TI 2002-005/1
Tinbergen Institute Discussion Paper

Delegation or Voting

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December 10, 2001

Abstract

Collective decision procedures should balance the incentives they provide to acquire information and their capacity to aggregate private information. In a decision problem in which a project can be accepted or rejected once information about its quality has been acquired or not, we compare the performance of a delegation structure with that of two voting procedures. Delegation makes one's acceptance decision pivotal by definition. The decisiveness of one's vote in a voting procedure depends on the other agent's vote. This in turn determines the decision to acquire information. In the debate about a rational choice foundation of Condorcet's Jury Theorem, the distribution of information was left exogenous. Mixed (acceptance) strategies were required to validate the Theorem. Endogenizing information acquisition as we do reveals mixed (acceptance) strategies to be detrimental for welfare as they lead to indifference between buying and not buying information.

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1 Introduction

This paper deals with the problem of selecting a decision rule for a group that has to make a decision under uncertainty. We focus on situations where each individual of the group can acquire information at a cost. Such situations are common. Let us give three examples. First, in the U.S., legislative committees have gatekeeping authority and proposal power. Committees are the "lords of their jurisdictional domains" (Shepsle and Bonchek, 1997). Giving individual legislators incentives to acquire information is often considered as the rationale for granting so much power to legislative committees (Gilligan and Krehbiel, 1997). Second, some business decisions are also made collectively, for example in management teams, whereas others are made by individual members of the team. In either case, the effort involved in gathering advice and preparing the decision can be substantial. Finally, the editor of this journal has kindly requested specialists to referee our article. The referees are supposed to take great pains with studying our paper.

We study a model in which two agents have to make a binary decision about a project. The agents' common goal is to make the correct decision. The problem is that the correct decision is unknown. Each agent can buy information. By buying information an agent may learn the correct decision. We analyze three decision procedures. In the first one, the decision about the project is delegated to one individual. This agent first chooses whether or not to acquire information and then chooses whether or not to implement the project. In the two other decision procedures, the decision about the project is made by voting. With two agents, two voting rules make sense: implementation either requires one agent to vote favourably or both agents. When the decision about the project is made by a voting rule, each agent can buy information.

Our paper is closely related to the literature on Condorcet's Jury Theorem and the literature on organizational decision making by error–prone agents. Our paper deviates from these literatures in that the decision to acquire information is made endogenous. The recent literature on Condorcet's Jury Theorem focuses on the way alternative decision rules aggregate private information (see, for example, Young, 1988, Ladha, 1992 and Piketty, 1999). This literature typically assumes a distribution of information among agents that is exogenously specified.

The literature on organizational decision making by fallible agents examines how alternative organization structures affect the economic consequences of errors individuals make (see, for example, Ben–Yashar and Nitzan, 1997; Sah and Stiglitz, 1988). In this literature, the likelihood of an erroneous decision is exogenously specified. In our model each individual can improve the quality of a decision at a cost. Relaxing the assumption that information is manna from heaven forces one to evaluate organizational decision rules both in terms of their capacity to aggregate private information and on the basis of their adequacy in providing incentives to gather this private information in the first place.[1]

We derive three main results. First, we show that delegation provides a stronger incentive to acquire information than voting. The reason is simple. For an individual, the benefits of acquiring information depend on the probability that his vote is decisive. Under delegation, the vote of the decision maker is decisive by definition. Under a voting rule, the voting behavior of the other agent determines the decisiveness of one's vote.

Second, Austen-Smith and Banks (1996) show that always voting in line with one's information is not an equilibrium strategy when decisions are made by majority

[1] In our model, information is a public good that raises a free-rider problem. None of the three decision rules always solves this problem.

voting. In other words, rational voters follow a mixed strategy. They conclude "[a] satisfactory rational choice foundation for the claim that majorities invariably "do better" than individuals, therefore, has yet to be derived" (p. 34). Wit (1998) establishes that allowing for mixed strategies in fact saves the Condorcet's Jury Theorem. We show that when information is endogenous, mixed strategies in the vote decision lead to disastrous outcomes. When agents are indifferent between voting for and voting against implementation, they are also indifferent between acquiring information and remaining ignorant. The expected payoff to each agent is then equal to the expected pay off when no information is acquired at all.

Our third result is less pessimistic about voting rules. We show that when equilibria exist in which voters mix in the vote decision, there also exists an equilibrium in which the agents vote sincerely and buy information with a positive probability. When the costs are low, one of the voting rules is usually superior to delegation from a social point of view. Moreover, the more a second piece of information adds to a first piece of information, the more atractive voting becomes.

The punch line of this paper is that endogenizing information has important consequences for the relative performance of decision rules.

