Consensus building: How to persuade a group

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Abstract

Many decisions in private and public organizations are made by groups. The paper explores strategies that the sponsor of a proposal may employ to convince a qualified majority of group members to approve the proposal. Adopting a mechanism design approach to communication, it emphasizes the need to distill information selectively to key members of the group and to engineer persuasion cascades in which members who are brought on board sway the opinion of others. The paper unveils the factors, such as the extent of congruence among group members and between them and the sponsor, and the size and governance of the group, that condition the sponsor's ability to maneuver and get his project approved.

Keywords Group decision-making, selective communication, persuasion cascade, internal and external congruence.

1 Introduction

Many decisions in private and public organizations are made by groups. For example, in western democracies Congressional committees command substantial influence on legislative outcomes through their superior information and their gate-keeping power. Academic appointments are made by committees or departments; corporate governance is run by

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boards of directors; firms' internal strategic choices are often made by groups of managers; and decisions within families or groups of friends usually require consensus-building.

"Group decision-making" is also relevant in situations in which an economic agent's project requires adhesion by several parties as in joint ventures, standard setting organizations, or coalition governments, or complementary investments by several other agents. For example, an entrepreneur may need to convince a financier to fund his project and a supplier to sink a specific investment; similarly, for its jumbo jet A380, Airbus had to convince its board and relevant governments, and must now convince airlines to buy the planes and airports to make investments in order to accommodate the new plane; finally, a summer school organizer may need to convince both a theorist and an empiricist to accept teaching.

While the economic literature has studied in detail whether the sponsor of an idea or a project can persuade a single decision-maker to endorse his proposal, surprisingly little has been written on group persuasion. Yet group decision-making provides for a rich set of additional persuasion strategies, including "selective communication" and " persuasion cascades" : Sponsors can distill information selectively. They can also try to "bootstrap" namely to approach group members sequentially and build on one's gained adhesion to the project to convince another to either have a careful look or to rubberstamp altogether.

Persuasion cascades are relied upon early in life as when a child tries to strategically convince one of his parents with the hope that this will then trigger acceptation by the other. Lobbyists in Congress engage in so-called "legislator targeting"; and organizations such as the Democracy Center provide them with advice on how to proceed.[1] Supporters of an academic appointment trying to get the department to vote an offer, or corporate executives hoping to get a merger or an investment project approved by the board, know

[1]The reader interested in a pragmatic approach to these questions in the political context is invited to refer to the Democracy Center's website at http://www.democracyctr.org/.

that the success of their endeavor depends on convincing key players (whose identity depends on the particular decision), who are then likely to win the adhesion of others.

The paper builds a sender/multi-receiver model of persuasion. The receivers (group members) adopt the sender's (sponsor's) project if all or a qualified majority of them are in favor at the end of the communication process. Unlike existing models of communication with multiple receivers, which focus on soft information ("recommendations"), the sender can transmit hard information (evidence, reports, material proofs) to a receiver, who can then use it to assess her payoff from the project. Communication is costly in that receivers who are selected to receive this hard information must incur a private cost in order to assimilate it. Thus, convincing a group member to "take a serious look at the evidence" may be part of the challenge faced by the sponsor.

The introduction of hard information in sender/multi-receiver modeling underlies the possibility of persuasion cascade, in which one member is persuaded to endorse the project or at least to take a serious look at it when she believes that some other member with at least some alignment in objectives has already investigated the matter and came out supportive of the project. Hard information also provides a foundation for strategies involving selective communication. We for example give formal content to the notion of "key member" or "member with string pulling ability" as one of "informational pivot", namely a member who has enough credibility within the group to sway the vote of (a qualified majority of) other members.

