends

[6] Both field and lab experiments have their advantages and limitations (e.g. Camerer 2015). Field experiments are strong in demonstrating causal effects in large-scale natural settings but are often weak in explaining why these effects occur. Our lab experiment is simple and uses small groups but has the advantage of allowing for tight control. For example, "good" and "bad" choices are clearly defined in our setting. This affords us with a clear measure of the quality of voting outcomes. We can also vary the conditions of interest in a controlled way. For example, we can change the cost of information while holding everything else constant. Field studies that investigate the effect of a variation in voting cost, e.g. the introduction of postal voting, often lack a clear measure of that cost and need to address selection issues. For example, Hodler et al. (2015) show that lowering voting costs is a selection device in that it attracts voters with fewer years of education and who know less on the ballot propositions. Funk (2010) shows that postal voting not only reduces the direct cost of participation but it also reduces social pressure to be seen at the ballot box. Funk shows that the latter effect tends to dominate in villages and small towns leading to a decline in participation in Swiss villages.

had voted, has many more “I voted” clicks. Similarly, Gerber and Rogers (2009) show that messages emphasizing high expected turnout are more effective at motivating voters to turn out than messages emphasizing low turnout. Both of these field experiments therefore suggest that providing social information that indicates high participation by others increases turnout. We are inspired by these findings on participation and investigate whether they extend to the dimension of information acquisition. We are, to the best of our knowledge, the first to show that the belief that others are motivated to cast an informed vote (because they signed the petition) induces higher willingness to cast an *informed* vote, which improves the outcome.

Our results not only corroborate the findings in the field experiments cited above, but, in addition, shed light on the questions of how much and why. First, we can gauge the effect of our treatment variation involving social information to the effect of a controlled variation in cost. Second, by eliciting expectations and complementary measures, e.g. on conditional cooperation, we can show that the treatment is effective because it operates through beliefs of reciprocal voters. In a nutshell, we find that the success of the petition (i.e., many others sign) induces optimism about others’ willingness to cast an informed vote which, in turn, motivates reciprocal voters to also cast an informed vote. This mechanism is well-known to increase cooperation in laboratory experiments on public goods games (e.g. Fischbacher and Gächter 2010, Thöni et al. 2012) and field experiments (e.g. Fellner et al. 2013, Hallsworth et al. 2014, Schultz et al. 2007), but we seem to be the first to show that this logic also applies to voting in a common-interest situation.

Since our interest is in voters’ motivation, not in their cognitive biases, our instructions give a rather precise intuition for the possible extent of information aggregation in our experiment. Thus, we aim at reducing irrational choices to avoid confounds with our subjects’ preferences. Our paper is hence complementary to the literature on behavioral biases in voting behavior as exemplified by, e.g., Elbittar et al (2014) and Dittmann et al (2014).

Markussen, Putterman and Tyran (MPT 2014) is closely related to our paper insofar as these authors also study a two-stage process in their main treatment (*Endo*). In the self-governance stage, subjects vote on how to punish free-riding (by formal vs. informal sanctions). In the contribution stage, subjects individually decide on contributions to the public good (and on punishing free-riders if they have opted for informal sanctions in the self-governance stage). The control treatment (*Exo*) in MPT is the same as *Endo*, except that there is no self-governance stage, i.e., formal or informal schemes are imposed on groups. MPT find, as we do, that subjects make smart governance choices and that there is an “endogeneity premium" in the sense that efficiency is higher when informal sanctions were endogenously chosen than when they are exogenously imposed. While similar endogeneity effects have been found in a number of other papers, most notably in Dal Bo et al. (2010) and in Sutter et al. (2010), we are the first to find an endogeneity premium in a common-interest problem with costly information acquisition.

Our lab experiment conceptually builds on a stream of literature studying information aggregation (e.g. Austen-Smith and Banks 1996) and more specifically on a considerable literature on voting experiments exploring common-interest situations (e.g. Guarnaschelli et al. 2000, Battaglini et al. 2008, 2010, Goeree and Yariv 2010, Morton and Tyran 2011, Morton et al. 2012, Fehrler and Hughes 2014, Kartal 2015). However, none of these experiments involve endogenous information acquisition.

The papers that match ours closest are Bhattacharya, Duffy and Kim (BDK 2017) and Großer and Seebauer (GS 2016) which both study endogenous information acquisition while varying group sizes. GS focus on the effect of compulsory vs. voluntary (i.e., allowing for abstentions) voting on information acquisition. BDK vary the cost and precision of information under compulsory voting (i.e., no abstentions allowed). In line with our results, BDK find that the demand for information is higher than theoretically predicted and that it responds to the cost of information. Another close match is Elbittar, Gomberg, Martinelli and Palfrey (EGMP 2014) who show that voters acquire more information under majority than under a unanimity voting rule.

While our study has many elements in common with these studies, we take a more behavioral perspective as we study the effect of providing social information (whether the petition has been accepted) which is ineffective according to standard theory, and our experiment is somewhat more complex as it has an additional stage which allows us to study stylized self-governance. Because of its complexity, our experiment is also couched in a naturalistic scenario (citizens choosing whether to delegate the choice to a mayor or vote on construction projects in their city) to facilitate understanding.

We proceed as follows. Section 2 presents the experimental design, section 3 reports the results and section 4 concludes.

2 Parameters, predictions, and procedures

Experimental design and parameters. In abstract terms, our basic design is as follows. Consider a group of $n = 7$ citizens facing two alternative policies, P_A and P_B. The state of the world, ω, has two possible realizations, A and B, which are equally likely to prevail ex ante,

$prob\ (A) = prob\ (B) = 0.5$. All citizens get a positive monetary payoff u_m if the policy that matches the state of the world is implemented ($u_m(P_A \mid A) = u_m(P_B \mid B) = 25€$), but they get a zero payoff if not ($u_m(P_A \mid B) = u_m(P_B \mid A) = 0$). One round is randomly selected for payment.

The mayor has some known competence q to make the right choice ($prob(P_A \mid A) = prob(P_B \mid B) = q$) which can take two values $q_H = 0.9$ and $q_L = 0.6$. When the choice is made by majority vote, voters simultaneously decide whether to acquire costly information. Subjects also estimated how many others in their group would acquire information. If their estimate was correct, they earned 0.10€.[7] Information acquisition means to incur a private cost c to obtain a private signal $s_i \in \{A^*, B^*\}$. The cost can take three values: $c_L = 0.1€$, $c_M = 0.9€$ and $c_H = 1.7€$. Signals are imperfect but informative about the state of the world, and are of the same quality but uncorrelated across subjects: $Pr\{\omega = A \mid s_i = A^*\} = Pr\{\omega = B \mid s_i = B^*\} = p = 0.6$. After the information stage, and without knowing whether others have acquired information, subjects decide whether and how to vote.

Individuals who abstained answered an unpaid quiz question (that was entirely unrelated to the experiment) with a binary reply choice while the others voted.[8] This was designed to prevent that subjects perceive abstention as less interesting and vote simply to avoid the boredom of being idle. The computer implemented the policy that got a majority of the votes. Ties were broken randomly. At the end of each round, subjects learned how many group members bought information, how many participated in the vote, which policy was implemented, and whether it was the correct policy.

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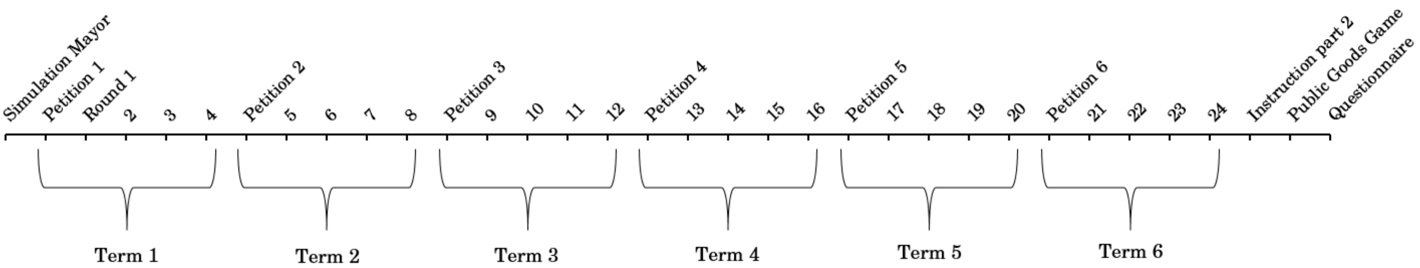
[7] The payment for a correct estimate was restricted to only 0.4% of the payoff resulting from a correct pivotal vote (0.10€/25€) to prevent hedging between reported beliefs and decisions on the information-acquisition and voting stage. There was no possible incentive to hedge between the reporting of the estimate and the information-acquisition or voting decision *within a single round*, since subjects could not *directly* influence the truth value of their belief report by their own decisions. However, if the payment for a correct belief report was large, subjects might have wanted to vote against their signal or without even acquiring a signal in order to reduce the value of informed voting for others, thus manipulating them into corroborating their pessimistic belief reports.

[8] At the voting stage, subjects first decided whether or not to participate in the vote. Those who decided to participate then voted for either of the two alternatives; and subjects who decided to abstain answered the binary quiz question. Both voters who participated and voters who abstained got feedback on the voting outcome. Subjects who abstained got feedback on their performance on the quiz question(s) at the end of the session. This was done in order not to induce subjects who performed better in the quiz question(s) than in the votes away from voting and vice versa for those who performed worse.

The time structure of our experiment is as follows (see also Figure 1): At the beginning of the play, subjects had the opportunity to use a simulation device for about three minutes to get an impression about how ten representative decisions of the experienced and unexperienced mayor may look like. [9] Then, six so-called *terms* of play followed. In *Endo*, each term consists of a *petition stage* and four subsequent rounds of either expert decisions or information acquisition and votes, depending on the outcome of the petition. Subjects signed the petition with a nickname that was assigned to them at the beginning of the experiment. If at least four group members signed the petition, the four policy choices in the upcoming term were each made by voting. Otherwise, the four upcoming choices were delegated to the automated expert who made each choice with publicly known chance q of being correct. At the end of the petition stage, subjects learned whether the petition was successful but not how many had signed. In *Exo*, each term consists of four rounds of either expert decisions or information acquisition and votes, depending on the outcome of the petition *in the matched group and term in Endo*. Parameters, i.e., mayor quality and information costs, were held constant within terms and between the matched terms and groups of *Endo* and *Exo*, but were varied across terms. We chose to have one term for each combination of q and c except that we did not implement the uninteresting combination q_H and c_H (because incentives are extremely stacked against voting in this case) and we had two terms with the most interesting combination q_L and c_M (because theoretical predictions are least sharp in this case). In the rounds in which subjects voted, the computer implemented the policy that got a majority of the votes. Ties were broken randomly. At the end of each round, subjects learned how many group members bought information, how many participated in the vote, which policy was implemented, and whether it was the correct policy.

Figure 1: Time structure of the experiment



9 The device was programmed to randomly draw ten independent decisions according to the correctness probability of each mayor's type and to give feedback on the correctness of each decision. The device could be used multiple times. The issue of the simulated mayors' decisions was different from the issues presented during the rounds of play, and the mayor was framed to be from the neighboring town, to prevent anchoring.

After completion of the main experiment consisting of 24 rounds in total, subjects participated in a standard one-shot public goods game in reshuffled groups of three. The purpose of this follow up is to obtain a proxy for (unconditional) cooperativeness. Subjects also filled in a questionnaire taken from the World-Value Survey on reciprocity and on attitudes on democracy and on delegation of decisions to experts. Subjects were paid out immediately at the end of the session, after about 2 hours, in cash. We randomly selected one of the 24 main rounds for payment, added earnings for correct expectations, added the earnings from the public goods game (9.7€ on average) and the survey (3€), for a total average of 32.5€ per subject.

Predictions. The voting game can be solved by backward induction assuming common knowledge of rationality and self-interest. The relevant equilibrium concept is subgame-perfect Nash equilibrium. A full characterization of the equilibria and a description of possible off-equilibrium improvements are available in our supplementary online materials (SOM) which can be downloaded from the authors' websites.[10]

Stage 3: *participation and voting choices*. The predictions for participation and voting given that the players are in the voting game are straightforward. First, given that voters are informed, they vote their signal. The reason is that because the signal is informative, voting against it decreases the probability of making the right choice. Second, uninformed voters abstain. The reason is that uninformed voting runs into the risk of canceling out an informed vote.

Stage 2: demand for information. Buying information is profitable for a citizen if his marginal expected benefit from doing so exceeds his marginal cost, $\Delta prob$ * 25€ > c_j. But the demand for information by voter i depends also on the demand by other voters. In particular, $\Delta prob$ depends on the number of informed voters k as follows.

We define $\Delta prob = \pi(k+1) - \pi(k)$, where the predicted "success probability" (SP) is

[10] Note that we only present equilibria for the stage game, although, due to partner matching, the game implemented in the lab is (finitely) repeated. To sustain equilibria in a finitely repeated game that are not outcome-equivalent to a series of stage-game equilibria, multiple equilibria in the stage game are required that can be played to reward or punish previous strategies. Typically, such equilibria sustain higher cooperation levels than the stage-game equilibria. In the final round, however, only stage-game equilibria can be played. Although we cannot exclude the possibility, we believe it to be highly unlikely that subjects successfully coordinate on such repeated-game strategies in a complex game without communication like ours. Moreover, we find information-acquisition levels well above those predicted for the stage-game equilibria in the last round, and last-round choices are not generally lower than those in the rounds before. Since solving for all equilibria of the repeated game would not help us explain this striking fact, we refrain from this exercise.

$$\pi(k) = \begin{cases} \sum_{l=0}^{\frac{k-1}{2}} \binom{k}{\frac{k+1}{2}+l} p^{\frac{k+1}{2}+l}(1-p)^{\frac{k-1}{2}-l} & \text{for } k \text{ odd} \\ \pi(k-1) & \text{for } k \text{ even.} \end{cases}$$

Table 1 serves to illustrate the pure-strategy Nash equilibria of the game (shaded cells). To derive those, we start with column (2) which shows that the success probability weakly increases in the number of informed voters k, and strictly increases with each odd-numbered informed voter. According to the Condorcet jury theorem (Condorcet 1785), $\pi(k) > p$ if $k > 2$, and $\pi(k)$ approaches 1 as k approaches ∞ due to information aggregation.