Our paper is organized as follows. The next section presents the model. We then analyze the relationship between the appropriateness of the alternative decision rules on the one hand and agents making progressively more consious choices on the other hand. In Section 3, we assume that agents always buy information and vote sincerely. In Section 4, we relax the assumption of sincere voting. In Section 5, we relax the assumption that agents always buy information. Section 6 concludes.

2 The Model

There are two agents, $i = 1, 2$, who have to decide whether to implement a project, $X = 1$, or to reject it, $X = 0$. The payoff of implemented projects accrues to both agents, and depends on the state of nature, θ. This state can be either good or bad, $\theta \in \{G, B\}$. The agents have identical preferences over outcomes: both prefer implementation in the good state, and rejection in the bad state. The payoff of rejected projects is independent of the state of nature. Formally,

$$\begin{aligned} U_i(X = 1; G) &= p + h \\ U_i(X = 1; B) &= p - h \\ U_i(X = 0) &= 0 \end{aligned} \tag{1}$$

where $p - h < 0 < p + h$, or $h > |p|$. The expected value of an implemented project, p, can be positive, negative, or zero.

The state of nature is unknown when the agents decide. Both states have equal prior probability. Agent i can obtain a private signal s_i about the state of nature, $s_i \in \{g, b\}$, before a decision is being taken. A signal costs C. This signal is informative with probability π, and uninformative with probability $1 - \pi$. An informative signal fully reveals the state of nature, while an uninformative signal adds no information to the prior beliefs of an agent. That is, in case of an informative signal $\Pr(G|g_i) = \Pr(B|b_i) = 1$, whereas in case of an uninformative signal $\Pr(G|g_i) = \Pr(B|b_i) = \frac{1}{2}$, where g_i (b_i) stands for $s_i = g$ $(s_i = b)$.

Once any agent who decided to obtain a signal has received one, a decision is taken about the project. The agents do not communicate once they have received any signal and before deciding on the project. We consider three commonly used decision rules, R. First, the decision can be taken by delegation, $R = D$. In this case, one agent is made responsible for the project. The other agent does not buy a signal. The second and third rule involve voting. The second decision rule requires just one agent to vote favorably for the project to be implemented, $R = V_1$, whereas the third rule requires the consent of both agents for implementation to take place, $R = V_2$.

Throughout, we assume that $\pi h > p$. As we show below, the implication of this assumption is that if the decision were delegated to one agent, his decision about the project would be in accordance with his signal, if bought.

3 The Benchmark Case

In this section, we analyze the alternative decision rules under the assumption that agents participating in the decision making process always buy a signal. Moreover, we assume sincere voting. We discuss the three decision rules in turn.

3.1 Delegation

Let agent i be the agent who is made responsible for the decision about the project. If i receives signal $s_i = g$ and chooses implementation, her expected payoff equals $p + \pi h$. If i receives signal $s_i = b$, implementation yields an expected payoff $p - \pi h$. Since $\pi h > p$, i chooses implementation if and and only if she receives signal $s_i = g$. The total expected payoff under delegation, that is the sum of the expected payoff to the two agents under delegation, equals

$$\begin{aligned} E(\Pi; R = D) &= 2(\Pr(G)\Pr(s = g|G)[p + h] \\ &\quad + \Pr(B)\Pr(s = g|B)[p - h]) - C \\ &= p + \pi h - C \end{aligned} \tag{2}$$

3.2 Voting Rule V_1

When individuals vote sincerely, voting rule V_1 implies that the project is implemented unless both agents receive signal $s_i = b$. The total expected payoff is

$$\begin{aligned} E(\Pi; R = V_1) &= 2(\Pr(G)\left[1 - \Pr(s = b|G)^2\right][p + h] \\ &\quad + \Pr(B)\left[1 - \Pr(s = b|B)^2\right][p - h] - C) \\ &= \left(\frac{3}{2} - \frac{1}{2}\pi^2\right) p + \pi h - 2C \end{aligned} \tag{3}$$

3.3 Voting Rule V_2

The project is implemented only if both agents receive signal $s_i = g$. The expected total payoff equals

$$\begin{aligned} E(\Pi; R = V_2) &= 2(\Pr(G)\left[\Pr(g|G)^2\right][p + h] \\ &\quad + \Pr(B)\left[\Pr(g|B)^2\right][p - h] - C) \\ &= \frac{1}{2}\left(1 + \pi^2\right) p + \pi h - 2C \end{aligned} \tag{4}$$

3.4 Delegation or Voting?

A comparison of the expected payoff of the voting rules V_1 and V_2 shows that the single acceptance rule is better than the double acceptance rule if and only if the expected value of the project is larger than zero. That is, $E(\Pi; R = V_1) > E(\Pi; R = V_2)$ if and only if $p > 0$. The outcome of the voting rules differs only if the two agents obtain opposite signals: under V_1 the project would be accepted, while under V_2 it would be rejected. Combining the information of contradictory signals suggests that the value of implementation equals p. If $p > 0$, the project should be accepted, and hence V_1 is best, whereas if $p < 0$, the project should be rejected, and hence V_2 is best. It is better to check twice if the project is relatively bad, while it is better not to be too strict if the project is relatively good.