Another departure from the communication literature is that we adopt a mechanism design approach: The sender builds a mechanism (à la Myerson 1982) involving a sequential disclosure of hard and soft information between the various parties as well as receivers' investigation of hard information. This approach can be motivated in two ways. First, it yields an upper bound on what the sponsor can achieve. Second, and more descriptively, it gives content to the pro-active role played by sponsors in group decision-making. Indeed, we show how both selective communication and persuasion cascades are in equilibrium engineered by the sponsor.

The sponsor's optimal strategy is shown to depend on the congruence between individual group members and the sponsor (a factor that we label "external congruence" and that has received much attention in the single-receiver literature); on the congruence among group members ("internal congruence"); and on the size of the group and its decision-rule. Interestingly, increasing group size and thereby the number of veto powers may make it easier for the sponsor to have his project adopted even when all members are a priori reluctant to adopt it. Surprisingly also, an increase in external congruence may actually hurt the sponsor; by contrast, an increase in internal congruence always benefits the sponsor. Finally, it may be optimal for the sponsor to create some ambiguity for each member as to whether other members are already on board.

The paper is organized as follows: Section 2 sets up the sender/multi-receiver model. Section 3, in the context of a two-member group, develops a mechanism-design approach. Section 4 derives the optimal deterministic mechanism, and Section 5 studies its properties as well as its robustness to the sender's inability to control communication channels among members. Section 6 extends the analysis to N members. Section 7 allows stochastic mechanisms and shows that ambiguity may benefit the sender. Finally, Section 8 summarizes the main insights and discusses alleys for future research.

Relationship to the literature.

Our paper is related to and borrows from a number of literatures. Of obvious relevance is the large single-sender / single-receiver literature initiated by Crawford and Sobel (1982) for soft information transmission and by the work of Grossman (1980), Grossman-Hart (1980), and Milgrom (1981) on the disclosure of hard information. Much of this work has assumed that communication is costless. One recent exception to this is Dewatripont-Tirole (2005), which emphasizes sender and receiver moral hazard in communication as well as the various modes (issue-relevant and issue-irrelevant) of communication.

This literature has been extended to analyze the aggregation of dispersed information within a group through debate (Spector 2000, Li-Rosen-Suen 2001).[2] Like ours, these papers analyze collective decision making processes, but they assume that group members have exogenous information, and they do not tackle the questions of whether and how a sponsor can maneuver to get his project adopted.

A large body of literature covers receiver / multi-sender situations, where the receiver is an uninformed decision-maker and senders are experts. Milgrom and Roberts (1986) pionnered this literature in the context of disclosure of hard information although later papers mostly focused on experts endowed with (or able to gather) soft private information. In this literature, the decision-maker elicits information from multiple senders with biased preferences (Glazer-Rubinstein 1998 and 2001, Krishna-Morgan 2001, Battaglini 2002, Battaglini-Bénabou 2003) or reputational concerns (Ottaviani-Sorensen 2001). This literature offers for example insights on the impact of the decision rules in committees (Austen-Smith 1993a and 1993b, Gilligan-Krebhiel 1989, Glazer-Rubinstein 2001), or of their composition (Dewatripont-Tirole 1999, Beniers-Swank 2004, and the empirical work of Krehbiel 1990). By contrast, we focus on sender / multi-receiver environments, and the concomitant phenomena of selective communication and persuasion cascades.

Closer to our contribution, the Farrell-Gibbons (1989) model of cheap talk with multiple audiences addresses the problem of selective communication. Besides the sole focus on cheap talk which precludes persuasion cascades, a key difference with our framework is that the members of the audience do not form a single decision-making body and so no

[2]For early applications to Congressional committees, see Austen-Smith (1990) or Austen-Smith - Riker (1987).

group persuasion strategies emerge in their paper.

Finally, our ruling out the possibility of targeting resources or paying bribes to committee members distinguishes our work from some of the literature on lobbying (e.g., Groseclose-Snyder 1996 or Lindbeck-Weibull 1987).