For example, according to the equation above, the probability to make the right choice with $k = 3$ is $\pi(3) = 0.648$ which is considerably higher than the probability of each voter making the right choice individually, $p = 0.6$. Intuitively, information aggregation occurs because a right choice results when all three vote for the right option ($0.216 = 0.6^3$) or when two out of three do so (and there are three ways for this to happen, $0.432 = 3 * 0.4 * 0.6^2$). Note that $\pi(k)$ only weakly increases with k. In particular, $\pi(k)$ does not increase when an informed voter (off equilibrium) joins an odd-numbered electorate. In these cases, we have $\Delta prob = 0$ in column (4). For example, when moving from $k = 3$ to $k = 4$, the success probability remains at 0.648 because uninformed voters may cancel out the vote of informed ones in a tie. Column (3) shows gross efficiency, i.e., the sum of expected earnings in a group, in euros (recall that each group member gets 25€ in case the group makes the right choice). Column (6) shows net efficiency which results from subtracting the cost of information for k voters from gross efficiency. Net efficiency increases with each odd-numbered k.

Table 1: Pure-strategy equilibria

(1) k	(2) $\pi(k)$	(3) Gross efficiency	(4) $\Delta prob$	(5) Gross private gain	(6) Net efficiency		
					c_L = 0.1	c_M = 0.9	c_H = 1.7
0	.500	87.5	-	-	87.5	87.5	87.5
1	.600	105.0	.100	2.50	104.9	104.1	103.3
2	.600	105.0	.000	0.00	104.8	103.2	101.6
3	.648	113.4	.048	1.20	113.1	110.7	108.3
4	.648	113.4	.000	0.00	113.0	109.8	106.6
5	.683	119.4	.035	0.86	118.9	114.9	110.9
6	.683	119.4	.000	0.00	118.8	114.0	109.2
7	.710	124.3	.028	0.69	123.6	118.0	112.4

Notes: k is the number of informed voters voting their signal. $\pi(k)$ is the predicted success probability that the group makes the right choice. The group size is equal to n = 7. Gross efficiency is the sum of expected earnings in the group in euros, $n * \pi(k) *$ 25€; $\Delta prob = \pi(k+1) - \pi(k)$. Gross private gain is $\Delta prob$ * 25€. Net efficiency is gross efficiency - kc_j. The three rightmost columns show net efficiency in euros for three cost levels. Shaded cells show pure-strategy equilibria, dark shading indicates Pareto-dominant equilibria.

The shaded cells in Table 1 indicate pure-strategy Nash equilibria of the voting game. In equilibrium, there is no incentive for one additional voter to join and to buy costly information (because the gross private benefit is zero), and there is no incentive for those who do buy information to stop buying it (because that would result in a loss). Table 1 shows, perhaps unsurprisingly, that demand for information in the Pareto-dominant equilibria falls as cost goes up. More precisely, the set of pure-strategy Nash equilibria is largest for low cost c_L and smallest for high cost c_H.[11]

Table 1 shows that multiple pure-strategy equilibria prevail. Coordinating on one of these equilibria is difficult despite the fact that they are Pareto-rankable (equilibria involving a larger number of informed voters have higher net efficiency). Coordination is difficult because these equilibria imply that some voters buy information while others do not (the exception is the equilibrium at c_L and k = 7 in which all citizens buy information). Given the presence of these difficult coordination problems, it may seem natural to believe that citizens

[11] The precise relations between cost and equilibrium number of informed voters are as follows: $k = 0$ for $c > c_0 = 2.5$, $k = 1$ for $1.2 = c_1 < c \leq c_0$, $\{k\} = \{1,3\}$ for $0.864 = c_2 < c \leq c_1$, $\{k\} = \{1,3,5\}$ for $0.691 = c_3 < c \leq c_2$, and $\{k\} = \{1,3,5,7\}$ for $c \leq c_3$.

randomize their choices and play a mixed-strategy equilibrium. We provide a discussion of symmetric mixed-strategy equilibria in the SOM. The conclusion of that discussion is, again unsurprisingly, that demand for information falls as its cost goes up. Moreover, for each cost there is at least one pure-strategy equilibrium that yields (weakly) more information aggregation than the symmetric mixed-strategy equilibrium. In the SOM, we also provide predictions for a symmetric quantal response equilibrium (QRE, McKelvey and Palfrey 1995, log-specification), assuming errors at the information-acquisition stage and setting the noise parameter equal to the corresponding estimate that GS obtain for a similar setting with seven players, voluntary voting, abstention allowed, and endogenous information acquisition. Moreover, in a different approach to apply QRE to our experiment, we also insert our observed information-acquisition rates into the existence condition of a symmetric log-QRE and derive the resulting noise parameter that would explain our data. We obtain the result that in both *Endo* and *Exo*, the noise parameter would have to be twice to five times as high as in GS to explain the information-acquisition rates that we observe for low costs. For medium and high costs, QRE does not explain the information-acquisition rates that we observe. In the main part of the paper, we thus concentrate on pure-strategy equilibria.

Stage 1: signing the petition. In *Endo*, citizens decide whether to delegate the policy choice to the mayor or to make the choice in a majority vote. Delegation to the mayor occurs if the petition fails and voting occurs if it succeeds, that is, if a majority of voters sign the petition (i.e., four out of seven citizens). Signing is costless.

It is dominant to delegate the choice (at all cost levels) if the mayor makes high-quality decisions ($q_H = 0.9$), because delegating is costless and the highest success probability that can be attained in voting is lower than that (0.71, see Table 1). However, matters are more complicated when the mayor is of low competence.

With a mayor of low competence, signing the petition leads to strictly lower expected payoffs at cost level c_H than not signing if players play equilibrium on the subsequent stages. Hence, at c_H expert delegation is still individually optimal. For the other two cost levels, however, signing the petition is no longer suboptimal. On the contrary, it becomes individually optimal if either $\pi(k^*)payoff - c > 0.6payoff$, with $payoff > 0$[12] (i.e., it is better to have a vote and cast an informed vote, given the equilibrium expectation that $k^* - 1$ others will do so as well), or one plans to free-ride on at least three informed voters. Hence, for $k^* \geq 3$ and $c \neq c_H$, it is individually optimal to sign the petition (both for those who plan to get informed and those who plan to free-ride).

[12] In our theoretical Appendix, *payoff* is normalized to 1; in the experiment, *payoff* = 25€.

Table 2: Summary statistics and standard predictions for voting (i.e., $q = q_L = 0.6$)

	Observed				Standard prediction			
	Endo		*Exo*		*Pure strategy*		*Mixed strategy*	
(1) Petition succeeds (percent of groups)	c_L	100.0	n.a. by design		c_L	100.0	c_L	100.0
	c_M	100.0			c_M	100.0	c_M	0.0
	c_H	100.0			c_H	0.0	c_H	0.0
	all	100.0			all	75.00	all	25.00
(2) Information acquisition (percent of subjects)	c_L	90.77	c_L	76.49	c_L	100.0*	c_L	100.0
	c_M	77.98	c_M	64.73	c_M	42.85*	c_M	22.10
	c_H	70.83	c_H	54.76	c_H	14.28*	c_H	6.80
	all	79.39	all	65.18	all	50.00*	all	37.75
(3) Vote in line with signal (percent of voters)	c_L	96.39	c_L	94.55	c_L	100.0	c_L	100.0
	c_M	97.71	c_M	93.79	c_M	100.0	c_M	100.0
	c_H	97.48	c_H	96.74	c_H	100.0	c_H	100.0
	all	97.28	all	94.63	all	100.0	all	100.0
(4) Vote against signal (percent of voters)	c_L	2.68	c_L	4.17	c_L	0.0	c_L	0.0
	c_M	1.64	c_M	2.98	c_M	0.0	c_M	0.0
	c_H	0.89	c_H	0.89	c_H	0.0	c_H	0.0
	all	1.71	all	2.75	all	0.0	all	0.0
(5) Voted uninformed (percent of voters)	c_L	3.87	c_L	9.82	c_L	0.0	c_L	0.0
	c_M	9.82	c_M	9.23	c_M	0.0	c_M	0.0
	c_H	12.80	c_H	12.20	c_H	0.0	c_H	0.0
	all	9.08	all	10.12	all	0.0	all	0.0
(6) Efficiency (percent of delegation bench-mark)	c_L	13.98	c_L	14.07	c_L	17.60*	c_L	17.60
	c_M	4.70	c_M	3.75	c_M	5.4*	c_M	6.70
	c_H	16.97	c_H	-5.51	c_H	-1.6*	c_H	0.80
	all	10.09	all	4.02	all	6.70*	all	7.60

Notes: We have a total 168 subjects, 84 subjects in 12 groups of 7 subjects per treatment (*Endo*, *Exo*). Each treatment has 4 terms with an expert of low quality ($q = q_L = 0.6$, 1 term with c_H and c_L each, 2 with c_M), 2 terms with an expert of high quality ($q = q_H = 0.9$, 1 term each with c_M and c_H). In 100% of all terms with high quality, our subjects choose delegation. Hence, voting occurred if and only if $q = q_L = 0.6$. Lines (2) to (6) indicate percentages conditional on voting. Standard prediction for pure-strategy equilibrium assumes perfect coordination at the Pareto-dominant equilibrium. * Upper bounds derived from the Pareto-dominant equilibria of the information-acquisition stage under voting.

Moreover, given that citizens can coordinate on an equilibrium involving at least $k = 3$ informed voters, voting entails both higher informational efficiency and, hence, higher net expected group payoffs, than delegation. Voting also Pareto-dominates the mayor's decision for any cost level $c \in \{c_L,\ c_M,\ c_H\}$ in this case. While coordination on such pure-strategy equilibria seems plausible at low cost[13], and is at least possible at medium costs, it is not an equilibrium outcome at high cost.

[13] It is also dominant to delegate when the cost is low and citizens play a mixed-strategy equilibrium, see SOM.

In summary, standard theory provides some (fairly clear) bounds on information acquisition in the coordination game described above with the main conclusion that the demand for information does not increase if cost goes up in both treatments, that delegation is common in *Endo* when cost of information is high and when the mayor is competent, and that at c_m, all pure-strategy equilibria under democracy are asymmetric and hence involve a serious coordination problem. As a consequence, incentives are rather stacked against voter motivation if the cost of information is not very low.

Procedures. The experiment was conducted at the Vienna Center for Experimental Economics with a total of 168 undergraduate subjects recruited from all disciplines using the software ORSEE (Greiner 2015) and the experimental software z-tree (Fischbacher 2007) to run the experiment. We have 24 independent groups of seven who make policy choices in six terms of four periods each, resulting in a total of 4,032 policy choices. Half of the subjects are randomly allocated to *Endo*, half to *Exo*.

3 Results

The presentation of results proceeds as follows. Section 3.1 shows that rational ignorance is not as pronounced as theory predicts, that the demand for information reacts to costs, and that information is used responsibly. Section 3.2 discusses our main results with respect to efficiency. We show that voting is more empirically efficient than delegation when the mayor is of low competence, that there is an endogeneity premium in the sense that voting is more efficient when it is demanded than imposed, and that this premium is caused by the treatment (i.e., the petition). We also find that self-governance is successful in the sense that the policy choice is delegated when doing so is more efficient and vice versa for voting. Section 3.3 investigates determinants of information demand. We find that the endogeneity premium is strong and robust, and that information demand may be mediated through beliefs. Section 3.4 shows that beliefs mirror actions closely, i.e., more optimistic voters are willing to buy more information.

3.1 Little rational ignorance, information is used responsibly

Table 2 shows in line (2) that rational ignorance is much less pronounced than predicted by standard theory when the policy choice is made by voting. In total, 79% and 65% of all subjects acquire information in *Endo* and *Exo*, respectively. These levels clearly exceed predicted rates of information even in the most favorable of all cases, i.e., assuming perfect coordination. The predicted rate of information acquisition is 50% on average in (Pareto-dominant) pure-strategy equilibria, and a meager 38% according to mixed-strategy equilibria (see SOM for calculations). Statistical testing (against an assumed degenerate distribution corresponding to the Pareto-dominant pure-strategy equilibrium) reveals that information demand is significantly higher for all cost levels jointly (p = 0.000 in *Endo* and *Exo*, Wilcoxon signed-rank test) and it is also higher when tested separately by cost level for c_M and c_H in both *Endo* and *Exo* (p = 0.002 for both c_M and c_H and *Exo* and *Endo*, WSR test).

Line (2) also shows that information demand responds systematically to voting cost as predicted. For example, the share of subjects buying information in *Exo* is about 76% when cost is low (c_L), 65% when intermediate (c_M), and 55% when high (c_H). In *Endo*, the respective values are 91%, 78% and 71%. The effect of cost is substantial, and information demand is therefore significantly lower at c_H than c_L in both *Endo* and *Exo* (p = 0.000 for both *Exo* and *Endo*, Fisher Exact test).