The best voting rule is better than delegation if and only if the cost of a second signal are lower than the increase in expected payoff:

$$C < \frac{1}{2}\left(1 - \pi^2\right)|p| \tag{5}$$

Voting yields a higher expected payoff than delegation if the second signal adds sufficient information to the first, and if the absolute value of the expected profits is relatively high. The more informative the first signal (i.e., the higher π), the less the second signal adds, and the more attractive delegation becomes. Similarly, the smaller the absolute value of p, the closer the expected revenues of delegation and voting, gross of the costs of acquiring signals.

If the signals are for free ($C = 0$), voting is always the best. Exclusion of individuals from the decision–making process would imply not fully utilitising the existing information. This is the basic argument of the Jury Theorem, which, in the simple setting used here, simply says that two persons know more than one.

Delegation and voting procedure V_1 perform equally well for $C = \frac{1}{2}\left(1-\pi^2\right)p$: $E\left(\Pi; R=D\right) = E\left(\Pi; R=V_1\right) = \frac{1}{2}p\left(1+\pi^2\right)+\pi h$. Had it been possible not to buy a signal, the comparison would have been with the expected payoff to an individual ensuing from not buying a signal, p under both delegation and V_1. Hence, if $C = \frac{1}{2}\left(1-\pi^2\right)p$, no signal would have been bought if $\frac{\pi h - p}{2} < \frac{p\left(1-\pi^2\right)}{2}$. If this inequality holds, V_1 would have performed at least as well as D for all values of C. We come back to this inequality in section 6.

4 Strategic Voting

In this section we relax the assumption that agents vote in line with their signal, but allow for strategic voting. Following Austen-Smith and Banks (1996), we focus on voting rules which constitute a symmetric Nash equilibrium. As allowing for strategic voting has no consequences for the outcomes when the decision about the project is delegated to one agent, this section only discusses the decision rules which involve voting. Agents still buy a signal at cost C.

In the rest of the paper we confine the analysis to the case $p > 0$. The discussion paper version of this article also deals with the case $p \leq 0$.

4.1 Voting Rule V_1

Under voting rule V_1 there are two equilibria. In the first one, each agent votes for implementation, irrespective of his signal. We refer to this equilibrium as the 'uninformative equilibrium'. In the second equilibrium, each agent votes in line with his signal. As a consequence, the project will be implemented, unless both players receive an unfavorable signal.

The existence of two equilibria raises the issue of equilibrium selection. The uninformative equilibrium will be excluded as it involves weakly dominated strategies. Notice that the informative equilibrium leads to the same outcomes as in Section 3.2. Hence, allowing for strategic voting does not affect the outcomes when the decision rule is V_1.

4.2 Voting Rule V_2

As in Subsection 4.1, an uninformative equilibrium exists: voting for rejection irrespective of one's signal is an optimal response if the other player behaves in the same way. However, this uninformative equilibrium is rather unlikely, as voting for implementation weakly dominates voting for rejection when an agent receives a favorable signal.

In contrast to Subsection 4.1, sincere voting is not an equilibrium. To see this, suppose that agent 1 votes in line with his signal. Then, it is optimal for agent 2 to vote for implementation when he receives an unfavorable signal. The reason is that agents 2 prefers implementation to rejection unless both agents receive an unfavorable signal.

To examine whether there exists an equilibrium in mixed strategies, define γ_i as the probability that agent i votes for implementation when $s_i = b$. Suppose $s_i = b$. When i votes for rejection his payoff equals 0. When he votes for implementation, his payoff depends on j's vote:

$$\begin{aligned} & (p+h)\Pr(G|s_i=b)\left[\Pr(s_j=g|G)+\Pr(s_j=b|G)\gamma_j\right] \\ & +(p-h)\Pr(B|b_i)\left[\Pr(s_j=g|B)+\Pr(s_j=b|B)\gamma_j\right] \\ = \; & \frac{p}{2}\left(1-\pi^2\right)+\gamma_j\left(\frac{p}{2}\left(1+\pi^2\right)-h\pi\right) \end{aligned} \tag{6}$$

For a mixed strategy profile to be an equilibrium, an agent i who receives $s_i = b$

must be indifferent between voting for implementation and voting for rejection. This occurs when

$$\gamma_j = \frac{p\left(1-\pi^2\right)}{2\pi h - p\left(1+\pi^2\right)} \tag{7}$$

As we limit attention to symmetric equilibria, $\gamma^* = \gamma_i = \gamma_j$ in equilibrium. Since $\pi h > p$ by assumption, $\gamma^* \in (0,1)$ holds.