2 Model

We consider a sender (S) / multi-receivers (R_i) communication game. An N-member committee $(R_1, R_2, ..., R_N)$ must decide on whether to endorse a project submitted by a sponsor S. Each committee member can individually support or oppose the project and the decision rule defines an aggregation procedure. Under the unanimity rule, all committee members must approve the project and so the sponsor needs to build a consensus. Under the more general K-majority rule, no abstention is allowed and the project is adopted whenever at least K members approve it.

The project yields benefits $s > 0$ to S and r_i to committee member R_i. The status quo yields 0 to all parties. The sponsor's benefit s is common knowledge and his objective is to maximize the expected probability that the project is approved.

R_i's benefit r_i is a priori unknown to anyone and the question for R_i is whether her benefit from the project is positive or negative. A simple binary model captures this dilemma; r_i can a priori take two values, $r_i \in \{-L, G)$, with $0 < L, G$. The realization of r_i in case the project is implemented is not verifiable. Committee member R_i can simply accept or reject the project on the basis of her prior $p_i \equiv \Pr\{r_i = G\}$. She can also learn the exact value of her individual benefit r_i by spending time and effort investigating a detailed report about the project if provided by the sponsor: the sponsor is an information gatekeeper. Investigation is not verifiable, and so is subject to moral hazard. The personal cost of investigation is denoted c and is identical across committee members. There are several possible interpretations for the "report". It can be a written document handed over by the sponsor. Alternatively, it could be a "tutorial" (face–to-face communication) supplied by the sponsor. Its content could be "issue-relevant" (examine the characteristics of the project) or "issue-irrelevant" (provide the member with track-record information about the sponsor concerning his competency or trustworthiness). Committee member R_i can also try to infer information from the opinion of another member who has investigated. That is, committee member R_i may use the correlation structure of benefits $\{r_i\}_{i=1}^N$ to extract information from R_j's investigating and deciding to approve the project.

The dictator case.

Let $u^I(p)$ denote the expected benefit from investigation for a single decision-maker (a "dictator"), when her prior is $\Pr\{r = G\} = p$, and let $u^R(p)$ denote her expected benefit when granting approval without investigation, i.e. when rubberstamping S's proposal:

$$\begin{aligned} u^I(p) &= pG - c \\ u^R(p) &= pG - (1-p)L. \end{aligned}$$

The dictator prefers rubberstamping to rejecting the project without investigation if[3]

$$u^R(p) \geq 0 \Longleftrightarrow p \geq p_0 \equiv \frac{L}{G+L}.$$

Similarly, when asked to investigate, she prefers investigating and approving whenever $r = G$ to rejecting without investigation if

$$u^I(p) \geq 0 \Longleftrightarrow p \geq p_- \equiv \frac{c}{G}.$$

And she prefers rubberstamping to investigating and approving whenever $r = G$ if

$$u^R(p) \geq u^I(p) \Longleftrightarrow p \geq p_+ \equiv 1 - \frac{c}{L}.$$

[3]In the analysis, we neglect boundary cases and always assume that when indifferent, a committee member decides in the sponsor's best interest.

These thresholds play a central role in the analysis.

Assumption 1. $c < \frac{GL}{G+L}$.

If c were too large, i.e. violated Assumption 1, a committee member would never investigate even if she were a dictator, and a fortiori a member of a multi-member committee. The dictator's behavior is summarized in Lemma 1 and depicted in Figure 1.