Table 2 also shows that most subjects make good use of their information. Line (3) shows that among voters who bought information, the vast majority votes in line with their signal (97% and 95% in *Endo* and *Exo*, respectively), as predicted by standard theory. Line (4) shows that, again as predicted, very few vote against their signal (2% and 3%, respectively), and a tiny rest abstains despite being informed. There is a share of about 10% of uninformed voters, and this share tends to increase slightly with information cost in both treatments. We summarize our discussion above in

Result 1: *Rational ignorance is much less pronounced than predicted by standard theory, and voters acquire significantly more information in Endo than in Exo. The demand for information responds to its cost. Voters tend to use information optimally and uninformed voting is rather rare (about 10%) in both conditions.*

3.2 Efficiency of voting

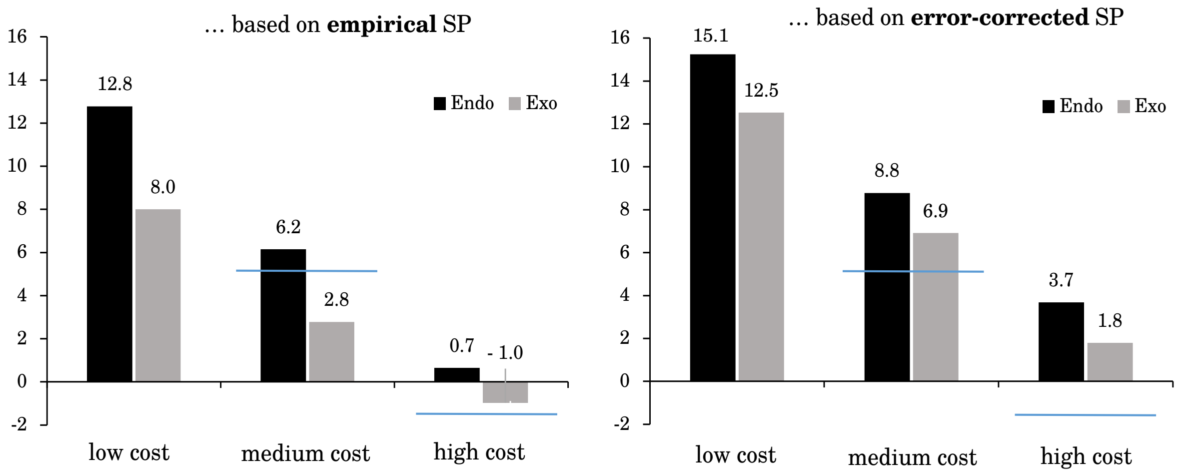
Economic efficiency in our setting is driven by how many voters buy information (and at what cost), and whether they make good use of it. Voter motivation to acquire costly information may increase efficiency, while errors – voting against one's signal, informed abstention and uninformed voting – undermine it. We now discuss alternative measures that allow us to isolate these effects.

We define the efficiency of voting (EV) relative to efficiency of delegation to the expert, using the success probability (SP) which is the chance to choose the correct policy as a group. That is, we calculate net expected payoffs of voting for a group (EPV = SP x 25€ x n – kc_j) relative to expected payoffs from delegating to the expert (EPD = q_L x 25€ x n), where

q_L = 0.6 and k is the number of informed group members out of n = 7. More precisely, EV = (EPV – EPD)/EPD.

SP can be calculated in two ways. The *empirical* SP of a group is calculated from observed demand for information and from observed use of information in that group according to $\pi(k)$ (see predictions in section 2 and Table 1). The empirical SP therefore allows for error resulting from voting against one's signal, informed abstention and uninformed voting. By contrast, the *error-corrected* SP, though also calculated from observed information demand, is based on (counterfactual) error-free use of information and participation behavior. The error-corrected SP shows how likely a group would have been to make the correct choice had its members all used information optimally and abstained if uninformed.

Figure 2: Efficiency of voting (in % of earnings with delegation to the expert)



Notes: Panels show efficiency of voting (EV), i.e., the net excess return of voting over delegating the policy choice to the expert as a percentage of earnings with expert judgment for q_L = 0.6. Expected net group earnings with voting are SP x 25€ x $n - kc_j$, where k is the number of informed voters, n = 7 is the number of group members. Expected net group earnings with delegation are q_L x 25€ x n. Left panel uses empirical (uncorrected) success probabilities (SP), right panel uses error-corrected SP. Horizontal lines indicate EV in Pareto-dominant pure-strategy subgame equilibria with voting.

Comparing EV based on empirical SP to EV based on error-corrected SP measures the inefficiency that is due to errors. Comparing EV based on error-corrected SP to efficiency according to the theoretical prediction measures what we call the motivational effect, i.e., the part of efficiency that is due to citizens' motivation to buy information above and beyond what is predicted for rational and self-interested participants. Note that EV can go up or down when information demand increases, depending on whether or not the information aggregation effect trumps the cost of information. We therefore focus on measures of economic rather than informational efficiency below.[14]

Figure 2 summarizes our main results with respect to the efficiency of voting (EV). First, voting is more efficient than delegation. Bars in Figure 2 show EV and are, except for one, all in the positive domain, meaning that EV was systematically higher with voting than with delegation. For example, the leftmost bar in the left panel indicates that voting with low information cost on average generated 13% higher net group earnings than delegation to the expert with empirical SP, i.e., when allowing for errors in using available information. When aggregating over all three cost levels, we find that EV is higher with voting than with delegation with empirical SP (left panel, $p = 0.000$ in *Endo* and $p = 0.007$ in *Exo*, WSR test) and with error-corrected SP (right panel, $p = 0.000$ for both treatments, WSR test). Except for high costs, voting is also significantly better than delegation when considering each cost level separately ($p < 0.05$ for both empirical and error-corrected SP, WSR tests).

Second, we find that sorting into voting is polar depending on expert competence, and that self-governance was successful in the sense that voting is more efficient than delegation to the expert when subjects demand to vote, and vice versa when they do not. In other words, subjects consistently chose the mode of decision making that maximizes their net earnings in *Endo*. They *always* demanded the vote (by signing the petition) with $q = q_L$ which is more efficient than expert judgment as shown above, and *always* delegate to the expert when $q = q_H$. The latter result is perhaps not too surprising because the expert is more efficient by design than voting with $q = q_H = 0.9$ since the maximum SP of voting is $0.71 < q_H$, see Table 1. However, the result that citizens always demand to vote with $q = q_L$ is remarkable because voting is not predicted to dominate the expert by standard theory (see line (1) in Table 2) and it is not predicted to outperform delegation in all cases. For example, the petition is predicted to be rejected whenever the cost is not low in mixed-strategy equilibrium (see line (1) in Table 2). We summarize the discussion above in

Result 2: *Voting is more efficient than delegation to a low-quality expert. Self-governance is successful, i.e., subjects always delegate when it is efficient (with a high-quality expert) and never delegate when it is not.*

Third, there is an "endogeneity premium" in the sense that EV is higher in *Endo* than in *Exo*. In Figure 2, black bars are higher than grey bars in every single case in both panels.

[14] Suffice it to say that empirical SPs exceed the probability with expert judgment ($q = q_L = 0.6$) both in *Endo* (79%) and in *Exo* (65%, see Table 2, line (2)). Voting in *Endo* significantly outperforms *Exo* in terms of empirical SP ($p = 0.033$, MWU test).

Endo is significantly more efficient overall than *Exo* (p = 0.065 for empirical SP, p = 0.021 for error-corrected SP, MWU tests). The endogeneity premium shows that voters are more willing to collect costly information when they know that the majority of subjects has demanded the vote than when the vote is imposed on them.

Fourth, the endogeneity premium is caused by the treatment and is not due to selection. This is a surprising finding because selection effects are a plausible reason for observed differences between *Endo* and *Exo* a priori: More cooperative people may both be more likely to sign the petition and to buy information which means that more cooperative people are more likely to sort into voting while less cooperative people would delegate in *Endo*. If this were the case, comparing information demand by those who selected into voting in *Endo* to the demand by randomly assigned subjects in *Exo* would indeed be partly driven by unobserved cooperativeness and not entirely by the treatment. However, because of the polar outcomes of the petition, the endogeneity premium can be interpreted as being *caused* by demanding the vote. The reasons why selection can be ruled out is that we randomly allocate subjects to both treatments (which guarantees that subject characteristics are equally distributed across treatments before the petition stage) and that there can be no selection when *all* subjects in treatment *Endo* get the *same* condition (i.e., the petition succeeds in all cases with a mayor of low competence). In addition, our design guarantees that each group in *Exo* perfectly matches a group in *Endo* in terms of parameters q and the sequence of the costs. The treatment comparison therefore controls for the effects of sequencing of parameters.

Fifth, we argue that superior efficiency of voting is importantly driven by information demand above and beyond the benchmark, i.e., the level predicted by standard theory, and this effect is stronger in *Endo* than in *Exo*. We call the surplus efficiency that results from this "excess" demand the motivational effect (ME). Our measure of ME is conservative because the benchmark assumes that rational self-interested citizens succeed to perfectly coordinate on a pure-strategy equilibrium, and if there are several equilibria, to perfectly coordinate on the Pareto-dominant equilibrium, which is difficult to achieve in practice. Hence, our measure of ME tends to underestimate the true motivational effect. In fact, the ME for mixed equilibria is at least twice as large as the ME for pure-strategy equilibria as shown in Figure 2 for both c_M and c_H.

The horizontal lines in Figure 2 at medium and high cost indicate EV at pure-strategy equilibrium values (note that there is no scope for a motivational effect at low cost because everyone is predicted to buy information in the Pareto-dominant equilibrium in this case). EV in equilibrium at c_M is 5.4% (= (110.7-105)/105), and at c_H it is -1.6% (= (103.3-105)/105, see Table 1 for values). Despite being a very conservative measure, we find that the ME is sizeable at c_M (3.4% in *Endo*, 1.5% in *Exo*), and particularly large at c_H (5.3% in *Endo*, 3.4% in *Exo*) when correcting for errors (right panel). Moreover, the ME is statistically significant (p = 0.005 for c_M and p = 0.003 for c_H in *Endo*; p = 0.050 for c_M and p = 0.012 for c_H in *Exo,* WSR tests). However, errors mitigate the beneficial ME as can be seen by the smaller positive distance of the bars from the benchmark line in the left compared to the right panel. Due to errors, EV is clearly below predictions for medium cost in *Exo* but still exceed equilibrium values in *Endo* when allowing for errors (0.8% at c_M and 2.3% at c_H, left panel). In summary, we conclude that the observed efficiency of voting does not exceed the predicted values much because of errors (voting against one's signal and uninformed voting). However, when correcting for these errors, we find that there is considerable "excess" demand for information which results in efficiency gains that clearly exceed predicted levels.

We summarize the discussion above in

Result 3: *Voting is more efficient when the vote has been demanded rather than imposed on the group, i.e., there is an endogeneity premium. Errors mitigate the beneficial effects of voter motivation but the efficiency gain due to motivation is substantial.*

3.3 Determinants of information demand

Table 3 shows results from logit regressions on the determinants of a citizen's demand for information (*Infobuy*). The coefficients on *Endo* in the first line show that the endogeneity premium is significant, i.e., that subjects acquire more information when they vote because the group demanded it than when voting is imposed on them. The coefficient is highly significant in a specification without any controls (1) and is robust to adding many controls in (7), e.g. post-experimental survey measures on whether the respondent thinks there is a duty to vote or a duty to gather information if one votes.[15] The effect of the cost of information (*Infocost*) in line 2 is strong and robust which confirms our earlier conclusion that information demand systematically responds to its cost.

The effect of *Endo* is remarkably strong and its size can be compared to the effect of the cost of information. As Table B1, in particular B1.2, reveals, it corresponds to cutting the cost of information by 1 euro; in fact, the effect of *Endo* is even stronger. To be precise, consider B1.2: At high costs, moving from *Endo* = 0 to *Endo* = 1 increases information acquisition by 12 percentage points (third column); and moving from high costs (1.7 euros) to

[15] Subjects had to indicate their agreement on a scale from 1 to 4 to the following statements: "In a democracy, there is a duty to participate in elections" (average answer: 3.3), and "In a democracy, there is a duty to gather information before participating in an election" (average answer: 3.7).

a hypothetical level one unit below (0.7 euros) while remaining at *Endo* = 0 increases information acquisition by something between 7.2 (first column) and 8.4 percentage points (second column). The effect of *Endo* is thus stronger than cutting the cost of information from high to medium (the difference between these cost levels is 0.8).

The coefficient on *Belief* is significant in all specifications and thus robust. This finding supports our earlier conclusion that one's own information demand is strongly correlated with one's belief about others' demand for information. The drop of the coefficient on *Endo* when adding *Belief* is particularly interesting (compare specification (2) to (3)). This drop suggests that the effect of *Endo* on information demand partly operates through beliefs. This conclusion is supported by mediation analysis (Baron and Kenny 1986) which yields partial mediation with highly significant test results, see Appendix, Table B3.

Table 3: Determinants of information acquisition

Dep.var. *Infobuy*	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Endo	0.722** (0.280)	0.743*** (0.286)	0.473*** (0.181)	0.471** (0.187)	0.524*** (0.198)	0.527*** (0.199)	0.418** (0.196)
Infocost		-0.683*** (0.113)	-0.399*** (0.082)	-0.398*** (0.082)	-0.403*** (0.087)	-0.445*** (0.092)	-0.470*** (0.093)
Belief			0.498*** (0.076)	0.506*** (0.077)	0.536*** (0.077)	0.528*** (0.078)	0.513*** (0.078)
High cooperation				0.361 (0.269)	0.354 (0.258)	0.353 (0.258)	0.348 (0.245)
Conditional cooperation					0.736*** (0.241)	0.737*** (0.242)	0.675** (0.262)
Period						-0.017 (0.011)	-0.019* (0.011)
Controls	No	No	No	No	No	No	Yes
Constant	0.627*** (0.195)	1.264*** (0.239)	-1.035*** (0.355)	-1.240*** (0.379)	-1.727*** (0.399)	-1.508*** (0.430)	-0.827 (0.694)
Wald Chi^2	6.63	56.66	140.1	135.0	152.1	178.1	469.7
Prob > Chi^2	0.010	0.000	0.000	0.000	0.000	0.000	0.000
AIC	3108.85	3035.27	2839.93	2826.81	2768.48	2767.88	2746.50
BIC	3120.65	3052.96	2863.52	2856.29	2803.86	2809.16	2834.95
Pseudo R^2	0.022	0.045	0.108	0.112	0.131	0.132	0.144
N	2,688	2,688	2,688	2,688	2,688	2,688	2,688

Notes: Table shows logit regressions with *Infobuy*, i.e., individual information demand, as the dependent variable. Standard errors are in parentheses, clustered at the group level. *Endo* is a dummy for the treatment. *Infocost* is the cost of information acquisition (c_L = 0.1, c_M = 0.9, c_H = 1.7). *Belief* indicates how many other group members are believed to acquire information. *High cooperation* = 1 if the individual contributes more than the median in a one-shot public goods game at the end of the experiment, 0 otherwise. *Conditional cooperation* = 1 if the individual claims to be more willing to return a favor to a stranger than the average person, 0 otherwise. *Period* is a round with voting. Controls include answers to a post-experimental questionnaire on attitudes to democracy. Stars indicate significance of coefficients as follows: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

We interpret the significant coefficient on *Belief* as indicating that beliefs drive individual information demand. But this need not be so in the specification above. The reason is that the regressions in Table 3 include 16 rounds of voting within the same group. Subjects get feedback at the end of each round about how many others acquired information, and one's belief about others' information acquisition in t is therefore likely to depend on observed information demand in t-1. However, these effects do not seem to be strong for two reasons. First, there are no clear patterns in information demand over time which suggests that learning and feedback effects are not pronounced. In particular, the variable *Period* is at most weakly significant (see Table 3, (6) and (7)); and *Period²* is insignificant (not reported in the tables).[16] Second, we redo the regressions with first-round data only, which means there is no period t-1 that could have affected choices in t. We find that the effects of *Endo* and *Belief* remain significant ($p < 0.05$) in all specifications (see Table B2 in the Appendix). This finding suggests that optimism about others' information demand has indeed a positive causal effect on information acquisition.