Because agents are indifferent between voting for implementation and voting for rejection when their signal is negative, the expected payoff in this equilibrium is equal to the expected payoff in Subsection 3.3.

5 Costly Signals and Strategic Voting

We now relax the assumption that agents always buy a signal. Thus, at the beginnning of the game agents have to decide whether to buy a signal or not.

5.1 Delegation

In case of delegation, one agent decides first whether or not to buy a signal, and then decides whether to implement the project. Suppose the agent decides not to buy a signal. Because $p > 0$, it is optimal for him to vote for implementation and his expected payoff equals p. Now suppose the agent decides to buy a signal. Our assumption that $\pi h > p$ ensures that it is optimal for the agent to choose implementation if and only if $s_i = g$. The expected payoff of buying is equal to $\frac{1}{2}\left(p + \pi h\right) - C$. It immediately follows that the agent buys a signal if and only if

$$C < \frac{1}{2}\left(\pi h - p\right). \tag{8}$$

Obviously, if (8) holds, the total expected surplus amounts to $(p + \pi h) - C$, whereas if it does not hold, the total expected surplus equals $2p$. Notice that maximization of the total expected surplus would have required the acquisition of a signal whenever $C < (\pi h - p)$; however, for $\frac{1}{2}(\pi h - p) < C < \pi h - p$, an individual has no incentive to buy a signal.

5.2 Voting Rule $V1$

In the case where single acceptance suffices for a project to be implemented an obvious Nash equilibrium profile is for both agents not to buy a signal and to vote favorably. The expected total surplus equals $2p$.

This is not the only equilibrium, however. To find the other equilibria, we first eliminate dominated strategies. Buying a signal, and always voting Y (or N) irrespective of the signal received is dominated by always voting Y (or N) and not buying a signal (it saves costs, without affecting expected payoff ex post). Moreover, voting in line with your signal dominates voting contrary to your signal (i.e., Y when g_i and N when b_i strictly dominates N when g_i and Y when b_i). The remaining undominated strategies are therefore: buy signal, and vote in line with signal received; don't buy signal, vote Y; don't buy signal, vote N. Let β_i be the probability that i votes Y when he has not bought a signal. Let α_i be the probability that i buys a signal.

Suppose i has not bought a signal. Conditional on not buying a signal, he votes N if the ensuing expected payoff exceeds p, the expected payoff of voting Y. If i votes N, the expected payoff depends on j's decision. If j buys a signal, the project is implemented when g_j, in which case the expected payoff equals $p + \pi h$. If j does not buy a signal, the project is implemented with probability β_j, and the expected payoff equals p. Formally, if i does not buy a signal, he votes Y if and only if

$$p > \alpha_j \frac{1}{2} (p + \pi h) + (1 - \alpha_j) \beta_j p \tag{9}$$

In a mixed strategy equilibrium, players are indifferent between voting Y and N. Because we limit our analysis to symmetric equilibria, it follows that

$$\beta^* = \frac{(2 - \alpha) p - \alpha \pi h}{2 (1 - \alpha) p} \tag{10}$$

As $\pi h > p$ by assumption, $\beta^* < 1$. That is, there is always a chance that not buying a signal will lead to voting against[2]. The intuition is as follows: Remember that in this section single acceptance is sufficient for a project to be implemented. Hence, voting Y although one has not bought a signal, may mean losing valuable information bought by the other agent. This becomes the more costly (i) the more likely the other person buys a signal, i.e, the higher α; (ii) the larger the variance in the payoff, i.e., the larger h; and (iii) the more informative the signal, i.e, the larger π. This is borne out by Equation (10). In fact, if the probability of buying a signal is sufficiently large, one will vote Y with zero probability in case no signal was bought: if $\alpha \geq \frac{2p}{p+\pi h}$, $\beta^* = 0$. The value of lost information diminishes the higher the ex ante expected payoff of the project. As a result, β^* increases in p.

The next step is to determine the probability that each player buys a signal.

[2] Remember that we already determined that not buying and voting Y forms an equilibrium strategy.

Suppose that $\alpha^* < \frac{2p}{p+\pi h}$ so that $\beta^* > 0$. If i buys a signal his expected payoff equals

$$\begin{aligned}
& (p+h)\Pr(G)\left[\alpha_j \left(\pi^2 + 2\pi(1-\pi) + (1-\pi)^2 \frac{3}{4}\right)\right. \\
& \left. +(1-\alpha_j)\left(\pi + (1-\pi)\frac{1}{2} + (1-\pi)\frac{1}{2}\beta^*\right)\right] \\
& +(p-h)\Pr(B)\left[\alpha_j \left(\pi(1-\pi) + (1-\pi)^2 \frac{3}{4}\right)\right. \\
& \left. +(1-\alpha_j)\left(\pi\beta^* + (1-\pi)\frac{1}{2} + (1-\pi)\frac{1}{2}\beta^*\right)\right] - C \\
= \; & \alpha_j \left(\frac{p}{4}\left(3-\pi^2\right) + \frac{\pi h}{2}\right) + \frac{(1-\alpha_j)}{2}[p+\pi h] + \beta^* \frac{(1-\alpha_j)}{2}(p-\pi h) - C
\end{aligned} \tag{11}$$

