EXTENDED ABSTRACT
The Value of Consensus: An Experimental Analysis of Costly Pre-Vote Communication[⋆]

Marcello Puca[a], Krista J. Saral[1], Simone M. Sepe[c]

[a] *University of Bergamo, CSEF, Webster University Geneva*
[b] *University of North Carolina at Charlotte, Webster University Geneva, GATE Lyon Saint-Etienne*
[c] *University of Arizona, Toulouse School of Economics*

Abstract

Small groups tasked with making a collective decision often deliberate prior to taking a vote. How a group reaches agreement depends on the voting institution in place and requiring a higher degree of consensus will likely influence the level of communication, particularly when communication is costly. Using a combination of theory and experiments we examine communication decisions and the resulting outcomes under three voting rules: simple majority rule, consensus unanimity, and veto unanimity. We also vary the cost of communication, and the presence of an "expert" in the group. In line with previous findings, under costless communication, we find that outcome differences across voting rules are minimized due to high levels of communication. In contrast, when communication is costly, differences in voting rules reemerge as communication only remains high under consensus unanimity. Experts increase communication, but not necessarily efficiency.

Keywords: Collective Choice, Communication, Costly Communication, Experts, Experiments, Group Decision Making

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1. Summary

Deliberation is frequently employed by small groups tasked with making a decision. Trial juries, university committees, or company boards are just a few examples where consequential decisions are typically preceded by discussion. A seminal result, provided by Goeree and Yariv (2011) demonstrated that as long as communication is costless, differences in decision outcomes generated by differing institutional (voting) rules are essentially mitigated because groups can

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Email address: `University of North Carolina at Charlotte. Corresponding author:` `ksaral@uncc.edu` (Krista J. Saral)

communicate until they reach consensus. In other words, when groups can freely communicate they all reach the same decision through full consensus, so the voting rule is irrelevant. Arguably, however, the majority of communication is not costless. Deliberation carries the opportunity cost of time, which can substantially impact both the quality and breadth of communication. Moreover, if deliberation is costly, then differences in voting rules will reemerge as deliberation will only take place until the minimum required consensus is reached rather than the group always reaching full consensus of free communication.

We present laboratory experiments designed to study the impact of different voting rules on communication behavior and group decisions when communication is costly. In our experiment, groups of five individuals are presented with two boxes of mixed red and blue balls which must be matched to a box with an unknown distribution of balls. Each member of the group is able to draw a signal from the unknown box and they are given the choice or whether they would like to communicate with the other members of their group prior to taking a vote for the decision of the box. Experimental treatments vary the voting rule between simple majority, consensus unanimity, and veto unanimity as well as the cost of communication between a costless environment and a costly environment. The voting rule governs both the group decision making process for the box, but also the decision to communicate, which is novel to the literature.[1]. Treatments also vary the information structure of the group. In one case, all group members have the same quality of information and in another treatment we have an expert added to the group, who has a higher quality of information than the other members.

Our results show that across the three rules, costless communication leads to the highest rates of communication and efficiency levels, where efficiency is a binary variable defined as 1 if the group makes the optimal decision given all information (0 otherwise). Comparing across rules, we partially replicate the results of Goeree and Yariv (2011) for the simple majority and consensus unanimity rules, which result in similar rates of efficiency. We also find that this result still holds for the no expert and expert treatment conditions. However, the veto unanimity rule results in slightly lower efficiency than the other two rules.

When communication is costly, differences between all voting rules reemerge. Groups choose to communicate significantly less often *only* under simple majority and veto unanimity, while consensus unanimity continues to achieve high rates of communication (1 group out of 640 groups chose not to communicate). Consensus unanimity also results in the highest efficiency levels, followed by simple majority and then veto unanimity. Experts increase communication, but have a mixed effect on efficiency - helping only in simple majority and consensus unanimity.

[1] Other papers have assumed the same structure for entering communication across rules. For example, everyone is automatically entered into communication and can exit when they choose. We argue that the rule dictates whether the group starts communication and when it can end.