Why do we find a positive relation between beliefs and information demand? Our conjecture is that the relation is driven by the interaction of optimism about information demand by others and a preference for conditional cooperation. Such a tendency has been documented in many cooperation experiments (e.g. Thöni et al. 2012) and is plausible to prevail here, too, since buying information beyond the equilibrium prediction is an act of cooperation and corresponds to the provision of a public good. The significant coefficients on *Conditional cooperation* ("How would you rate your willingness to do a favor for someone whom you have just met and who is doing you a favor?", scale 1-10) suggest that more conditionally cooperative voters tend to buy more information. The coefficient on *Conditional cooperation* remains significant when including *High cooperation*, a measure of cooperativeness. Perhaps surprisingly, *High cooperation* itself is not significant.[17] Taken together, this finding suggests that conditional cooperation drives information demand.

We summarize the discussion above in

Result 4: *The endogeneity premium is statistically robust to inclusion of controls and is larger than the effect of cutting the cost from a high to a medium level. The effect of Endo is mediated through optimistic beliefs about information demand by others.*

3.4 Beliefs on information acquisition

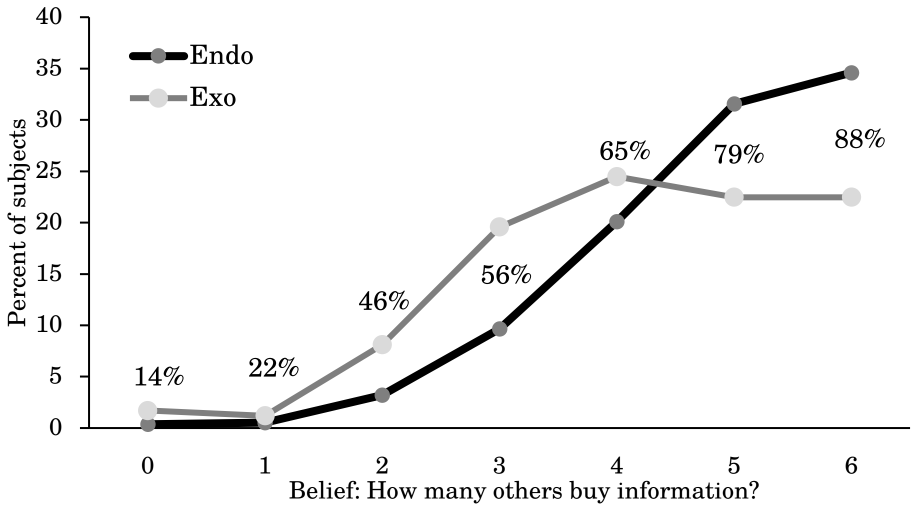
Figure 3 shows that most subjects are optimistic about information acquisition by others and that subjects act in a way compatible with conditional cooperation, i.e., that they are more likely to acquire information when they expect many others to do so, too. Most subjects

[16] Interacting *Period* with the treatment variable *Endo* does not yield a significant result either (not reported in the tables).

[17] The measure of cooperativeness is obtained from the contribution to a public goods game played at the end of the experiment. The game had the following parameters: Endowment = 8€, group size = 3, marginal per-capita return = 0.5. The average contribution was 40% of the endowment (3.18€) and the average belief was 3.83€.

have highly optimistic beliefs. For example, only about 1% of all subjects are pessimistic and expect that none of the others would buy information, while more than 28% expect that all others buy information.[18] The numbers next to the graphs show that actions mirror beliefs closely. For example, among those with the most pessimistic beliefs, only 14% buy information. In contrast, among those with the most optimistic beliefs, 88% buy information. The strong positive correlation (Spearman's rho = 0.321, highly significant with p = 0.000) between beliefs and own informedness is suggestive of conditional cooperation which has been shown to be an important preference in social dilemma situations. Another possibility is false consensus, i.e., that subjects who acquire information project their behavior on others and are hence more optimistic than subjects who remain uninformed.[19]

Figure 3: Distribution of beliefs about information demand by others and total percentages of information acquisition



Notes: Figure 3 shows the share of subjects holding a particular belief about how many others in one's group will buy information. Percentages next to the lines indicate the share of informed subjects in each bin. For example, a total of 28.5% of subjects expected 6 (i.e., all) others in their group to buy information (35% in *Endo*, 22% in *Exo*). Of those subjects, 88% bought information (*Endo* and *Exo* combined).

Figure 3 also shows that there is a treatment effect on beliefs. We find that subjects are more optimistic about information acquisition by others when the group demanded to vote (in *Endo*) than when the vote is imposed on them (in *Exo*). For example, the share of

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18 Beliefs are correct to a high degree. The correlation between individual beliefs about the number of informed others and the actual number of informed others is 0.55 (Spearman's rho is 0.54; p = 0.000, Spearman test).

19 We are grateful to an anonymous referee for pointing this alternative interpretation out to us.

very optimistic subjects, i.e., those who expect all others to buy information, is higher in *Endo* (35%) than in *Exo* (22%). Conversely, the share of subjects with an intermediate belief of 3 is higher in *Exo* (20%) than in *Endo* (10%). Over all levels, optimism about others' information demand is significantly higher in *Endo* than *Exo* (p = 0.069, MWU test). While this result shows that there is a treatment effect, one may again worry that a subject's information demand is driven by observed information demand by others in the past rather than contemporaneous, i.e., expected, information demand by others. However, we find that this test is also significant when using first-round beliefs only (for c_M and c_H jointly, p = 0.026, MWU test), showing that past experience is not the only driver.

While beliefs and information demand are higher in *Endo* than *Exo*, it is also true that most of the subjects who sign the petition (90% = 303/336) in *Endo* buy information and seem committed. This commitment effect is in line with evidence from field experiments that have shown that explicit plans about whether and when to vote increase turnout (Nickerson and Rogers 2010, see introduction). Signing the petition in *Endo* is like making a plan to vote. However, our results encompass previous findings that planning (in our paper in the guise of signing the petition) increases turnout. In addition, we find in regression analysis (see Appendix, Table B4) that *informed* voting is higher among those who sign the petition, i.e., we extend previous results about turnout to a result about informed voting. We summarize our discussion in this section in

Result 5: *Beliefs mirror actions closely: those expecting high information demand by others tend to demand more information themselves. Subjects in Endo are more optimistic about others' information demand than subjects in Exo.*

4 Concluding remarks

The main contributions of this paper are to show in a controlled setting that voter motivation to cast an *informed* vote is higher than predicted by standard theory, that voter motivation can be further improved by providing information about widespread plans of informed voting in the electorate, that this effect operates through expectations, and that it is larger than cutting the costs of information by one unit. Below, we discuss some caveats and alternative interpretations.

Common interest. We have studied voter motivation and its effect on information aggregation in the context of a common-interest situation. In this context, voter motivation adds to the "epistemic quality" of collective choice, and it is clearly desirable. But voter motivation in the guise of high participation may of course have benefits other than information aggregation. It may, for example, add legitimacy to decisions and thereby improve compliance. We think a pure common-interest situation provides an ideal starting point to investigate voter motivation. The reason is that casting an informed vote is crucial in such settings and we can calculate a clear benchmark for optimal information acquisition in our controlled setting. However, we also feel that a useful next step would be to analyze situations in which both conflicting and common interests play some role.

High motivation. We observe in our experiment that the motivation to acquire costly information and to participate was higher than predicted by standard theory. Candidate explanations for this observation are a sense of civic duty and expressive voting. Brennan and Lomasky (1993) argue that voters derive utility from expressing support for ethical or ideological principles and Feddersen et al. (2009) show that this may result in a "moralistic bias" (see also Feddersen and Sandroni 2006, Coate and Conlin 2014, and Tyran and Wagner 2018 for a survey of the experimental literature). Ethical considerations do not seem plausible for the choice between A and B in our context (the options are ex ante identical), but they do seem plausible with respect to casting an informed vote as such. Tyran (2004) shows that expressive voting on an ethical issue depends on expectations. In particular, he shows that people are more likely to vote for taxing everyone and to donate tax revenues if they think many others do. As in the present experiment, voters are more willing to incur a personal cost for a "good cause" if they think others are also willing.

Informed voting. Our design allows for various types of error in voting which undermine efficiency. In particular, casting an uninformed vote, voting against one's signal, or abstaining despite being informed are admitted. However, the observed rates of such counterproductive behavior are low (12%, 3%, and 1%, respectively) in our experiment compared to other studies that also allow for such behavior. For example, Großer and Seebauer (2016) find rates of uninformed voting that are almost three times (about 30 percent) and Elbittar et al. (2014) about five times as large in comparable cases. We think that we observe much lower rates of uninformed voting because the awareness of information aggregation created by the instructions reduces confusion and errors and facilitates subjects' understanding.

Field studies have also found correlations between participation and information. For example, Jones and Dawson (2008) find in a survey study that those who believe that there is a duty to vote (and are therefore more likely to turn out) are better informed than those who do not. But this correlation may well be driven by unobserved characteristics such as the respondents' upbringing and education, or their "civic-mindedness". Lassen (2005) finds in a natural experiment in Denmark that better informed people are more likely to vote, Lopez de Leon and Rizzi (2014) find that forcing people to vote does not increase their informedness.

Size of electorate. Our electorates with $n = 7$ voters have a size comparable to similar studies (Großer and Seebauer 2016 and Elbittar et al. 2014 use groups of size 3 and 7, Bhattacharya et al. 2015 of size 3, 7 and 13). Understanding the effect of group size is important for attempts to extrapolate the results to naturally occurring settings with large electorates. The benefits of buying information decrease with participation, i.e., information aggregation gets weaker as n increases. If the cost of information remains constant, a threshold is soon reached when voting is not individually rational for a self-interested voter, and another threshold may be reached later when voting is not socially optimal (see Corollary 2 in the SOM). While the basic characteristics (e.g. free-riding incentives, lower demand for information with higher cost) discussed in section 2 remain the same with larger electorates, increasing n does not improve (nor reduce) informational efficiency in theory beyond some point. However, things are not entirely straightforward even in theory when the cost of information increases with its precision. Martinelli (2006) shows for this case that even large electorates may be informationally quite efficient.

Social information. We find that the effects of providing social information are mediated by beliefs. Hence, we find a correlation between optimism about others' willingness to be informed and one's own willingness to be informed. Such correlations have also been observed in field studies. For example, Knack (1992) and Opp (2001) find that citizens are more likely to vote if they have politically active friends or partners. However, such a correlation may well be due to sorting: citizens with a strong interest in politics are more likely to choose friends and partners with similar interests. In contrast, our results cannot be due to sorting because we randomly assign subjects to treatments.

Our results may well underestimate the relevance of such reciprocal relations for voting in the field because our design rules out (i.e., controls for) supply-side responses. In the field, an increased demand for information is likely to induce an increase in the supply of information, i.e., reduce its cost. For example, Benz and Stutzer (2004) show that the media report more on a particular issue when citizens are about to vote on that issue than when parliament will decide. Relatedly, committees might receive more precise information if they vote on a given issue than if an expert decides.

We believe that further investigations into how social information shapes voter motivation both in the organizational and political context are important and promising. As was the case for the present study, field experiments could provide useful inspiration for further laboratory investigations. The field experiments of Della Vigna et al. (2014) and Rogers et al. (2016) show that (anticipated) social pressure may lead to higher turnout. Our framework would lend itself to investigate whether social pressure can also improve *informed* voting, not just participation. For example, an announcement that subjects will be asked (perhaps by other citizens) might prompt extra effort to collect information for fear to otherwise look like a clueless "idiot"[20] to one's peers.

[20] An "idiot" in Athenian democracy was someone who was characterized by self-centeredness and concerned almost exclusively with private — as opposed to public — affairs, according to Wikipedia. Declining to take part in public life, such as democratic government of the polis (city state), was considered dishonorable. "Idiots" were seen as having bad judgment in public and political matters.

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Appendix A: Instructions for *Endo* (translated from German)

Welcome! You will now take part in a decision-making experiment. You can earn money during the experiment, and all earnings will be paid out immediately at the end of the experiment. Your earnings depend on the decisions you and other participants in this experiment make.

The instructions below are identical for all participants. It is important that you read the instructions carefully so that you understand the decision-making situation well. In case anything is unclear or if you have questions, please raise your hand. We will answer your questions in private.

Please do not ask your questions aloud. Passing on any kind of information to other participants is not allowed. Talking to other participants during the entire experiment is not allowed. Whenever you have a question, please raise your hand; we will come to you and answer your question in private. Following these rules is essential for the scientific value of the experiment.

Once all participants have read the instructions and have no more questions, all participants will answer a short quiz. The quiz serves to make sure everyone understands the instructions.

All participants and their decisions will remain anonymous to other participants during the entire experiment. You will neither learn the true identity of your interaction partners nor will others find out about your identity.

General description. The experiment consists of three parts, and the first part has several rounds. In the first two parts participants may collect information and make decisions. You can earn money by your decisions. At the end of the entire experiment, the computer will randomly pick one round from the first part, which means that each round has the same chance to be picked. The amount that you earn in that round and the amounts you earn in the remaining parts will be paid to you in cash immediately at the end of the experiment.