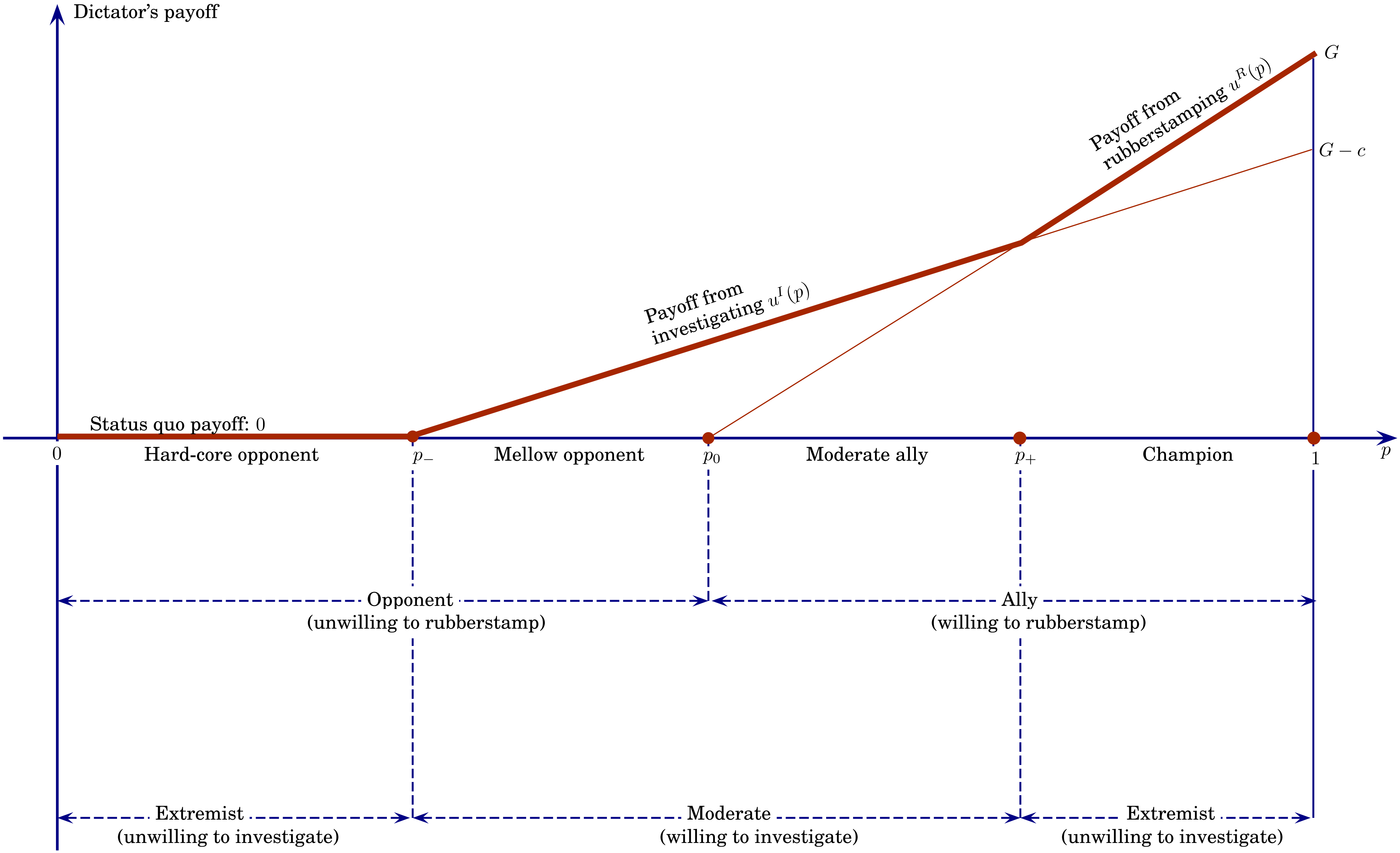
Lemma 1. *In the absence of report, the dictator rubberstamps whenever $p \geq p_0$. When provided with a report, she rubberstamps the project whenever $p \geq p_+$, investigates whenever $p_- \leq p < p_+$, and turns down the project whenever $p < p_-$. Under Assumption 1, $p_- < p_0 < p_+$.*

The following terminology, borrowed and adapted from the one used on the Democracy Center website,[4] may help grasp the meaning of the three thresholds. Based on her prior, a committee member is said to be a *hard-core opponent* if $p < p_-$, a *mellow opponen*t if $p_- \leq p < p_0$, an *ally* if $p_0 \leq p$; an ally is a *champion* for the project if $p \geq p_+$. The lemma simply says that only a *moderate* $p_- \leq p < p_+$ investigates when she has the opportunity to do so, while an *extremist*, i.e. either a hard-core opponent or a champion, does not bother to gather further information by investigating.