We also empirically explore the communication process for groups that choose to communicate. Communication is (unsurprisingly) longest when costless across all rules. Qualitative content analysis demonstrates that the majority of communication is about aggregating information (34.4% of all chat) while 28.7% is about coordination on a decision. When communication is costly, consensus unanimity results in the longest communication and also the highest rates of in-treatment chat about coordination (61.4% versus 21.6% in simple majority and 14.5% in veto unanimity).

In what follows, we provide an (early draft) of our theory, experiment design, and behavioral hypotheses for your reference. (please excuse typos!)

2. Theory

Basics

A benevolent planner needs to choose a decision alternative $a \in \{0, 1\}$ (e.g. acquit or convict), which is optimal when it matches an unknown and equiprobable state of nature $\theta \in \{0, 1\}$ (e.g. innocent or guilty). The planner delegates the choice of a to a group of $n \geq 3$ agents (e.g. jurors), where n is odd and each agent is indexed by $i \in \{1, \dots, n\}$. The planner sets a voting rule $K \equiv \{k_0, k_1\}$, where $k_0 \in \{1, \dots, n\}$ (resp. $k_1 \in \{n - k_0 + 1, \dots, n\}$) represents the minimum number of votes required to implement $a = 0$ (resp. $a = 1$).[2]

Decision outcomes and voting rules. Once each agent i simultaneously and privately casts a vote $v_i \in \{0, 1\}$, a decision alternative $a = 0$ (resp. $a = 1$) is implemented when at least k_0 (resp. k_1) agents vote for that alternative. When an alternative does not obtain the minimum number of votes, a "no decision" outcome $\emptyset$ is implemented. Therefore, agents' voting can generate three different outcomes $d \in \{0, 1, \emptyset\}$ (e.g., acquittal, conviction, or hung-jury).

We consider three different voting rules: (i) majority, i.e. $K^M = \{\frac{(n+1)}{2}, \frac{(n+1)}{2}\}$; (ii) consensus (or *two-sided*) unanimity, i.e. $K^C = \{n, n\}$; and (iii) veto (or *one-sided*) unanimity, i.e. $K^C = \{1, n\}$. Majority and veto unanimity always bring about a decision outcome, consensus unanimity instead brings about either a decision outcome or a no-decision.

Information and communication. Before voting, each agent i privately observes an independent binary signal $s_i \in \{0, 1\}$, which is informative with precision $p \equiv \mathbb{P}(s_i = \theta|\theta) > \frac{1}{2}$. We also consider the case where one agent, the "expert" receives superior information that is a non-binary signal with precision e with $\frac{1}{2} < p < e < 1$, and the remaining $n - 1$ agents receive a

[2] This framework supports any type of voting rule, which can be either symmetric ($k_0 = k_1$) or asymmetric ($k_0 \neq k_1$).

signal with precision p. In both cases (with or without the expert) the information structure is common knowledge.

Prior to casting their votes, agents can communicate. Upon observing their signal, each agent i makes a communication choice $c_i^{open} \in \{0,1\}$ where $c_i^{open} = 1$ (resp. $c_i^{open} = 0$) means that agent i would like to open (resp., not open) communication. We assume that the requirements to implement a decision outcome implicitly set the rules governing communication.[3] Therefore, the group communicates when at least $\Phi_K^{open} \equiv n - \min\{k_0, k_1\} + 1$ agents choose $c_i = 1$, otherwise they move forward to the voting stage. Under consensus unanimity n agents must agree to implement an alternative and so communication opens if at least *one* agent chooses to communicate, *i.e.* $\Phi_C^{open} = 1$. Similarly, under majority any majoritarian coalition can implement an alternative, so the same coalition can open communication, *i.e.* $\Phi_M^{open} = \frac{(n+1)}{2}$. Finally, under veto unanimity, communication opens only when *all* agents choose to communicate, *i.e.* $\Phi_V^{open} = n$.