Below, you will find the instructions for the first part of the experiment. Once the first part is completed you will receive instructions for the second part. After the second part, a survey with a few questions follows in a short third part. After that, you will receive your payment and the experiment ends. The sequence of the first part of the experiment, the decisions and the payment modalities are explained now.

First part. In this experiment you are in the role of a citizen and make decisions about **construction projects** in your city. Each construction project can be implemented by one of two companies. One of the companies is fit to do the job, the other is not. The task is to **hire the company that is fit** for the job.

The choice of a construction company can be made in two ways. The first way is that citizens **vote** on which company to hire. Citizens will only vote if they have demanded a vote. They can demand the vote by **signing a petition**. If sufficiently many sign the petition, a vote takes place. Citizens can individually investigate about which company is fit before voting, but investigating is costly. The second way to choose which company to hire is to delegate the choice to the **mayor**. The mayor only makes the choice if not sufficiently many citizens demand to vote by signing the petition. The mayor's competence to pick the right company for the job is known to all citizens.

The decision whether to demand a vote can depend on various factors. Under some conditions the citizens can be expected to make better choices, under other conditions the mayor is more likely to make better choices. The more citizens investigate about the companies, the more likely they are to choose the better company through voting. The more competent the mayor is, the more likely he is to choose the better company. The exact procedure of the decision-making process is described below.

At the beginning of the experiment, all participants are randomly matched into groups of 7 participants. Group composition remains constant during the entire first part. As a member of your group, you are one of the 7 citizens who are all entitled to vote.

Choose one of two companies. The city plans to make a series of construction projects which benefit all citizens equally. For each project, two companies are eligible. Only one of the two companies is fit for the job, i.e., has the necessary specialists to implement the project successfully. The other company is unfit and if it is chosen, the construction project will be a failure. Hence, one of the two companies is fit for the job, the other is not. Which company is fit does not depend on the success or failure of prior projects and each of the two companies is equally likely to be the right one. If the fit company is chosen, the project is a success. In this case, all residents benefit equally. In particular, each citizen earns **25 euros** when the construction project is a success, and each earns **0 euros** when the project is a failure.

Who has information about the companies and how can it be collected? At the beginning of the period, nobody can infer which of the two companies is fit for the job. To find out which company is better, investigations are necessary. There are two possibilities: Either the mayor does the investigation and decides by himself which company to hire. Or citizens vote, and in this case each citizen decides for him- or herself whether to investigate and collect information about the companies. The company who gets the majority of the votes is hired for the construction job.

Mayors are more or less used to make the choice between companies but they differ with respect to the level of their competence. Experienced mayors select the fit company in **90 out of 100 cases**, inexperienced mayors select the fit company in **60 out of 100 cases**. The role of the mayor is played by the computer.

Each citizen is uninformed about which is the fit company in each case, but when **all or a sufficient** number of citizens investigate, they are as a group **better** informed than the inexperienced mayor but they remain less well informed than the experienced mayor. If an individual citizen investigates, the **information** that he or she obtains serves to identify the company that is fit for job in **60 out of 100 cases**. If all citizens investigate, they choose the fit company by voting in 71 out of 100 cases.

In general: the more citizens are informed the more likely the majority is to make the right choice. However, investigating is costly. The cost is either 0.10 euros, 0.90 euros or 1.70 euros.

The cost of information collection as well as the experience of the mayor can vary from one "term" to the next, but remain constant within a given term. Altogether there are 6 terms with 4 rounds each, which means that there are in total 24 rounds in which a choice between two companies has to be made.

The petition: deciding about which company to hire. At the beginning of each term, all citizens are informed about the information costs and the level of the mayor's experience in the coming 4 rounds. There is the opportunity to sign a **petition** to demand a majority vote. If sufficiently many sign the petition, meaning that **at least 4 out of 7** citizens sign, the choice of which company to hire is made by **voting** of the citizens. Otherwise the **mayor** makes the choice.

If you are in favor of voting for the upcoming 4 periods, "sign" by typing your pseudonym into the form (you will receive a pseudonym at the beginning of the experiment which remains the same during the entire session. It will be displayed on your screen when signing is possible). If you favor the decision to be made by the mayor, please type "no, thank you" into the form. You can proceed by clicking "confirm" (see figure).

Depending on the situation in a term it can be profitable for the citizens to sign the petition and to demand the vote, but this is so only if sufficiently many citizens investigate about the fitness of the companies for the job before voting.

* Screenshot "petition" here *

The decision by the mayor. The mayor decides which company to hire if the petition fails, i.e., if insufficiently many citizens sign the petition. In this case, there is no voting and you have to wait briefly until a decision is made. During that waiting period you can answer quiz questions. (The answers to these questions do not affect your payments. You will be informed about the answers to all quiz questions at the end of the experiment). You will then be informed which company the mayor has chosen, which company was fit for the job and how much you have earned in the current round. This cycle is repeated 4 times for each construction project in a term.

Voting and the acquisition of information. You have the possibility to do costly investigations about which company is fit for the job when sufficiently many have signed the petition. If you investigate, you will obtain information that is correct in **60 out of 100 cases**. If several citizens investigate, citizens may therefore reach different conclusions. When all citizens investigate and participate in the vote, it is quite probable that the majority reaches the right conclusion and therefore hires the better company. The more citizens get informed and then vote, the more likely it is that the city chooses an appropriate company.

Independent of whether you decide to investigate, you will be asked to estimate the number of citizens in your group who have made investigations. If you guess the number correctly, you earn 0.10 euros.

Next, every citizen decides whether to participate in the voting or not.

You **increase** the chance that the city chooses the fit company for the job, i.e., you increase the chance that the construction project is successful, if you make investigations and vote according to the information you obtain. However, you **decrease** the chance that the better company is chosen if you have not investigated but vote anyway.

If you decide not to participate in voting you can answer quiz questions in the meantime. (The quiz does not affect your earnings. You will be given all answers to the quiz at the end of the experiment).

The company that receives the majority of votes is hired for the construction job. If there is a tie of votes or if nobody participates in voting, one of two companies will be picked at random by the computer. In this case, each company is equally likely to be hired.

After the voting you will learn how many citizens have investigated and received information, which company the majority has voted for, which company is fit for the job and how much you have earned.

This cycle is repeated 4 times for each construction project in a given term.

Your payment. At the end of the experiment the computer randomly chooses a round of the first part of the experiment that is relevant for your payment. If the construction project has been concluded successfully in this round you will receive 25 euros, otherwise 0 euros. Additionally you will receive 0.10 euros if you have correctly estimated the amount of informed citizens in the selected round. Any information costs in this round will be deducted.

Simulation. At the beginning of the first part you will have the opportunity to review, for 2 minutes, the track record of experienced vs. inexperienced mayors in other (fictitious) cities. In contrast to your city, there is no petition in these fictitious cities which means that the mayor makes all decisions. Reviewing the track records of mayors elsewhere is supposed to improve your understanding of the situation in your city and does not affect your payment.

Summary. At the beginning of a term, you are informed about the experience of the mayor (can be high or low) and the information costs (can be high, medium or low). These values describe the situation for the next 4 rounds in which one of two companies is hired for a construction job.

A petition to demand a majority vote in the next 4 rounds is run. You sign the petition if you are in favor of making the hiring choices by voting. You do not sign if you are in favor of having the mayor decide by himself which company to hire. The petition succeeds if at least 4 out of 7 citizens sign.

If the petition fails, the mayor decides which company to hire in the next 4 rounds. An inexperienced mayor makes the right choice in 60 out of 100 cases whereas an experienced mayor makes the right choice in 90 out of 100 cases. If the better company is chosen, each citizens gets 25 euros in the current round. If worse company is chosen, each resident gets 0 euros in the current round.

If the petition succeeds, you and the other citizens decide on which company to hire by voting in the next 4 rounds. Prior to voting you and the other citizens can buy information that is correct in 60 out of 100 cases. In addition, you are asked to guess how many group members get informed.

The citizens who participate in the voting vote in favor of one of the two companies. Citizens who do not participate in the voting answer quiz questions that are not relevant for payments.

The company that obtains more votes is hired for the job. In case of a tie or if no citizen has bought information, one of the two companies will be picked at random with equal probability. If the city has hired the better company, each citizen receives 25 euros minus any information costs the citizen may have incurred. You will be informed about the company the city has hired and whether it was the better one. You will receive 0.10 euros in addition for correctly estimating the number of informed citizens.

At the end of the experiment, one round will be chosen at random from the first part for the payments. All rounds are equally likely to be picked.

Part 1 has 24 rounds. Part 2 follows after part 1. You can earn additional amounts of money in part 2.

Appendix B: Additional tables

Table B1.1: Marginal effects with all explanatory variables at their mean values

Dep.var. *Infobuy*	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Endo	0.143** (0.056)	0.145** (0.057)	0.089*** (0.034)	0.088** (0.035)	0.097*** (0.036)	0.097*** (0.037)	0.077** (0.036)
Infocost		-0.133*** (0.024)	-0.075*** (0.016)	-0.075*** (0.017)	-0.075*** (0.017)	-0.082*** (0.019)	-0.086*** (0.018)
Belief			0.094*** (0.014)	0.095*** (0.014)	0.099*** (0.014)	0.098*** (0.014)	0.094*** (0.015)
High cooperation				0.068 (0.052)	0.066 (0.049)	0.065 (0.049)	0.064 (0.046)
Conditional cooperation					0.136*** (0.043)	0.136*** (0.043)	0.124*** (0.047)
Period						-0.003 (0.002)	-0.004* (0.002)
Controls	No	No	No	No	No	No	Yes
Constant	0.124*** (0.034)	0.246*** (0.040)	-0.195*** (0.067)	-0.233*** (0.072)	-0.320*** (0.075)	-0.279*** (0.079)	-0.151 (0.128)
N	2,688	2,688	2,688	2,688	2,688	2,688	2,688

Table B1.2: Marginal effects of *Endo* and *Infocost* at specific values (based on Regression 5)

	Endo = 0 *Infocost = 0.1*	*Endo = 0* *Infocost = 0.9*	*Endo = 0* *Infocost = 1.7*	*Endo = 1* *Infocost = 0.1*	*Endo = 1* *Infocost = 0.9*	*Endo = 1* *Infocost = 1.7*
Endo	0.094** (0.041)	0.109** (0.045)	0.122** (0.049)			
Infocost	-0.072*** (0.013)	-0.084*** (0.018)	-0.094*** (0.022)	-0.052*** (0.011)	-0.065*** (0.016)	-0.077*** (0.021)

Notes: Table B1.1 shows logit margins regressions with *Infobuy*, i.e., individual information demand, as the dependent variable. Standard errors are in parentheses, clustered at the group level. *Endo* is a dummy for the treatment. *Infocost* is the cost of information acquisition ($c_L = 0.1$, $c_M = 0.9$, $c_H = 1.7$). *Belief* indicates how many other group members are believed to acquire information. *High cooperation* = 1 if the individual contributes more than the median in a one-shot public goods game at the end of the experiment, 0 otherwise. *Conditional cooperation* = 1 if the individual claims to be more willing to return a favor to a stranger than the average person, 0 otherwise. *Period* is a round with voting. Controls include answers to a post-experimental questionnaire on attitudes to democracy. In Table B1.2 the values of *Endo* and *Infocost* are set to specific values (as shown in the first line), the values of the other explanatory variables are in each case set to their respective means, i.e., *Belief* = 4.51, *High cooperation* = 0.48, *Conditional cooperation* = 0.49. Stars indicate significance of coefficients as follows: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table B2: Information acquisition (first round only)

Dep.var. *Infobuy*	(1)	(2)	(3)	(4)	(5)	(6)
Endo	0.839** (0.386)	0.864** (0.386)	0.777** (0.397)	0.795** (0.403)	0.852** (0.407)	0.889** (0.421)
Infocost		-0.701** (0.324)	-0.531 (0.345)	-0.605* (0.349)	-0.613* (0.344)	-0.887** (0.420)
Belief			0.403*** (0.156)	0.397** (0.160)	0.393** (0.162)	0.418** (0.173)
High cooperation				0.594 (0.405)	0.580 (0.406)	0.693* (0.418)
Conditional cooperation					0.448 (0.402)	0.224 (0.437)
Controls	No	No	No	No	No	Yes
Constant	0.859*** (0.239)	1.573*** (0.446)	-0.501 (0.899)	-0.676 (0.945)	-0.873 (0.955)	-1.507 (1.165)
Wald Chi^2	4.73	11.16	16.53	17.77	18.79	24.31
Prob > Chi^2	0.030	0.004	0.001	0.001	0.002	0.028
AIC	178.67	175.81	171.49	171.25	171.99	177.78
BIC	184.92	185.19	183.99	186.87	190.73	221.51
Pseudo R^2	0.028	0.056	0.090	0.102	0.109	0.166
N	168	168	168	168	168	168

Notes: Table shows logit regressions with *Infobuy*, i.e., individual information demand, as the dependent variable, for first-round data only. Standard errors are in parentheses, clustered at the subject level. *Endo* is a dummy for the treatment. *Infocost* is the cost of information acquisition (c_L = 0.1, c_M = 0.9, c_H = 1.7). *Belief* indicates how many other group members are believed to acquire information. *High cooperation* = 1 if the individual contributes more in a one-shot public goods game at the end of the experiment than the median, 0 otherwise. *Conditional cooperation* = 1 if the individual claims to be more willing to return a favor to a stranger than the average person, 0 otherwise. Controls include answers to a post-experimental questionnaire. Stars indicate significance of coefficients as follows: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table B3: Mediation analysis

	(1) OLS Regression	(2) Logit Regression 1	(3) Logit Regression 2
	Dep.var.: *Belief*	Dep.var.: *Infobuy*	Dep.var.: *Infobuy*
Endo	0.604*** (0.050)	0.722*** (0.089)	0.434*** (0.094)
Belief	-	-	0.540*** (0.036)
Standardized coefficients of variable Endo	-	0.195 (0.024)	0.109 (0.024)
Tests	Sobel	Aroian	Goodman
Test statistic	9.421 (0.006)	9.408 (0.006)	9.433 (0.006)
p-value	0.000	0.000	0.000
N	2,688	2,688	2,688

Notes: *Endo* is a dummy for the treatment. *Belief* indicates how many other group members are believed to acquire information. *** p < 0.01, ** p < 0.05, * p < 0.1.