FIGURE 1 HERE

Faced with a dictator, the sponsor has two options: present a detailed report to the dictator and thereby allow her to investigate, or ask her to rubberstamp the project (these two strategies are equivalent when $p \geq p_+$ since the dictator rubberstamps anyway, and when $p < p_-$, as the dictator always rejects the project).

[4]See http://www.democracyctr.org/resources/lobbying.html for details.



Dictator's payoff
G
Payoff from rubberstamping $u^R(p)$
$G-c$
Payoff from investigating $u^I(p)$
Status quo payoff: 0
0
Hard-core opponent
p_-
Mellow opponent
p_0
Moderate ally
p_+
Champion
1
p
Opponent (unwilling to rubberstamp)
Ally (willing to rubberstamp)
Extremist (unwilling to investigate)
Moderate (willing to investigate)
Extremist (unwilling to investigate)

Figure

Proposition 1. (The dictator case) *When $p \geq p_0$, the sponsor asks for rubberstamping and thereby obtains approval with probability 1; when $p_- \leq p < p_0$, the sponsor lets the dictator investigate and obtains approval whenever $r = G$, that is with probability p.*

It is optimal for S to let the dictator investigate only when the latter is a mellow opponent; in all other instances, the decision is taken without any information exchange. A moderate ally, in particular, would prefer to investigate if she had the chance to, but she feels confident enough not to oppose the project in the absence of investigation; S therefore has real authority[5] in this situation.

3 Mechanism design with $N = 2$

For a two-member committee, let $P \equiv \Pr\{r_1 = r_2 = G\}$ denote the joint probability that both benefit from the project. The Bayesian update of the prior on r_i conditional on the other member's benefiting from the project is: $\hat{p}_i \equiv \Pr\{r_i = G \mid r_j = G\} = P/p_j$. We assume that committee members' benefits are affiliated for $i = 1, 2$, $\hat{p}_i \geq p_i$.[6] Finally, we label committee members so that R_1 is a priori more favorable to the project than R_2; that is, $p_1 \geq p_2$. Finally, we focus on the unanimity rule.[7]

We characterize the sponsor's optimal strategy to obtain approval from the committee: S chooses which committee members to provide the report to, in which order, and what information he should disclose in the process. The specification of the game form to be played by S and committee members is part of S's optimization problem, and so it is not possible to specify a priori the timing of the game to be analyzed. Therefore we follow a mechanism design approach (see Myerson 1982), where S is the mechanism designer, to

[5] Following the terminology in Aghion-Tirole (1997).

[6] See Proposition 6 for the case of negative correlation in two-member committees.

[7] We do not consider governance mechanisms in which e.g. voting ties are broken by a randomizing device (for example the project is adopted with probability 1/2 if it receives only one vote).

obtain an upper bound on S's payoff without specifying a game form; we will later show that this upper bound can be attained through a simple implementation procedure.

The formal mechanism design analysis is relegated to the appendix; this section provides only an intuitive description of the approach and a presentation of the simplified mechanism design problem. Regardless of the game form, a payoff-relevant outcome consists, for each state of nature, of the list of members who actually incur the cost of investigating and of the final decision, that is whether the project is implemented. The set of states of nature Ω is characterized by the possible values of r_1 and r_2. A (stochastic) direct mechanism is a mapping from the set of states of nature Ω to the set of probability distributions over the set of possible outcomes. From the Revelation Principle, we know that we can restrict attention to obedient and truthful mechanisms, i.e. mechanisms that satisfy incentive compatibility: when given information and asked to investigate by S, a member must have an incentive to comply with the recommendation and then to report truthfully to S whether she benefits from the project. The optimal obedient and truthful mechanism maximizes Q, the expected probability that the project is implemented, under incentive constraints, individual rationality constraints, feasibility constraints (probabilities are positive and sum to one in each state of nature), and measurability constraints.