During communication, each agent i publicly sends a message $m_i \in M$, where M is the set of all possible messages, which includes the possibility to remain silent (i.e. $m_i = m^{\emptyset}$). Communication continues until at least $\Phi_K^{close} \equiv n - \Phi_K^{open} + 1$ agents decide to take communication closing decision $c_i^{close} \in \{0,1\}$, with $c_i^{close} = 1$ (resp. $c_i^{close} = 0$) representing the agent i's choice to close (resp. not close) communication. This means that under consensus unanimity $\Phi_C^{close} = n$, under majority $\Phi_M^{close} = \frac{(n+1)}{2}$, and under veto unanimity $\Phi_V^{close} = 1$.

We consider both costless and costly communication. If communication is costly, once communication starts, each agent i bears the time cost $\gamma \in (0,1)$ of aggregating information, which we assume to be invariant across voting rules.

Payoffs and timing. Each agent's net payoff function is $\pi(d,\theta) - \gamma$, which maps a state of nature $\theta \in \{0,1\}$ and an outcome $d \in \{0,1,\emptyset\}$ into a payoff $\pi \in \{0,\mu,1\}$, with $\mu \in (0,1)$. Agents' payoffs are maximized ($\pi = 1$) when they implement the right decision alternative ($d = \theta$), minimized ($\pi = 0$) when they implement the wrong decision alternative ($d \neq \theta$ and $d \neq \emptyset$), and are equal to μ when they fail to take a decision alternative (i.e., $d = \emptyset$). Similar to Coughlan (2000), μ can be interpreted as the reservation payoff of the agents, when a decision alternative is implemented in the future either by the planner or another group of agents.[4,5]

The game evolves as follows:

[3] For example, if the voting rule is majority, any majoritarian coalition of agents has the authority over communication.

[4] In the experiment we set μ to a relatively low number, based on the idea that agents may be frustrated for not being able to fulfill their duty in decision making (Asch, 1956; Kaplan and Miller, 1987), even though the planner can appoint another group to select a decision alternative.

[5] Our approach differs from Breitmoser and Valasek (2021) who normalize the payoff for a no decision to zero.

1. Nature randomly selects θ.
2. Each agent i observes s_i.
3. Each agent i chooses c_i^{open}.
4. When at least Φ_K^{open} agents choose $c_i^{open} = 1$, the group communicates (i.e., each agent i sends m_i) until Φ_K^{close} agents choose $c_i^{close} = 1$. Otherwise, agents do not communicate, and directly move to the next stage.
5. Each agent i casts v_i.
6. Final net payoffs $\pi(d, \theta) - \gamma$ are realized.

2.1. Equilibrium predictions

Before voting for a decision alternative, each agent decides whether to communicate. In the analysis that follows, we solve the agent's communication decision by backward induction. In addition, we look for symmetric response equilibria, where agents who have received the same signal play the same strategies (Duggan and Palfrey, 2017). Finally, we use Perfect Bayesian Equilibrium as the solution concept of the game.

Voting with no communication

Voting behavior, absent communication, depends on voting rules . Under majority , agents vote sincerely (i.e., $v_i = s_i$) at the equilibrium independent of the game information structure (Austen-Smith and Banks, 1996; Feddersen and Pesendorfer, 1998).[6] For the same reason, sincere voting also takes place under consensus unanimity (Coughlan, 2000). In contrast, under veto unanimity , sincere voting is no longer an equilibrium strategy since an agent receiving information favoring the status quo, i.e. $s_i = 0$, may strategically vote against their private information, i.e. $v_i = 1$ (Feddersen and Pesendorfer, 1998).[7]

Voting with communication

When communication takes place, it is a dominant strategy for each agent i to: (i) truthfully share her private information (see, for example, Austen-Smith and Feddersen, 2006; Goeere and Yariv, 2011), leading them to form ; and a common posterior belief $\mathbb{P}(\theta | \{s_1, ..., s_n\})$and (ii) end communication by choosing $c_i^{close} = 1$. Remarkably, once agents aggregate their information, they all vote in unison implying thatindividual voting behavior no longer depends on a given voting rule (e.g. Gerardi and Yariv, 2007; Goeree and Yariv, 2011).