The mediation analysis above follows Baron and Kenny (1986). The purpose is to test whether the effect of *Endo* on *Infobuy* is mediated by *Belief*, i.e., whether there is an indirect effect of demanding the vote on a subject's willingness to acquire information that operates through a higher expectation that others are acquiring information.

Column 2 confirms our finding from Table 3 that *Endo* is indeed a significant predictor of *Infobuy*. Column 1 confirms that the *Endo* is a significant predictor of the mediator *Belief*. The comparison of logit regressions 1 and 2 shows that the (standardized) coefficient of *Endo*, the treatment variable, remains significant but becomes smaller when *Belief*, the mediator, is added as an explanatory variable. This effect is statistically significant according to three tests statistics. The interpretation is that *Endo* is partly mediated through beliefs, i.e., that *Endo* has both direct and indirect (through beliefs) effects on *Infobuy*.

Table B4: Effects of signing the petition on *Infobuy* (treatment *Endo* only)

Dep.var. *Infobuy*	(1)	(2)	(3)	(4)
Petition signed	1.413*** (0.489)	1.342*** (0.485)	1.280*** (0.486)	1.420*** (0.430)
Infocost		-0.737*** (0.175)	-0.519*** (0.148)	-0.518*** (0.154)
Belief			0.379** (0.178)	0.406** (0.174)
Conditional cooperation				0.728* (0.440)
Constant	0.121 (0.413)	0.899* (0.481)	-1.021 (1.025)	-1.575* (0.872)
Wald Chi^2	8.35	46.05	64.93	151.27
Prob > Chi^2	0.004	0.000	0.000	0.000
AIC	1319.52	1286.61	1247.84	1225.63
BIC	1329.93	1302.22	1268.65	1251.64
Pseudo R^2	0.038	0.064	0.093	0.111
N	1,344	1,344	1,344	1,344

Notes: Table shows logit regressions with *Infobuy*, i.e., individual information demand, as the dependent variable. Standard errors are in parentheses, clustered at the group level. *Petition signed* is a dummy variable that equals 1 if the subject signed the petition. *Infocost* is the cost of information acquisition (c_L = 0.1, c_M = 0.9, c_H = 1.7). *Belief* indicates how many other group members are believed to acquire information. *Conditional cooperation* = 1 if the individual claims to be more willing to return a favor to a stranger than the average person, 0 otherwise. Controls include answers to a post-experimental questionnaire (available on request). Stars indicate significance of coefficients as follows: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Supplementary online materials

This document provides the calculation of equilibria and proofs for claims in the paper "Voter Motivation and the Quality of Democratic Choice" by Lydia Mechtenberg and Jean-Robert Tyran (August 13, 2018).

1. A model of selfish democrats

Consider an odd number n of individuals forming a group that has to choose whether they want some expert decision-maker to decide for them between two alternative policies or whether they want to clamor democracy in order to make this decision themselves, by vote. For instance, citizens of a town choose whether they want to let their mayor decide which firm to mandate with an important construction project or whether they want to claim this right for themselves, signing a petition in favor of having a vote on which firm to mandate. Alternatively, the faculty of a currently reforming university department must choose whether they want to make a specific type of decisions themselves, by committee voting, or whether they want to delegate this type of decisions to the dean. Generally speaking, the group makes a collective constitutional choice between direct and expert judgment.

Under any of these two constitutions, the ultimate aim is to select the correct policy among two alternatives, P_A and P_B. To give meaning to the idea of a correct policy, define the state of the world, ω, that has two possible realizations, A or B. Realizations are drawn by nature with equal probability and cannot be directly observed. What it means for a policy to be correct is implied by the group's monetary interests which are as follows: Each individual earns a fixed payoff normalized to 1 if the policy matches the state of the world and zero otherwise. Hence, the individuals' interests in the outcome of the decision-making process are perfectly aligned; and the policy that matches the state of the world is the correct policy. Formally, if u_m denotes monetary payoffs, then $u_m(P_A \mid A) = u_m(P_B \mid B) = 1$ and $u_m(P_A \mid B) = u_m(P_B \mid A) = 0$.

A policy $P \in \{P_A, P_B\}$ must be implemented either by an expert decision-maker (expert judgment) or by the group itself (democracy). The default constitution implies expert judgment; but if at least $\nu \in [1, n]$ individuals are in favor of democracy, the constitution is changed accordingly.

If democracy is imposed, the procedure is as follows: First, at the informational stage, all group members individually decide whether to acquire a private signal $s_i \in \{A^*, B^*\}$ indicating the state of the world at individual costs $c > 0$. Signals are imperfect but informative and uncorrelated across subjects: $Pr\{\omega = A \mid s_i = A^*\} = Pr\{\omega = B \mid s_i = B^*\} = p \in (\frac{1}{2}, 1)$ for all i. Second, at the voting stage, the group members individually and simultaneously decide whether to vote for P_A or P_B or abstain. The policy that gets a simple majority of votes is implemented (if there is a tie the policy is chosen randomly, both policies with equal probability); and the resulting payoff is realized.

If, by contrast, the constitution remains unchanged, i.e., under expert judgment, the expert acts in the group's monetary interests with probability $q \in [p, 1)$, then implementing the correct policy, and fails to do so with the remaining probability. The parameter q measures the quality of expert judgment and can be taken to refer to either the quality of the incumbent's information or the probability with which his preference is to serve the "common good"; it may also represent the quality of unmodelled decision processes under expert judgment to which the incumbent has to submit. By setting $q \geq p$, we assume that expert judgment works at least as well as democracy with one informed voter.[1]

The sequence of events is as follows: First, the group chooses its constitution (constitutional stage). Second, if the constitution prescribes democracy, the individuals privately decide whether to get informed prior to the vote (informational stage). Third, nature draws the state of the world and the signal realization(s). Fourth, the policy is chosen, either by a simple majority vote under democracy (voting stage) or by expert (policy-making stage), depending on the group's constitution. Finally, payoffs are realized.

As a benchmark, we assume that individuals' preferences are given by expected monetary payoffs $E[u_m \mid \sigma]$; i.e., individuals are selfish. We test this assumption in the experimental part of the paper.

Let $\hat{\pi}(\sigma)$ denote the probability of a "correct" policy choice, given the strategy profile σ, and assume risk neutrality. Then, the individuals' preferences are fully described by $\hat{\pi}(\sigma)$; and the game can be solved by backward induction. The relevant equilibrium concept is subgame-perfect Nash equilibrium. In the SOM, section 2 (SOM 2), we restrict our equilibrium analysis to pure-strategy equilibria. Off-equilibrium improvements are analyzed in SOM 3. An additional analysis of symmetric mixed equilibria for the specification of our model that we implement in our experiment is relegated to SOM 4. SOM 5 contains a QRE analysis. All proofs are relegated to SOM 6.

Pure-strategy equilibria. Any pure-strategy equilibrium of the game involves a number $k \in \mathbb{N}_0{}^{\leq n}$ of players who acquire information and a number $n - k$ who do not. As a first step toward identifying the strategy profiles that can become equilibria, we make explicit two

[1] Dropping this assumption does not change the main results.

sets of conditions on equilibrium behavior. The first set of conditions characterizes the behavior of informed voters. The second set of conditions defines in which way uninformed voting can occur in equilibrium. The former are straightforward:

Lemma 1: Informed Voters *(a) Individuals get informed only if they can be pivotal at the voting stage. (b) Conditional on being informed and having a strictly positive pivot probability, individuals vote for the policy that is indicated by their signal.*

The corresponding conditions on uninformed voting are not equally obvious. First, let us distinguish between strategy profiles in which all uninformed voters cast the same vote, for instance for policy P_A, and such strategy profiles in which they cast different votes. We will refer to the first as "homogeneous uninformed voting" and to the second as "heterogeneous uninformed voting". Second, consider all strategy profiles in which, for all draws of nature, the voting outcome is always the policy indicated by the majority of signals or, if no such majority exists, the outcome of a random draw of nature. Note that any strategy profile in this class is, in expectation, outcome-equivalent to a profile in which the same number of informed voters vote and the uninformed abstain. Define this latter class of strategy profiles as "let the experts decide" strategy profiles. Then, we get the following restrictions on uninformed voting in equilibrium:

Lemma 2: Uninformed Voters *Let the number of voters who do not abstain be denoted by $m \leq n$. (a) Homogenous uninformed voting occurs in a pure-strategy equilibrium if and only if all m voters stay uninformed. (b) Heterogeneous uninformed voting occurs in a pure-strategy equilibrium only if the numbers of uninformed voters for either policy are exactly equal and the number of informed voters k and hence the total number of voters m is odd.*

As a consequence of these two Lemmata, we can pin down the two most important properties that all non-trivial pure-strategy equilibria must have in common:

Definition: *A strategy profile exhibits "informational efficiency" at the voting stage if, for any draw of nature, the policy implemented by the majority vote is indicated by the signal realization most often received in the subgroup of informed individuals.*

Proposition 1: Non-trivial equilibria. *All pure-strategy equilibria in which any player can be pivotal are outcome-equivalent to "let the experts decide" equilibria and thus exhibit informational efficiency at the voting stage.*

Hereafter, we shall assume that only non-trivial equilibria are played; i.e., equilibria in which players can be pivotal. We will hence drop explicit reference to "let the experts decide" equilibria whenever possible, intending, when we speak of pure-strategy equilibria in general, to refer to such equilibria that are outcome-equivalent to "let the experts decide" equilibria. As a consequence, we can define classes of outcome-equivalent equilibria by defining the precise number k of informed voters. Each k entails one “let the experts decide” strategy profile and corresponding outcome-equivalent strategy profiles, all involving the k informed voters voting in favor of the policy indicated by their private signal. The “let the experts decide” strategy profile implies abstention for all $n-k$ uninformed voters. The outcome-equivalent strategy profiles allowing for uninformed voting involve $\frac{1}{2}(m-k)$ uninformed voters voting for policy P_A and $\frac{1}{2}(m-k)$ uninformed voters voting for policy P_B, thereby offsetting each others' votes, with m ranging from k to n. A class of equilibria is hence defined by an *odd* number k, as implied by Lemma 2, part (b), and an information cost c.

In SOM 2 and 3, respectively, we give a full characterization of the set of pure-strategy equilibria and describe possible off-equilibrium improvements in our model. The picture that emerges from this characterization provides us with four main insights: First, within a given interval of information costs, there are classes of equilibria that differ in the number of informed voters k^* and can be Pareto-ranked, their rank increasing in k^*. Second, generally a group under democracy could improve by having more informed voters than attainable in equilibrium. Third, and relatedly, groups that are more able to coordinate on high numbers of informed voters under democracy tend more to select into democracy. Fourth, however, there is no decision rule v at the constitutional stage that forestalls the group choosing the “wrong constitution”. Such a wrong choice is made if, for instance, the group chooses democracy despite the fact that the sum of expected net earnings would be higher under expert judgment or, conversely, the group chooses expert judgment although it would (or at least could) fare better under democracy.

2. Pure-strategy equilibria of the model

Consider the probability that a majority vote of k informed voters identifies the correct policy, i.e., the policy that matches the state of the world. We refer to this probability as the "success probability" (SP) and define it as

$$\pi(k) = \sum_{l=0}^{\frac{k-1}{2}} \binom{k}{\frac{k+1}{2}+l} p^{\frac{k+1}{2}+l}(1-p)^{\frac{k-1}{2}+l}$$

Note that $\pi(0) < \pi(1) = \pi(2) < \pi(3) = \pi(4) < \ldots < \pi(n)$, $\log_{n\to\infty} \pi(n) = 1$, and that $\pi(2x+1) - \pi(2x-1)$ is strictly decreasing and strictly convex in $x \in \{1, 2, 3, \ldots, \frac{n-1}{2}\}$. Hence, if the strategy profile σ contains only pure strategies, any given individual i can increase the SP by acquiring information if and only if the number of other informed voters is even. Moreover, starting from a given odd number of informed voters and adding two additional informed voters always increases the success probability, but at a decreasing rate.

Let c_0 denote the information cost that makes a given individual exactly indifferent between getting informed to vote his signal and remaining uninformed (and hence abstain), given that the other individuals stay uninformed and abstain. Hence, only cost levels below c_0 allow for informed voting. With regard to these cost levels, let c_x denote the cut-off information costs that make a given individual exactly indifferent between getting informed to vote his signal, on the one hand, and remaining uninformed to abstain, on the other hand, given that x other individuals get informed to vote in line with their signal, while the remaining individuals abstain, with $x \in \{1, 2, 3, \ldots, k-1\}$. Then, we get

Proposition 1 *(a) There are the following pure-strategy subgame equilibria in the voting game: (i) No individual is informed for $c \geq c_0$. (ii) There are intervals $(c_x, c_{x-1}]$, with $x \in \{1, 2, 3, \ldots, \frac{n+1}{2}\}$ and $k \in \{1, 3, \ldots, n\}$ such that k individuals get informed for $c_x < c \leq c_{x-1}$, with $c_{\frac{n+1}{2}} = 0$. (b) Suppose that the equilibrium played in the subgame involves k^* informed voters. Then, the group will select into voting in the equilibrium of the entire game if and only if either (i) $\pi(k^*) - c \geq q$ or (ii) $\pi(k^*) \geq q$ and $n - k^* \geq v$.*

Intuitively, moving the information costs from a high-cost interval to the neighbouring lower-cost interval brings into existence one more equilibrium; and in this equilibrium, two more individuals get informed and vote what their signal indicates. Thus, n equilibria exist in the lowest cost interval and only one equilibrium – with one informed voter – in the highest (closed) cost interval. For (1) = q, this equilibrium would be in weakly dominated strategies.