Measurability constraints refer to the fact that the outcome cannot depend upon information that is unknown to all players. The probability that no one investigates and that the project is implemented (or rejected) cannot depend upon the state of nature, since no committee member knows her benefit r_i in this outcome. Similarly, the probability that only R_i investigates and that the project is implemented (or rejected) cannot depend upon the value of r_j.

Individual rationality constraints reflect the fact that under unanimity the project cannot be implemented when R_i investigates and $r_i = -L$. Incentive constraints dictate that, when committee member R_i learns through investigation the true value of her benefit r_i, she must prefer reporting it truthfully to S to lying; and that a committee member must get higher expected utility by complying with S's request to investigate than by not investigating.

The appendix simplifies S's program drastically. Intuitively, the optimal mechanism should not involve wasteful investigation. When $r_i = G$, it should not let committee member R_i investigate and let the project not be implemented unless R_j investigates and $r_j = -L$. This property helps restrict attention to a simple class of mechanisms, the class of *no-wasteful-investigation mechanisms.*

Lemma 2. (No wasteful investigation) *There is no loss of generality in looking for the optimal mechanism within the class of no-wasteful-investigation mechanisms, that is the class of mechanisms described by an element of the 5-simplex* $(\gamma, \theta_1, \theta_2, \lambda_1, \lambda_2)$ *such that:*

- *with probability* γ*, both* R_1 *and* R_2 *rubberstamp the project, i.e. approve it without any investigation;*
- *with probability* θ_i*,* R_i *investigates, and* R_j *rubberstamps;*
- *with probability* λ_i*,* R_i *investigates;* R_j *investigates if* R_i *benefits from the project and votes against the project otherwise;*
- *with probability* $1 - \gamma - \Sigma_i \theta_i - \Sigma_i \lambda_i$*, there is no investigation and the status quo prevails.*

A further simplification results from the fact that we do not need to consider truthful revelation constraints. When R_i has investigated and $r_i = -L$, she will veto the project and so her utility is not affected by her report of r_i to S. And when $r_i = G$, lying can ony hurt R_i when the mechanism belongs to the class defined by Lemma 2.

A no-wasteful-investigation mechanism, henceforth a "mechanism", is thus a commitment by S to a lottery $(\gamma, \theta_1, \theta_2, \lambda_1, \lambda_2)$. With probability γ, he asks members to vote on the project without letting them investigate.[8] With probability θ_i, S presents only R_i with a report and asks her to approve or veto the project; S asks R_j to rubberstamp (given unanimity, this is equivalent to asking R_j to rubberstamp if R_i has approved the project). With probability λ_i, S presents R_i with a report and asks her whether she will vote for the project; then conditional on R_i's approval of the project, S presents R_j with a report.

The sponsor maximizes Q, the overall probability of approval:

$$Q = \gamma + \theta_1 p_1 + \theta_2 p_2 + (\lambda_1 + \lambda_2)P,$$

with respect to $(\gamma, \theta_1, \theta_2, \lambda_1, \lambda_2)$ in the 5-simplex, subject to incentive constraints, which we now describe.