If i decides not to buy, expected payoff equals

$$\begin{aligned}
& (p+h)\Pr(G)\left[\beta^* + (1-\beta^*)\left(\alpha_j \Pr(g_j|G) + (1-\alpha_j)\beta^*\right)\right] + \\
& (p-h)\Pr(B)\left[\beta^* + (1-\beta^*)\left(\alpha_j \Pr(g_j|B) + (1-\alpha_j)\beta^*\right)\right] \\
= \; & p\beta^* + (1-\beta^*)\alpha_j \left(\frac{p+\pi h}{2}\right) + (1-\beta^*)(1-\alpha_j)\beta^* p
\end{aligned} \tag{12}$$

In a mixed strategy equilibrium, α^* is such that Equations (11) and (12) have the same value. Hence, the solution for α is $\alpha^* = \frac{4pc}{\pi^2(h^2-p^2)}$. For $\alpha^* < \frac{2p}{p+\pi h}$ to hold the costs of buying a signal should be sufficiently small, $C < \frac{\pi^2\left(h^2-p^2\right)}{2(p+\pi h)}$.

Above we saw that if $\alpha \geq \frac{2p}{p+\pi h}$, then $\beta^* = 0$. We use Equations (11) and (12) when $\beta^* = 0$ to obtain the expressions for the expected payoff if i buys a signal,

$$\alpha_j \left(\frac{p}{4}\left(3-\pi^2\right) + \frac{\pi h}{2}\right) + \frac{(1-\alpha_j)}{2}[p+\pi h] - C \tag{13}$$

and if i does not buy a signal,

$$\alpha_j \left(\frac{p+\pi h}{2}\right) \tag{14}$$

In a mixed equilibrium players are indifferent between buying and not buying a signal. Therefore

$$\alpha^* = \frac{2(p+\pi h) - 4C}{(1+\pi^2)p + 2\pi h} \tag{15}$$

From Equation (15) it follows that no signal is bought when they are too expensive ($C \geq \frac{p+\pi h}{2}$), while a signal is bought with probability one if they are cheap enough ($C \leq \frac{1-\pi^2}{4}p$). However, for $\beta^* = 0$ to hold, we derived that $\alpha^* \geq \frac{2p}{p+\pi h}$ should hold too. This restriction, in combination with Equation (15) gives rise to the inequality $C \leq \frac{\pi^2(h^2-p^2)}{2(p+\pi h)}$. In summary:

If $C \leq \frac{\pi^2(h^2-p^2)}{2(p+\pi h)}$ then three equilibria exist:

1. $(\alpha^*, \beta^*) = (0, 1)$
2. $(\alpha^*, \beta^*) = \left(\frac{4pc}{\pi^2(h^2-p^2)}, \frac{2c(p+h\pi)-\pi^2(h^2-p^2)}{4pc-\pi^2(h^2-p^2)}\right)$
3. $(\alpha^*, \beta^*) = \left(Min\left\{\frac{2(p+\pi h)-4c}{(1+\pi^2)p+2\pi h}, 1\right\}, 0\right)$

If $C > \frac{\pi^2(h^2-p^2)}{2(p+\pi h)}$, one equilibrium exists: $(\alpha^*, \beta^*) = (0, 1)$

The existence of multi-equilibria when $C \leq \frac{\pi^2(h^2-p^2)}{2(p+\pi h)}$ raises the problem of equilibrium selection. In the remaining part of this paper, we focus on the third equilibrium. The main reason is that when evaluating the performance of V_1, V_2, and D, the first two equilibria are not interesting. They both yield an expected total surplus of $2p$, which is always lower or equal than the expected payoff under delegation. The third equilibrium leads to a higher expected total surplus if $C < \frac{\pi^2(h^2-p^2)}{2(p+\pi h)}$. The surplus is:

$$\alpha(p+\pi h) \text{ with } \alpha = \frac{2(p+\pi h) - 4c}{(1+\pi^2)p + 2\pi h} \text{ if } C > \frac{1}{4}p\left(1-\pi^2\right) \tag{16}$$

and is

$$\left(\frac{3}{2} - \frac{1}{2}\pi^2\right) p + \pi h - 2c \text{ if } C \leq \frac{1}{4} p \left[1 - \pi^2\right] \tag{17}$$

Notice that by focusing on the third equilibrium, we give decision rule V_1 the benefit of the doubt when comparing it with delegation.