Corollary 1 *Let $\bar{k}$ denote the highest number of informed voters attainable in a pure-strategy subgame equilibrium under democracy, for given c. Then, all pure-strategy subgame equilibria under democracy with $k \leq \bar{k} - 2$, if existent (i.e., if $\bar{k} \geq 3$), can be Pareto-ranked for any given c; the rank increases with the number k of informed voters. Moreover, moving from the equilibrium with $\bar{k} - 2$ informed voters to the equilibrium with $\bar{k}$ informed voters weakly increases everybody's expected net payoff.*

Corollary 1 implies that, once democracy has been chosen in the constitutional stage, it is socially beneficial to coordinate on the most informative equilibrium, i.e., the equilibrium with the highest number of informed voters. In general, the picture emerging from the model at this stage suggests that democracy works well when the issue at hand is easy to solve (low c and/or high p) but tends to fail in its purpose when a reasonably good decision requires intense aggregation of hard-to-get information (high c and low p).

This insight opens up the question whether the group succeeds in making the socially optimal constitutional choice in the face of known information costs and informational quality. To give a precise meaning to the concept of a socially optimal constitution, we will henceforth speak of one constitution "socially dominating" the other if the former generates a strictly higher expected net group payoff $n\pi(k^*) - kc$ in equilibrium.

Proposition 2 *(a) Let $n\pi(k^*) - q > k^*c$ in the subgame under democracy. Then, democracy socially dominates expert judgment but is chosen if and only if either $\pi(k^*) - q > c$ or $v \leq n - k$. (b) Let $0 < n\pi(k^*) - q) < k^*c$ and $\pi(k^*) - \pi(k^* - 1) \geq c$. Then, if $v \leq n - k^*$, democracy is chosen although socially dominated by expert judgment. (c) If $\pi(k^*) > q$, then democracy is the socially optimal constitutional choice for large n. (d) If $\pi(k^*) < q$, then expert judgment is the socially optimal constitutional choice for large n.*

As Proposition 2 reveals, the question which of the two opposite constitutional choices is optimal for the group has no straightforward theoretical answer but depends on parameters and group coordination under democracy.

3. Off-equilibrium improvements

The fact that the subgame equilibria under democracy can be Pareto-ranked, their rank increasing with the odd number k of informed voters, suggests that the group would be able to improve its expected net payoff even beyond the bounds of equilibrium if it could increase the number of informed voters above the highest that is attainable in equilibrium. Remember that this number is denoted by $\bar{k}$ and let $\triangle\,\pi(k)$ denote the difference in success probabilities $\pi(k+2) - \pi(k)$. Moreover define the socially optimal number of informed voters k^{**} by

$$k^{**} = arg \max_{k,k\leq n}\{n\pi(k) - kc\}.$$

Then, we get:

Corollary 2. *(a) For large n, $k^{**} > \bar{k}$. (b) For any finite group size n, the socially optimal number of informed voters is n if $\frac{1}{2}\triangle\,\pi(n) > \frac{c}{n}$ and some k^{**} with $k \leq k^{**} < n$ otherwise.*

Intuitively, if the group size converges to infinity, then the positive externality that two additional informed voters generate outweighs their costs of information acquisition, at least at the limit. Moreover, if in a group of finite size everyone gets informed and would still profit from two more additional votes, it is obvious that the best what they can do is to get all informed. If, by contrast, the information costs are so high that at some point, the increased SP would not be sufficient to outweigh the additional information costs, then there is an interior solution to the problem of finding the socially optimal number of informed voters. This solution may well lie above the highest number attainable in equilibrium.

4. Symmetric mixed-strategy equilibria in the example

Let EU_i^I denote the expected utility of i if i gets informed and votes his signal with probability $r \in [0,1]$ and remains uninformed and abstains with probability $(1-r)$, given that the other six individuals apply the same mixed strategy. Let EU_i^{NI} denote the expected utility of i if i remains uninformed and abstains, given that the other six individuals each get informed and vote their signal with probability $r \in [0,1]$ and remain uninformed and abstain with probability $(1-r)$. Note that

$$EU_i^I = \sum_{k=0}^{6} \frac{6!}{k!\,(6-k)!} r^k (1-r)^{6-k} \pi(k+1)25 - c$$

$$EU_i^{NI} = \sum_{k=0}^{6} \frac{6!}{k!\,(6-k)!} r^k (1-r)^{6-k} \pi(k)25$$

in our example. The indifference condition required for i to apply the mixed strategy described amounts to $EU_i^I - EU_i^{NI} = 0$, i.e.,

$$25(1.366r^6 - 4.516r^5 + 6.338r^4 - 4.88r^3 + 2.22r^2 - 0.6r + 0.1) - c = 0.$$

Solving for the different cost levels 0.1, 0.9, and 1.7, and denoting the equilibrium probability of getting informed by r_l, r_m, and r_h for low, medium and high costs, we get $r_l = 1, r_m = 0.221$, and $r_h = 0.068$. Denoting the mixing probability by r_c, the expected utility of the mixed subgame equilibrium with voting amounts to:

$$EU = \sum_{k=0}^{7} \left(\frac{7!}{(7-k)!k!} r_c^k (1-r_c)^{7-k} \pi(k)25 \times 7 - kc \right).$$

Plugging in the mixing probabilities for the three cost levels reveals that the expected utility from the mixed strategy equilibria with voting lies strictly below 105, the expected utility from delegation, if costs are high or medium. Hence, for these two cost levels, individuals will not sign the petition in equilibrium. For low costs, the result from the pure-strategy equilibrium analysis applies.

5. Log-QRE

We now present the existence condition for the symmetric quantal response equilibrium (QRE; McKelvey and Palfrey 1995) at the information-acquisition stage, using the logit-specification of QRE (Goeree and Holt 2005). Let μ denote a noise parameter with $\mu \geq 0$. Then, the existence condition for a log-QRE is

$$\mu\left(-\ln\left(\frac{1-r}{r}\right)\right) = EU_i^I(r) - EU_i^{NI}(r),$$

with r, $EU_i^I(r)$, and $EU_i^{NI}(r)$ defined analogously to above (SOM, section 4). Since the derivation of this condition is analogous to the derivation of equation (1) in Großer and Seebauer (2016), we skip it here.

Inserting the respective definitions for $EU_i^I(r)$ and $EU_i^{NI}(r)$, we get

$$\mu\left(-\ln\left(\frac{1-r}{r}\right)\right) = 25(1.366r^6 - 4.516r^5 + 6.338r^4 - 4.88r^3 + 2.22r^2 - 0.6r + 0.1) - c.$$

Großer and Seebauer (2016) estimate three different values of μ for their voluntary-voting game with 7 voters and endogenous information acquisition, $\hat{\mu} = 0.05$ for the second half of periods, $\hat{\mu} = 0.06$ for all periods, and $\hat{\mu} = 0.07$ for the first half of periods. In a first step, we insert these for μ into the above existence condition, generating three different existence conditions for the log-QRE per cost level c.[2] The table below summarizes the resulting predictions for the individual information-acquisition probability r. With "n.a." we denote the non-existence of a log-QRE for the given values of c and μ.

c / μ	$\mu = 0.05$	$\mu = 0.06$	$\mu = 0.07$
$c = 0.1$	n.a.	n.a.	n.a.
$c = 0.9$	0.24389	0.24822	0.25249
$c = 1.7$	0.082397	0.085165	0.087913

To test whether our observed information-acquisition rates differ significantly from the above QRE predictions, we proceeded as follows: We simulated information acquisition in a group of 7 voters according to the above predicted values for r. We then tested our observed information-acquisition distributions against the simulated ones, using Wilcoxon-signed rank tests. We did this multiple times. In all cases (i.e., for $c = 0.9$ and $c = 1.7$), our

[2] We are grateful to an anonymous referee for suggesting this type of approach.

observed information-acquisition distributions differ significantly from the simulated ones ($p = 0.0022$, see Table SOM 1 below). We obtain an analogous result when testing the observed average frequencies of information acquisition on the group level against the predicted values for r (degenerate distribution, see Table SOM 2 below).

Hence, for the three estimates of μ $(0.05, 0.06$, and $0.07)$ taken from Großer and Seebauer (2016), we do not find that log-QRE can explain our observed rates of information acquisition.

Since we did not find a game more similar to ours than the one in Großer and Seebauer (2016) for which estimates of μ exist, we refrain from inserting further out-of-sample estimates for μ. Instead, we implement the reverse procedure: We insert our observed average frequencies of information acquisition (per treatment, taken from Table 2) for r into the existence condition for the log-QRE and solve for μ. The resulting solutions for μ are summarized in the table below.

c / treatment	Exo	Endo
$c = 0.1$	$\mu = 0.26939$	$\mu = 0.16077$
$c = 0.9$	$\mu = -0.73152$	$\mu = -0.38307$
$c = 1.7$	$\mu = -6.2587$	$\mu = -1.4286$

Since the predicted values for μ for cost levels $c = 0.9$ and $c = 1.7$ violate the condition that $\mu \geq 0$, we conclude that log-QRE cannot explain the (off-equilibrium) overinvestment into information that we find for medium and high cost levels. Note that log-QRE explains *under*investment in information in Großer and Seebauer (2016) and can also explain the underinvestment in information acquisition that we observe for low costs, where the predicted information-acquisition rate in the symmetric mixed- and pure-strategy Nash equilibria are 100%.

Table SOM 1: Wilcoxon signed-rank tests, averages calculated by group, simulation

μ	0.05				0.06				0.07			
Endo / Exo	Endo		Exo		Endo		Exo		Endo		Exo	
Infocost	0.9	1.7	0.9	1.7	0.9	1.7	0.9	1.7	0.9	1.7	0.9	1.7
QRE prediction*	0.2439	0.0824	0.2439	0.0824	0.2482	0.0852	0.2482	0.0852	0.2525	0.0879	0.2525	0.0879
Z	3.061	3.061	3.062	3.062	3.059	3.061	3.061	3.061	3.059	3.062	3.061	3.059
Prob > |z|	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022

Table SOM 2: Wilcoxon signed-rank tests, averages calculated by group

μ	0.05				0.06				0.07			
Endo / Exo	Endo		Exo		Endo		Exo		Endo		Exo	
Infocost	0.9	1.7	0.9	1.7	0.9	1.7	0.9	1.7	0.9	1.7	0.9	1.7
QRE prediction*	0.2439	0.0824	0.2439	0.0824	0.2482	0.0852	0.2482	0.0852	0.2525	0.0879	0.2525	0.0879
Z	3.065	3.062	3.065	3.065	3.065	3.062	3.065	3.065	3.065	3.062	3.065	3.065
Prob > $\|z\|$	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022

* No QRE predictions for c = 0.1 available due to non-existence of log-QRE for these specific parameter combinations.

6. Proofs

Proof of Lemma 1. Let π_{-i} denote the probability with which the group votes for the correct policy if group member i abstains from the vote and let π_{Σ_i} denote the corresponding probability if i participates in the vote according to his strategy Σ_i. The expected utility of i is $\pi_{-i} - c$ if i plans to acquire information and either abstain or participate without ever being pivotal and π_{-i} if i plans to abstain without information or if i plans to participate without information but cannot be pivotal. Since $c > 0$, $\pi_{-i} > \pi_{-i} - c$. Hence, i will buy information only if he plans to participate and has a positive pivot probability. This proves part (a) of the Lemma. Consider now part (b) and let Σ_i denote i's strategy to get informed and vote in line with the signal. By contrast, let $\Sigma_i^{'}$ denote i's strategy to get informed and vote the opposite of what the signal indicates. Since conditional on being informed, i has a positive pivot probability (part (a)), and since the quality of the signal is $p > 0.5$, we have $\pi_{\Sigma_i} > \pi_{\Sigma_i^{'}}$. Thus, conditional on being informed, i has the highest expected utility when voting in line with his signal. This proves part (b).

Proof of Lemma 2. *Step 1*: Let $m \leq n$ denote the *odd* number of group members participating in the vote. Among those, k group members are informed and vote in line with their signal; and $m - k$ cast identical uninformed votes. W.l.o.g., we assume this vote to be in favor of policy P_A. The remaining group members (if there are any) abstain. Let $\hat{k}$ denote the number of signals that indicate state of the world A. Policy P_A wins the vote if and only if it gets more votes than the alternative, P_B, i.e., if and only if $m - k + \hat{k} > k - \hat{k}$. Consider now an uninformed voter i. He is pivotal if and only if $\hat{k} + m - k = k - \hat{k} + 1$ with $\hat{k} \geq 0$. This is equivalent to $\hat{k} = k - \frac{1}{2}(m-1) \geq 0$ which we will refer to as condition (i). Condition (i) implies that a number $k \geq \frac{1}{2}(m-1)$ group members get informed to vote in line with their signal.

We will now prove the following *claim*: Conditional on pivotality of an uninformed voter voting for P_A, the number $\hat{k}$ of signals in favor of state of the world A is strictly lower than the number $k - \hat{k}$ of signals in favor of B, which implies that the uninformed voter wants to deviate to voting for P_B.

Proof of the claim: Suppose for the sake of the argument that the opposite holds true, i.e., $\hat{k} \geq k - \hat{k}$, while the uninformed voters are pivotal. Due to condition (i), this implies $2\left(k - \frac{1}{2}(m-1)\right) \geq k$ or $k \geq m - 1$. This is equivalent to saying that either $k = m - 1$ or $k = m$. Since we are assuming that a strictly positive number of group members are uninformed voters, we have $k < m$ and hence conclude that $k = m - 1$, i.e., we have one single uninformed voter voting for P_A. Since m is odd, this implies that k be even. Hence, pivotality of the uninformed voter implies that half of the informed voters vote (according to their signals) for P_A while the other half vote (according to their signals) for P_B. Consider one of the informed voters with a signal in favor of A. He is pivotal among the informed voters if and only if this signal creates a tie. Hence, conditional on his pivotality, he is indifferent between both policies; and in all other cases, he wants the policy to win that is indicated by the majority of signals received by the other $k - 1$ informed voters. Hence, he can strictly improve his expected payoff by deviating to remaining uninformed (saving c) and voting in favor of P_B, thereby offsetting the other uninformed vote and making sure that the policy indicated by the majority of $k - 1$ signals always wins the vote. Therefore, $m = k - 1$ cannot be an equilibrium. In sum, we have shown by contradiction that our claim must be true.