Since communication can be costly, agents communicate whenever the expected payoff with communication exceeds the expected payoff without communication, that is when:

[6] Specifically, if all agents vote according to their signal, a pivotal agent knows that $((n-1)/2)$ agents observed $s = 0$ and $((n-1)/2)$ agents observed $s = 1$. Because these two events cancel each other out, pivotal agent best responds by voting according to her own signal.

[7] See Table X In Appendix Y for the equilibrium voting predictions generated by our experimental design.

$$\underbrace{\mathbb{E}_K[\pi(d,\theta)|s_i]}_{\text{Expected payoff without communication}} \leq \underbrace{\mathbb{E}[\pi(d,\theta)|\{s_1,\ldots,s_n\}] - \gamma}_{\text{Expected payoff with communication}} \tag{1}$$

where $\mathbb{E}_K[\cdot]$ is the expectation operator under voting rule K.

Because the likelihood of a correct decision is increasing when agents are more informed, by communicating costlessly (i.e., $\gamma = 0$), the agents can always achieve a higher expected payoff than without communication. However, with costly communication (i.e., $\gamma \in (0,1)$), agents trade off the increased likelihood of a correct decision with γ .

From (1) let $\gamma^*_K(s_i)$ be the threshold cost that an agent is willing to pay to choose to communicate upon observing signal s_i, that is

$$\gamma^*_K(s_i) \equiv \mathbb{E}[\pi(d,\theta)|\{s_1,\ldots,s_n\}] - \mathbb{E}_K[\pi(d,\theta)|s_i]$$

This threshold equals the expected increased payoff achievable with a fully informed decision. Therefore, an agent will choose to communicate under voting rule K as long as

$$\gamma \leq \gamma^*_K \tag{2}$$

.

Comparing these thresholds across voting rules, agent i is more likely to communicate under K rather than under $K\prime \neq K$ if

$$\begin{aligned} &\gamma^*_{K\prime} \leq \gamma^*_K \\ \Leftrightarrow &\mathbb{E}_K[\pi(d,\theta)|s_i] \leq \mathbb{E}_{K\prime}[\pi(d,\theta)|s_i] \end{aligned}$$

Since expected decision payoffs with communication do not vary across voting rules, we can compare the threshold γ^*_K across different voting rules by restricting our attention to expected decision payoffs under no communication.

We are now able to formulate the following proposition:

Proposition 1. *When communication is free, $\gamma = 0$, agents always communicate under all voting rules and information conditions, and all voting rules are equally efficient.*

Proof. Proposition 1 follows directly from condition (1). With $\gamma = 0$, agents' choice to communicate is a weakly dominant strategy., They always aggregate all private information - independent of voting rules and take an efficient decision outcome. ■

With costly communication, the irrelevance result of Proposition 1 no longer holds. For simplicity, the following analytical statements are parameterized to the specific n, p, and e that we use in our experiment design. Furthermore, we also assume that the no-decision payoff is sufficiently low to avoid that agents can secure a reservation value with no communication. In particular, we assume that:

$$\mu < \overline{\mu} \equiv \frac{1}{\mathbb{P}\left(d=\emptyset \,| s_i\right)} \sum_{\theta} \left(\mathbb{P}_{K'}\left(d=\theta \,|\theta\right) - \mathbb{P}_{K^C}\left(d=\theta \,|\theta\right)\right) \mathbb{P}\left(\theta \,| s_i\right) \tag{3}$$

for any rule $K' \in \{K^M, K^V\}$, with $\mathbb{P}\left(d=\emptyset \,| s_i\right) > 0$.