5.3 Voting Rule V_2

In this case an obvious Nash equilibrium profile is for both agents not to buy a signal and to vote N. The expected total surplus then equals zero. Moreover, if $C > \frac{\pi h - p}{2}$, a Nash equilibrium profile is for both agents not to buy a signal and vote Y. In the Appendix, we show that another equilibrium exists if the cost of a signal is not too large ($C \leq \frac{\pi h - p}{2}$). In this equilibrium, each agent votes Y if he has not bought a signal or has received signal g_i. Each agent buys a signal with probability

$$\alpha^* = \frac{2(\pi h - p) - 4c}{2\pi h - p(1 + \pi^2)} \tag{18}$$

Notice that $\alpha^* < 1$. The reason for this result is that decision rule V_2 is too strict. As discussed in subsection 4.2, when agents always receive a signal, it is optimal for each of them to vote sometimes Y when the signal is b. In this way, the agents reduce the probability that the project is rejected when the agents receive conflicting signals. When agents have to decide whether to buy a signal or not, they can reduce the probability that the project will be rejected while its expected payoff is positive by not buying a signal and voting Y.

6 Evaluation

In this section, we compare the performance of the delegation structure and the two voting rules when information is consciously gathered and strategic considerations determine the vote cast. We summarise the performance of the three decision procedures here

Expected surplus of delegation:

$$\begin{array}{ll} (p+\pi h)-C & \text{for } C<\frac{1}{2}(\pi h-p) \\ 2p & \text{for } C\geq\frac{1}{2}(\pi h-p) \end{array}$$

Expected surplus of voting procedure 1:

$$\begin{array}{ll} \left(\frac{3}{2}-\frac{1}{2}\pi^2\right)p+\pi h-2C & C\leq\frac{1-\pi^2}{4}p \\ \frac{2(p+\pi h)-4C}{(1+\pi^2)p+2\pi h}(p+\pi h) & C\in\left(\frac{1-\pi^2}{4}p,\frac{\pi^2\left(h^2-p^2\right)}{2(p+\pi h)}\right) \\ 2p & C\geq\frac{\pi^2\left(h^2-p^2\right)}{2(p+\pi h)} \end{array}$$

Expected surplus of voting procedure 2:

$$\begin{array}{ll} 2\frac{\pi^2\left(h^2-p^2\right)+2c(p-\pi h)}{2\pi h-p(1+\pi^2)} & \text{for } C<\frac{1}{2}(\pi h-p) \\ 2p & \text{for } C\geq\frac{1}{2}(\pi h-p) \end{array}$$

First of all, the surplus generated by delegation exceeds the surplus obtained by voting procedure V_2 if signals are relatively inexpensive, $C<\frac{1}{2}(\pi h-p)$, while delegation and V_2 perform equally well for more costly signals. The intuition is that for $C<\frac{1}{2}(\pi h-p)$, a signal is bought with probability one under delegation, but with probability lower than one under V_2. If and when a signal is bought, V_2 requires double acceptance even though the a priori expected value of the project is positive. V_2 is too strict. Moreover, if no signal is bought, projects are accepted with probability one. This further reduces the performance relative to delegation.

Secondly, just as in the benchmark case of the naive voter in section 3, if $\frac{(\pi h-p)}{2}<p\frac{1-\pi^2}{2}$ the voting procedure V_1 is at least as good as delegation D for all C.

If, on the other hand $\frac{(\pi h-p)}{2} > p\frac{1-\pi^2}{4}$, the price of information matters. For inexpensive signals, $C < C_1 := p\frac{(p+\pi h)-\pi^2(p+\pi h)}{2(p+\pi h)+p(1-\pi^2)}$, voting is best, whereas for more costly signals, $C > C_1$, delegation is best. If signals are relatively expensive it is better to buy just one signal than to have a chance of two being bought.[3] For $C \geq \frac{\pi^2h^2-\pi^2p^2}{2(p+\pi h)}$ signals have become prohibitively expensive, and everyone votes favourably without having bought a signal as the a priori expected value of a project is positive. In this case, delegation and voting perform equally well. There is a small interval of costly signals in which voting turns out to be better than delegation. This is the case for $C \in \left(\frac{\pi^2h^2-p^2}{2(p+\pi h)}, \frac{\pi^2h^2-\pi^2p^2}{2(p+\pi h)}\right)$, where $\frac{\pi^2h^2-p^2}{2(p+\pi h)} > C_1$. For these values of C, signals have become too costly to be bought under delegation, and the agent votes Yes in the absence of a signal. On the other hand, in the voting procedure, information is still bought, be it with a small probability.