Step 2: Let $m \leq n - 1$ denote the *even* number of group members participating in the vote. Among those, k group members are informed and vote in line with their signal; and $m - k$ place identical uninformed votes. Without loss of generality, we assume this vote to be in favor of policy P_A. The remaining group members (if there are any) abstain. Let $\hat{k}$ denote the number of signals that indicate state of the world A. Policy P_A wins the vote if and only if it either wins a tie or gets at least two more votes than the alternative, P_B. Hence, uninformed voter i is pivotal if and only if there is a tie without him, i.e., $m - k + \hat{k} = k - \hat{k}$ with $\hat{k} \geq 0$ which amounts to $\hat{k} = k - \frac{1}{2}m$. We will refer to this equality as condition (ii).

We will now prove the following *claim*: Conditional on pivotality of an uninformed voter voting for P_A, the number $\hat{k}$ of signals in favor of state of the world A is strictly lower than the number $k - \hat{k}$ of signals in favor of B, which implies that the uninformed voter wants to deviate to voting for P_B.

Proof of the claim: Suppose for the sake of the argument that the opposite holds true, i.e., $\hat{k} \geq k - \hat{k}$, while the uninformed voters are pivotal. Then, $\hat{k} \geq k - \hat{k}$ and condition (ii) imply that $k \geq m$, i.e., that there are no uninformed voters. This proves our claim by contradiction.

Hence, we conclude from steps 1 and 2 that there is no pure-strategy equilibrium in which uninformed group members place identical votes and have a positive pivot probability. This proves part (a) of Lemma 2.

Consider now **part (b)** of the Lemma, i.e., uninformed voters who need not place identical votes (heterogeneous uninformed voting). Again, we will provide the proof in two steps, first assuming an odd number and then an even number of voters.

Step 1: Let $m \leq n$ denote the *odd* number of group members participating in the vote. Among those, k group members are informed and vote in line with their signal; $m - k - j$ stay uninformed and vote for P_A; and j stay uninformed and vote for P_B. The remaining group members (if there are any) abstain. Let $\hat{k}$ denote the number of signals that indicate state of the world A.

Consider now an uninformed voter i who votes for P_A. He is pivotal if and only if $m - k - j + \hat{k} = k - \hat{k} + j + 1$ which is equivalent to $\hat{k} = k + j - \frac{1}{2}(m-1)$. We refer to this equation as condition (i'). The uninformed voter i does not want to deviate to abstaining or voting for P_B if and only if conditional on his pivotality, "A" is not the signal received by a strict minority of the k informed group members. Formally, $\hat{k} \geq k - \hat{k}$, which we refer to as condition (ii'). Conditions (i') and (ii') imply that $j \geq \frac{1}{2}(m - k - 1)$ which we refer to as condition (iii'). The difference between uninformed votes in favor of P_A and uninformed votes in favor of P_B is $m - k - 2j$. Condition (iii') implies that this difference does not exceed 1: $m - k - 2j \leq 1$. This, together with condition (iii'), implies that

$$j = \begin{cases} \frac{1}{2}(m-k) & iff\ k\ is\ odd \\ \frac{1}{2}(m-k-1) & iff\ k\ is\ even \end{cases}$$

which we refer to as condition (iv').

Consider now an uninformed voter h who votes for P_B. An argument analogous to the one above (replacing $\hat{k}$ by $k - \hat{k}$ and $m-k-j$ by j) yields that h does not want to deviate, conditional on his pivotality, if and only if

$$m-k-j = \begin{cases} \frac{1}{2}(m-k) & iff\ k\ is\ odd \\ \frac{1}{2}(m-k-1) & iff\ k\ is\ even \end{cases}$$

which we refer to as condition (v'). It is easy to see that conditions (iv') and (v) are consistent if and only if $j = m-k-j = \frac{1}{2}(m-k)$. Hence, heterogeneous uninformed voting with an odd number of voters occurs in equilibrium only if the numbers of uninformed votes for P_A and P_B are exactly equal, implying that k be odd.

Step 2: Let $m \leq n$ denote the *even* number of group members participating in the vote. Among those, k group members are informed and vote in line with their signal; $m-k-j$ stay uninformed and vote for P_A; and j stay uninformed and vote for P_B. The remaining group members (if there are any) abstain. Let $\hat{k}$ denote the number of signals that indicate state of the world A.

Consider now an uninformed voter i who votes for P_A. He is pivotal if and only if his vote creates a tie: $m-k-j+\hat{k} = j+k-\hat{k}$, which is equivalent to $\hat{k} = k+j-\frac{1}{2}m$, with $j < m-k$. We refer to this equality as condition (i"). The uninformed voter i does not want to deviate to abstaining or voting for P_B if and only if conditional on his pivotality, "A" is not the signal received by a strict minority of the k informed group members. Formally, $\hat{k} \geq k - \hat{k}$, which we refer to as condition (ii"). Conditions (i") and (ii") imply that $j \geq \frac{1}{2}(m-k)$ which we refer to as condition (iii').

Consider now an uninformed voter h who votes for P_B. An argument analogous to the one above (replacing $\hat{k}$ by $k-\hat{k}$ and $m-k-j$ by j) yields that h does not want to deviate, conditional on his pivotality, if and only if $m-k-j \geq \frac{1}{2}(m-k)$ which we refer to as condition (iv'). Conditions (iii') and (iv') imply that $j = m-k-j = \frac{1}{2}(m-k)$. Hence, heterogeneous uninformed voting with an even number of voters occurs in equilibrium only if the numbers of uninformed votes for P_A and P_B are exactly equal, implying both that k be odd and that the number of uninformed voters is even. This, however, is a contradiction, because we assumed that the total number of voters m is even.

Hence, step 1 and 2 of this proof imply that heterogeneous uninformed voting occurs in equilibrium only if the numbers of uninformed votes for P_A and P_B are exactly equal, implying that both k and m be odd. (Note that this also captures the case in which the numbers of uninformed votes for P_A and P_B are both zero, as in the "let the experts decide" equilibria.) This proves part (b) of the Lemma.

Proof of Proposition 1. Lemma 2 implies that in any pure-strategy equilibrium in which all voters can be pivotal, the probability of any policy being implemented would remain the same if only the votes of the informed group members were counted. Hence, all pure-strategy equilibria are outcome-equivalent to "let the experts decide" profiles. Two claims remain to be shown: first, that "let the experts decide" profiles and the corresponding profiles with heterogeneous uninformed voting can be equilibria if the number k of informed voters is odd, and, second, that these equilibria exhibit informational efficiency at the voting stage.

Consider first a strategy profile with heterogeneous uninformed voting (half of the uninformed voters vote for P_A and the other half for P_B) and an odd number k of informed voters. We have established the no-deviation conditions for the uninformed voters in the proof of Lemma 2. Hence, it remains to be shown that no informed voter has an incentive to deviate on the voting stage or on the informational stage. Since the signal quality is $p > 0.5$, and since any voter can be pivotal, no informed voter wants to deviate to abstaining or voting the opposite of what his signal indicates. Consider now the informational stage. Deviating to remaining uninformed implies that the number of informed voters becomes even. This strictly decreases the probability that the correct policy is implemented after the vote (a tie replaces the win of the majority signal by one more vote). Hence, if the information costs are sufficiently small, it is strictly better not to deviate but to acquire the signal and vote what it indicates.

Consider now a strategy profile with the same k informed voters in which all uninformed group members abstain. Since this "let the experts decide" profile is outcome-equivalent to the profile considered above, the argument why no informed voter wants to deviate if c is sufficiently small remains the same. Hence, it only has to be shown that no uninformed voter wants to deviate. Consider the uninformed voter i. If he deviates to, say, voting for P_A, he is pivotal if and only if he creates a tie. He creates a tie if and only if there has been one more signal indicating B than indicating A. Hence, conditional on his pivotality, i would vote for the policy that is less likely than its alternative to be correct. Thereby, i would strictly decrease his expected payoff. This proves Proposition 1.

Proof of Proposition 2. Lemma 1 implies that individuals either stay uninformed or get informed and vote in line with their signal. Hence, whoever gets informed then votes in line with his signal. Let k denote the number of informed voters and $\pi(k)$ the probability that a simple majority of the k informed voters makes the correct decision. Then, given Lemma 1 and 2, the difference in individual payoffs from casting an informed vote and remaining uninformed amounts to $\pi(k) - \pi(k-1) - c$. Next, we argue that $\pi(k) - \pi(k-1) = 0$ for all k even. To see this, assume that the total number of informed voters is even. Then, a voter is pivotal if and only if he creates a tie. Hence, conditional on pivotality, half the signals are in favor of state of the world A and half in favor of state of the world B, and the voter is indifferent between abstaining, voting for P_A, and voting for P_B. Hence, the voter is indifferent between voting his signal and abstaining: $\pi(k) - \pi(k-1) = 0$ for all k even. Hence, k must be odd. Next, we know from Condorcet's Jury theorem as formally stated in Berg (1996), Theorem 1, that $\pi(k)$ monotonously increases in k and $\lim_{k\to\infty}\pi(\mathrm{k}) = 1$. Thus, $\pi(k) - \pi(k-1)$ must be monotonously decreasing in k (strictly decreasing for odd k). Define the cut-off cost level $c(k) = \pi(k) - \pi(k-1)$. Then, $c(k+2) < c(k)$ for all odd k, $k = 0$ for $c > c(1)$, $k = 1$ for $c(3) < c < c(1)$, and generally k voters get informed in equilibrium iff $c(k+2) < c < c(k)$. Define $x = \frac{k+1}{2}$ and $c_x = c(k+2)$. Then, we have shown part (a) of Proposition 2. Consider now part (b) and note that the payoff of an informed voter under democracy is $\pi(k^*) - c$, while the payoff of an uninformed individual under democracy is $\pi(k^*)$, with k^* denoting the equilibrium number of informed voters. The payoff of everyone under expert judgment is q. Then, part (b) of Proposition 2 immediately follows.

Proof of Corollary 1. Let k be the number of informed voters in a strict "let the expert decide" equilibrium of the subgame under democracy. Then, $\pi(k) - c > \pi(k-1)$, otherwise, the equilibrium would not be strict or the informed voters would want to deviate to remaining uninformed and abstain. Since $\pi(k-1) = \pi(k-2)$ for any k, given that k must be odd, we get $\pi(k) - \pi(k-2) > c$, which, in its turn, implies that the two additional informed voters required for the equilibrium with k rather than $k-2$ strictly prefer the former over the latter equilibrium. Then, this holds true for the uninformed, too. Now let k be the number of informed voters in a "let the expert decide" equilibrium of the subgame under democracy that is not strict. Then, $\pi(k) - c = \pi(k-1)$, which implies that k is the highest number of informed voters attainable in equilibrium: $k = \bar{k}$. Hence, all equilibria with $k < \bar{k}$ are strict equilibria and can be Pareto-ranked as stated in the Corollary. For $k = \bar{k}$, the strict inequalities must be replaced by the corresponding weak inequalities: $\pi(\bar{k}) - c \geq \pi(\bar{k} - 1)$ and $\pi(\bar{k}) - \pi(\bar{k} - 2) \geq c$, which implies that everyone's expected net payoffs weakly increase if one moves from the equilibrium with $\bar{k} - 2$ informed voters to the equilibrium with $\bar{k}$ informed voters.

Proof of Proposition 3. Parts (a) and (b) of Proposition 3 are obvious implications of the simple payoff comparisons stated there; hence, we skip the proof. Now consider part (c) and let $\pi(k^*) > q$ as stated there. The choice of democracy is socially beneficial if and only if $\pi(k^*) - q \geq \frac{k^*}{n} c$. For any given k^*, this inequality is always fulfilled for sufficiently large n, which proves part (c). The proof of part (d) is analogous.

Proof of Corollary 2. Consider the difference in expected net group payoffs of having $k + 2$ informed voters and $n - k - 2$ abstainers, and having k informed voters and $n - k$ abstainers, with $k \geq \bar{k}$; and let this difference be denoted by $\Delta E\left(U_m(k) \mid \sigma^{LTED}\right)$. Similarly, let $\triangle \pi(k)$ denote the difference $\pi(k + 2) - \pi(k)$ and remember that $k^{**} = \arg\max_{k, k \leq n}\{n\pi(k) - kc\}$. Then, simple algebra provides uns with the following condition:

$$\Delta E\left(U_m(k) \mid \sigma^{LTED}\right) \geq 0 \text{ iff } \frac{1}{2} \triangle \pi(k) \geq \frac{c}{n}.$$

Since $\lim_{n \to \infty} \left(\frac{1}{2} \triangle \pi(k) - \frac{c}{n}\right) = \frac{1}{2} \triangle \pi(k) > 0$ for any given k, we have that $k^{**} \in [\bar{k}, n]$ for large n, which proves (a). Now consider part (b) and let $< k \longrightarrow n - 2 >$ denote the convergence of the *odd* numbers $k \in \{0,1,3 \ldots n - 2\}$ toward $n - 2$. Moreover, let $x \in \mathbb{N}^{>0}$ and note that $\triangle \pi(0) > 0$. Then, we have

$$\lim_{n \to \infty} \lim_{\substack{x \longrightarrow \frac{n-k}{2} \\ <k \longrightarrow n-2>}} \frac{1}{2}\left(\pi(k + 2x) - \pi(k)\right) = \lim_{n \to \infty} \frac{1}{2}\left(\pi(\mathrm{n}) - \pi(\mathrm{n} - 2)\right) = 0$$

However, at the same time, $\lim_{n \to \infty} \frac{c}{n} = 0$, too. Hence, if $\frac{1}{2}\left(\pi(n) - \pi(n - 2)\right) \geq \frac{c}{n}$, we have the corner solution $k^{**} = n$; and if $\frac{1}{2}(\pi(n) - \pi(n - 2)) < \frac{c}{n}$, there exists some interior solution $k^{**} \in (0, n)$ that maximizes net expected group payoffs.

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