We are now able to formulate the following proposition:

Proposition 2. *Under costly communication, $\gamma \in (0,1)$, for $K \in \{K^M, K^V, K^C\}$ and $K' \in \{K^M, K^V\}$:*
the communication cost threshold is maximal under consensus unanimity, i.e. $\gamma^*_{K'} < \gamma^*_{K^C}$;
when $\gamma \leq \gamma^*_K$, for any K, agents communicate under all rules, which are equally efficient;
when $\gamma > \gamma^*_K$, for any K, agents never communicate and majority is efficient ;

The implication of Proposition 2 is that once communication is costly, agents' communication behavior is voting rules dependent and there are three main results.

Case *(i)* consensus unanimity is more likely to induce agents to communicate.

Case *(ii)* if the cost of communication is sufficiently low then agents *always* communicate. As a consequence, all voting rules are equally efficient.

Case *(iii)* if the cost of communication is sufficiently high, then agents *never* communicate and majority most efficient rule.

3. Design of Experiments

The experiments are designed to empirically test how costly communication and the presence of an expert influence communication and decision making under different voting rules. The design is based on a standard group decision game which consists of two boxes containing a mix of red and blue balls. The first box (blue) has 7 blue and 3 red, while the second box (red) has 7 red and 3 blue. There is also a third box containing an unknown distribution of red and blue balls that matches either the first or second box with probability 0.5. The task facing each group is to decide which color distribution is the likely match for the unknown box, using a voting rule to make the decision. Treatments vary the voting rule, cost of communication, and presence of an expert in a $3 \times 3 \times 2$ experimental design.

Voting rules: Using a between subjects design, we implement three voting rules: simple majority (**Maj**), consensus unanimity (**Cons**), or veto unanimity (**Veto**). Under simple majority, 3 (out of the 5) group members need to vote for either the blue or red box for it to be selected. Consensus unanimity requires all 5 group members to vote for either the blue or red box for it to be selected, and in the event that all 5 members do not agree on a box, the outcome is recorded as no decision. Under veto unanimity, the status quo is defined as the blue box. For the red box to be selected, all 5 group members need to vote for the red box. If less than 5 agree to the red box, the group's decision is blue.[8]

Payoffs: All subjects in a group have identical payoffs. If the decision is correct, each group member receives a payoff of 100 experimental currency units (ECUs). If the group makes the wrong decision, they earn zero. Under consensus unanimity it is also possible to make no decision, so the payoff in this case is 1 ECU. This parameterization ensures that a no decision outcome results in a slightly higher payoff than a wrong decision, but the payoff is also low enough that a group should still strongly prefer a correct decision to none.

Information: At the start of a round, each member of the group is asked to select a single ball (the signal) from the unknown box to reveal its color. The draws are independent between group members with replacement. Subjects play 9 rounds under these uniform information conditions. We refer to these rounds as the **No Expert** treatment condition. After the initial rounds, the remaining 9 rounds have one subject per group (the expert), chosen randomly each period, who is able to reveal the color of 3 balls simultaneously, without replacement.[9] The four remaining group members continue to draw a single signal (one ball), with replacement.[10] The expert is randomly chosen each round, so being chosen as the expert in round did not guarantee being chosen as the expert in a subsequent round. We refer to the last rounds with an expert as the **Expert** treatment condition. The **No Expert/Expert** treatment manipulations always took place within a session, and in the order of No Expert periods followed by Expert periods.

Communication: After obtaining signals, subjects are asked if they would like to communicate with the other members of their group prior to voting on the unknown box. The voting rule is also used to determine if a group enters into communication. To start communication under simple majority, at least 3 members of the group must choose communication. Under consensus unanimity, communication begins if at least 1 member chooses to communicate, and

[8]Only the consensus unanimity rule can result in a no decision outcome. The majority and veto unanimity rules always result in a decision.

[9]During the experiment, this player was never referred to as an expert, but that this player would select 3 balls was common knowledge.