We can now illustrate the general point made in the introduction: decision structures have to be evaluated not just on the basis of their appropriateness in terms of aggregation of private information, but also in terms of the incentives they provide to generate private information. In case of the naive voter, where incentives are absent, delegation is better than the voting procedure V_1 if $C > \frac{1}{2}(1-\pi^2)\,p$. In case of full strategic behaviour, where agents make a conscious choice whether to buy costly information or not, delegation is better than V_1 if $C > C_1$. It is easy to check that with strategic behaviour, delegation is the better structure for more values of C. If the provision of incentives is immaterial, delegation performs worse than V_1in the range $C \in \left(C_1, \frac{1}{2}(1-\pi^2)\,p\right)$. If the process of information gathering is endogenised, and the incentives to obtain private information assume an important role, delegation outperforms V_1 in this range.

[3] There is one exception: if $\frac{(\pi h-p)}{2} < C_1$, then voting procedure V_1 is better than delegation for all C. This is the case, if, e.g., the possible loss is almost negligible, or $\pi h - p \approx 0$.

7 Discussion

In their analysis of Condorcet Jury Theorem, Austen–Smith and Banks (1996) replaced the behavioral assumption of sincere voting by rational voting. They left the assumption that information is exogenously distributed untouched. In this paper we make a step similar to theirs: we endogenize the acquisition of information by assuming agents to rationally purchase information or not. Hence, the capacity of a collective decision procedure to provide incentives to acquire information becomes as important as its capacity to aggregate private information.

In a two–agent model, we have compared a delegation structure with two voting rules that make project implementation either dependent on one or on two favorable votes. Delegation provides stronger incentives to acquire information than voting: under delegation one's vote will be decisive, whereas under voting its decisiveness depends on what the other votes. This reduced incentive to acquire information under voting procedures has to be compared with the desirable aspect of information aggregation that characterizes such procedures. Clearly, the cheaper information is, and the more a second piece of information adds to a first piece, the more attractive voting becomes.

Our analysis sheds light on the discussion concerning the Jury Theorem. Where mixed strategies ruling the voting behavior save the Jury Theorem when information is exogenous, we have shown such behavior to have disastrous effects on welfare once information has to be acquired by rational agents. Mixed strategies when voting make agents also indifferent between acquiring information and remaining ignorant. The expected payoff to each agent is then equal to the expected payoff when no information is acquired at all. We have also shown that other equilibria exist in which agents vote sincerely and buy information with a positive probability.

Replacing the naive agent by its strategic counterpart has a second important consequence. It increases the 'robustness' of voting procedures. By this, we mean the following. In case of naive agents, we showed that the better voting procedure for $p > 0$ is V_1. By the same token, V_2 is the better voting rule for $p < 0$. The introduction of strategically behaving agents reduces the performance of V_1 and increases the performance of V_2 for $p > 0$. Vice versa, for $p < 0$, acting strategically increases the surplus obtained from V_1 and reduces the performance of V_2. Hence, if an organizational designer or a legislator were somehow forced to use one and the same voting procedure for all possible projects, be they of positive or negative value, strategic behavior reduces the errors made. Allowing for strategic behavior helps agents to overcome the rigidities of what would otherwise have been the inferior voting procedure.

In the literature on collective decision-making, the Jury Theorem is sometimes regarded as the rationale for democracy. Piketty (1999, pp. 793-4) remarks "[the Jury Theorem] expresses in a formal way the commonsensical view according to which democracy is a good system tot the extent that one is ready to assume that 'more than half of the people are right more than half of the time'... It provides us with the most basic (and most fundamental) rationale for the most basic political institution." In the same spirit Ladha (1997, p. 617) writes: "The theorem thus provides a mathematical basis for majority-rule voting and potentially gives an important clue to our understanding of the strength of democratic government." Is our result that it is sometimes optimal to delegate decisions on public issues to individuals an argument against democracy? We do not think so. Most existing democracies are representative rather than direct. The traditional argument for representative democracy is that it leads to more informed policy decisions than direct democracy (Cukierman and Spiegel, 1998). Moreover, in democracies we usually observe a wide variety of decision procedures. The executive makes some decisions. Others are made in Parliament. But also civil servants make numerous decisions. In democracies, elected politicians often delegate policy decisions to civil servants. Our model demonstrates that providing incentives for acquiring information is a rationale for delegation. Of course we are aware that our two-agent model cannot fully describe under what conditions decision should be delegated. We are quite confident, however, that incentives for acquiring information are important.

Appendix

Let V2 be the voting rule.

Proposition 1 If $C \leq \frac{\pi h - p}{2}$, then there is one symmetric strategy profile in which with positive probability a signal is bought.

Proof. The proof is in two steps. We first determine the probability γ_i that i votes Y if b_i. When b_i and i votes N, i's payoff equals 0. When b_i and i votes Y, i's expected payoff equals

$$\begin{aligned} &(p+h)\Pr(G|b_i)\left[\alpha_j\left(\pi+\frac{1}{2}(1-\pi)(1+\gamma_j)\right)+(1-\alpha_j)\right]+\\ &(p-h)\Pr(B|b_i)\left[\alpha_j\left(\frac{1}{2}(1-\pi)+(\pi+\frac{1}{2}(1-\pi))\gamma_j\right)+(1-\alpha_j)\right] \end{aligned} \tag{A.1}$$

where α_i is the probability that i buys a signal. Using $\Pr(G|b_i) = \frac{1}{2}(1-\pi)$ and $\Pr(B|b_i) = \frac{1}{2}(1+\pi)$, it is straightforward to verify that the expression in (A.1) equals zero if

$$\gamma^* = \frac{\alpha(1-\pi^2)p + 2(1-\alpha)(p-\pi h)}{\alpha(2\pi h - p(1+\pi^2))} \tag{A.2}$$

Since $\gamma^* \geq 0$, $\alpha \leq \frac{2(\pi h - p)}{2\pi h - p(1+\pi^2)}$ The second step is to determine α^*, the equilibrium value of α_i. Two cases need to be distinguished: (i) $\alpha \leq \frac{2(\pi h - p)}{2\pi h - p(1+\pi^2)}$, so that $\gamma^* = 0$, and (ii) $\alpha > \frac{2(\pi h - p)}{2\pi h - p(1+\pi^2)}$, so that $\gamma^* > 0$. In (i), the expected payoff of buying equals

$$
\begin{aligned}
& (p+h)\Pr(G)\left[\alpha_j \left(\pi^2 + 2\pi(1-\pi)\frac{1}{2} + (1-\pi)^2 \frac{1}{4}\right) + \right. \\
& \left. (1-\alpha_j)\left(\pi + (1-\pi)\frac{1}{2}\right)\right] + \\
& (p-h)\Pr(B)\left[\alpha_j (1-\pi)^2 \frac{1}{4} + (1-\alpha_j)(1-\pi)\frac{1}{2}\right] - C \\
= \;& \frac{1}{2}\alpha_j \pi (p+h) + \frac{1}{4}\alpha_j (1-\pi)^2 p + \frac{1}{2}(1-\alpha)(p+\pi h) - C
\end{aligned}
\tag{A.3}
$$

whereas the expected payoff of not buying equals

$$
\begin{aligned}
& (p+h)\Pr(G)\left[\alpha_j \left(\pi + (1-\pi)\frac{1}{2}\right) + (1-\alpha_j)\right] + \\
& (p-h)\Pr(B)\left[\alpha_j (1-\pi)\frac{1}{2} + (1-\alpha_j)\right] \\
= \;& (1-\alpha_j)p + \frac{1}{2}\alpha_j (p+\pi h)
\end{aligned}
\tag{A.4}
$$

In a mixed equilibrium, player i is indifferent between buying and not buying. Limiting attention to symmetric equilibrium, this amounts to

$$
\alpha^* = \frac{2(\pi h - p) - 4c}{2\pi h - p(1+\pi^2)} \tag{A.5}
$$

Since the denominator of this expression is positive, α^* satisfies the restriction $\alpha^* \leq \frac{2(\pi h - p)}{2\pi h - p(1+\pi^2)}$. A signal will be bought with positive probability if $C \leq \frac{\pi h - p}{2}$. In (ii), when b_i, agent i's expected payoff is $-C$. When g_i, i's expected payoff is:

$$\begin{aligned}
&\frac{1}{2}(1+\pi)\left[\pi+\frac{1}{2}(1-\pi)(1+\gamma_j)\right]\alpha_j(p+h)\\
&\frac{1}{2}(1-\pi)\left[\frac{1}{2}(1+\pi)\gamma_j+\frac{1}{2}(1-\pi)\right]\alpha_j(p-h)+(1-\alpha)(p+\pi h)-C
\end{aligned} \tag{A.6}$$

When i does not buy a signal, his expected payoff equals

$$\begin{aligned}
&\frac{1}{2}\left[\frac{1}{2}(1+\pi)+\frac{1}{2}(1-\pi)\gamma_j\right]\alpha(p+h)+\\
&\frac{1}{2}\left[\frac{1}{2}(1-\pi)+\frac{1}{2}(1+\pi)\gamma_j\right]\alpha(p-h)+(1-\alpha)p
\end{aligned} \tag{A.7}$$

Using (A.2), straightfoward algebra shows that (A.7) equals the mean of $-C$ and (A.6) if $\alpha = \frac{2(\pi h-p)-2c}{2\pi h-p(1+\pi^2)}$. However, in (ii) $\alpha = \frac{2(\pi h-p)}{2\pi h-p(1+\pi^2)}$. Hence, no symmetric equilibrium exists in which $\gamma^* > 0$. ■

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