[10]The expert's three draw are also put back into the box, so between players the draws are always with replacement.

under veto unanimity, communication begins only if all 5 members of the group agree to it. If the minimum number of group members required to communicate is reached, the subjects enter into a e-chat room where they are allowed to free-form chat with other members of their group.[11]

In a between subjects design, the cost of communication is varied between a free condition (**F**), where no charge is levied for communication, and a low cost (**C**) and high cost (**HC**) condition. In the low cost treatment, groups are charged 20 experimental currency units (ECUs) for a minute of communication (0.33 per second), and in the high cost treatment, groups are charged 60 ECUs/minute (1 per second). The cost of communication is subtracted from the final decision earnings at the end of each round for each member of the group. In the chat room, there is a "cost clock" that updates each second with the current time and total cost of communication. Under free communication, in the F treatment, the clock simply updates with the current time of communication.

Groups that enter into communication must also agree to end communication, which again follows the voting rule.[12] Under simple majority, communication ends when at least 3 members choose to end communication. Under consensus unanimity, communication ends once 5 members of the group choose to end communication, and under veto unanimity, communication ends when 1 member chooses to end it. Votes to end communication are tabulated in real-time in the chat room until the necessary number is achieved. When the chat room closes, the subjects are immediately directed to a new screen where they place their vote for a box. If the group chooses not to communicate, the subjects are directed to this voting screen, bypassing the chat room.

The votes required for selecting a box, and the number of individuals that must choose to start and end communication are summarized in Table 1.

Votes Required (out of 5)	Simple Majority	Consensus Unanimity	Veto Unanimity
Select Blue Box / Red Box	3 / 3	5 / 5	1 - 4 / 5
Start Communication	3	1	5
End Communication	3	5	1

Table 1: Voting Rules

The treatments resulting from the between subjects/within subjects hybrid design are summarized in Table 2.

[11]The only restriction placed on chat was that the subjects did not identify themselves. We also asked that they please refrain from the use of profanity.

[12]The maximum time allowed for communication was 5 minutes. This was not a binding time limit as the average length of communication was 15.93 seconds, and the maximum length was 174 seconds (2.9 minutes).

	# Subjects	Description
Maj F	50	simple majority, free communication, No Expert / Expert
Veto F	45	veto unanimity, free communication, No Expert / Expert
Cons F	50	consensus unanimity, free communication, No Expert / Expert
Maj C	55	simple majority, low cost communication, No Expert / Expert
Veto C	55	veto unanimity, low cost communication, No Expert / Expert
Cons C	55	consensus unanimity, low cost communication, No Expert / Expert
Maj HC	60	simple majority, high cost communication, No Expert / Expert
Veto HC	55	veto unanimity, high cost communication, No Expert / Expert
Cons HC	60	consensus unanimity, high cost communication, No Expert / Expert

Table 2: Voting Rules

The experiments were conducted at the EIEF Laboratory in Rome, Italy. We conducted 3 sessions for each treatment yielding a total of 18 sessions. The number of subjects in the block of 3 sessions is provided in Table 2. Each session consisted of 18 rounds with the first nine rounds in the No Expert treatment and the last nine rounds in the Expert treatment. To ensure the least amount of changes between sessions, we used the same signal and box draws across all treatments. Prior to the beginning of each session, subjects were given instructions that included one example of a voting round with communication. Subjects were also given a new set of instructions when the treatment shifted from the No Expert to the Expert treatment. The experiment was programmed using Z-tree software (Fischbacher 2007). In each session, the subjects' earnings were denominated in ECUs, which were exchanged into Euros at a rate of €0.01 per ECU. Subjects were given 500 ECUs as an endowment that losses and profits were added to as the experiment progressed. Average earnings of the subjects were €17.61.

4. Hypotheses

In this section we provide testable hypotheses based on the theoretical analysis and the specific parameterization of the experiment. The key differences from the theoretical environment outlined above include the payoffs for no decision and correct decisions, as well as cost parameters for communication.

The first parameter of interest is the calculation of the threshold for communication for each rule, γ^*_K. Recall that this was theoretically defined at the individual level the difference between the expected payoff without communication and the expected payoff with communication.

To develop an aggregate view of this measure, we take the distribution of possible signal draws and use that to calculate the average expected payoffs with and without communication. These are then used to create an average measure of the cutoff across all rules which is presented in Table 3.

γ_K^*	Maj	Veto	Cons
No Expert	0	16.95	66.13
Expert	1.89	19.15	68.27

Table 3: Communication cutoff thresholds

It is clear that the threshold is highest for the consensus unanimity treatment, followed by veto and then majority. The expert increases the threshold for all treatments, but the increase is relatively minor. Majority results in a threshold of 0 under no expert conditions because communication is not necessary because the vote aggregates information. While an expert adds some value to communication in Maj, it's small. In light of these results and the cost parameterization of the experiment we develop the following behavioral hypotheses on communication.

Hypothesis 1 *Under costless (free) communication, groups will communicate under all rules except Maj.*

Hypothesis 2 *Under costly communication (low and high), the likelihood of communication is ranked as $Cons > Veto > Maj$.*

Hypothesis 3 *Experts increase the likelihood of communication.*

In Table 4 we present the average expected efficiency predictions, by treatment, without communication (No Communication) and with communication (Communication). Defining efficiency for the Maj and Veto treatments is straightforward; an optimal decision results in an efficient decision (efficiency = 1), and a non-optimal decision results in 0 efficiency. It is, however, less clear how one should define efficiency in the Cons treatment. If a decision is made, it is defined identically to the Maj and Veto treatments. The difficulty arises with the definition of efficiency in the case of no decision, since no decision was actually made to classify as efficient or inefficient. We have opted to classify these no decisions as inefficient decisions.

	No Communication			Communication		
Efficiency	Maj	Veto	Cons	Maj	Veto	Cons
No Expert	1	.70	.17	1	1	1
Expert	.97	.72	.20	1	1	1

Table 4: Efficiency predictions without communication and with communication

With communication, the groups make fully efficient decisions across all rules (the voting rule is irrelevant). Differences emerge when groups do not communicate. Maj always results in relatively high efficiency because the vote (with no expert) perfectly aggregates the information.

With an expert, there is additional information that is not conveyed through the simple vote, so it decreases efficiency in Maj slightly. Cons performs the worst in terms of efficiency because it is nearly impossible to reach the necessary consensus to make a decision without communicating, hence the low levels of efficiency driven by no decision outcomes.[13] While experts have a slight negative impact on efficiency with no communication in majority, they improve efficiency (also only a minor effect) in the Veto and Cons treatments.

This leads us to the following hypotheses on efficiency.

Hypothesis 4 *When groups communicate, full efficiency will be obtained across all voting rules*

Hypothesis 5 *When groups do not communicate, efficiency is ranked $Maj > Veto > Cons$.*

Arguably, the important question is how the rules will compare in terms of efficiency given the likelihood of communication. The only clear prediction is the costless case where groups always communicate and consequently always make efficient decision. For the costly treatments, this is primarily an empirical question, but we attempt the following behavioral hypotheses based on theory.

Hypothesis 6 *With no expert, overall efficiency is ranked $Cons = Maj > Veto$.*

Hypothesis 7 *With an expert, overall efficiency is ranked $Cons > Maj > Veto$.*

These predictions are based on the cost parameters of the experiment and the estimates of the cost thresholds in Table 3. We assume that communication always takes place in the Cons treatment since the cost will always be below the threshold. Further, we assume that communication never takes place in the Maj treatment since the cost will always exceed the threshold. While the thresholds for communication are higher in Veto than in Maj, they still remain relatively low and it takes communication to generate an efficient outcome in Veto, so we rank this treatment as the lowest level of efficiency.

[13]If the no decisions were omitted, then efficiency for the Cons treatment, even without communication, would be 1. This would be a very rare occurrence.