First, when R_i is asked to investigate, there is a probability $(\frac{p_j\lambda_j}{\theta_i+\lambda_i+p_j\lambda_j})$ that the other committee member has investigated and approved the project; from this, she infers that $r_j = G$ and so, that the project will be implemented if and only if she finds out that $r_i = G$, i.e. with probability $\hat{p}_i$. Or, R_i is the first member to investigate (probability $\frac{\lambda_i}{\theta_i+\lambda_i+p_j\lambda_j}$) and she expects the project to be implemented if and only if both members have positive benefits, i.e. with probability P; or else, R_i is the only member who will be asked to investigate (probability $\frac{\theta_i}{\theta_i+\lambda_i+p_j\lambda_j}$) and the project is implemented if and only if her own benefit is positive, i.e. with probability p_i. If she instead rubberstamps the project, with probability $\frac{\theta_i}{\theta_i+\lambda_i+p_j\lambda_j}$ the project is implemented and she benefits from the

[8] All implementation games we consider involve voting subgames in which multiple Nash equilibria can arise, e.g. everyone vetoes. So, throughout the paper, we assume that committee members never play according to weakly dominated strategies in voting subgames.

project with probability p_i, and with probability $\frac{(\lambda_i+\lambda_j)p_j}{\theta_i+\lambda_i+p_j\lambda_j}$, the project is implemented because the other member finds out that $r_j = G$, in which case R_i benefits from the project with probability $\hat{p}_i$. This yields the constraint:

$$\theta_i u^I(p_i) + \lambda_i u^I(P) + \lambda_j p_j u^I(\hat{p}_i) \geq \theta_i u^R(p_i) + (\lambda_i + \lambda_j) p_j u^R(\hat{p}_i). \tag{1}$$

Second, in the same situation, R_i must not prefer to simply veto the project:

$$\theta_i u^I(p_i) + \lambda_i u^I(P) + \lambda_j p_j u^I(\hat{p}_i) \geq 0. \tag{2}$$

Third, when R_i is asked to rubberstamp, and hence is not provided with any report, she must not prefer to simply veto the project, which would yield zero benefit. She may be asked to rubberstamp just like the other member (with probability $\frac{\gamma}{\gamma+\theta_j p_j}$) or after the other member's investigation and approval (with probability $\frac{\theta_j p_j}{\gamma+\theta_j p_j}$) in which case she updates her beliefs about her own benefit:

$$\gamma u^R(p_i) + \theta_j p_j u^R(\hat{p}_i) \geq 0. \tag{3}$$

To sum up, the problem to be solved is:

$$\max Q$$
$$\text{s.t. } (1), (2), \text{ and } (3).$$

4 Optimal deterministic mechanism

This section focuses on "deterministic mechanisms" that is, on mechanisms in which the outcome (who investigates and whether the project is adopted) is deterministic in each state of nature. This implies that γ, θ_i and λ_i all belong to $\{0, 1\}$. While focusing on deterministic mechanisms is restrictive, the analysis is simple and allows us to obtain a complete characterization of the optimum and to provide intuition for our main results.

The sponsor's preferences over deterministic mechanisms are immediate. There are four possible deterministic mechanisms that yield a positive probability of implementing the project, provided they are incentive compatible. Ignoring incentive compatibility, S has a clear *pecking order* over these mechanisms. He prefers a mechanism that asks both committee members to rubberstamp the project since the project is then implemented with probability $Q = 1$. His next best choice is to have only R_1 investigate and decide while R_2 rubberstamps, yielding $Q = p_1$. His third best choice is to have R_2 investigate and R_1 rubberstamp, yielding $Q = p_2$. Finally, his last choice is to have both committee members investigate, since this implies $Q = P$ irrespective of the member who investigates first. The optimal deterministic mechanism maximizes S's payoff within the set of incentive compatible deterministic mechanisms. We therefore simply follow down S's pecking order and characterize when a mechanism is incentive compatible while all preferred ones are not.

The committee rubberstamps ($Q = 1$) if and only if $u^R(p_i) \geq 0$ for each committee member, that is if and only $p_2 \geq p_0$ (since $p_1 \geq p_2$ by assumption).

Proposition 2. *If both committee members are allies of the sponsor, i.e. if $p_1 \geq p_2 \geq p_0$, members rubberstamp without investigation and so the project is implemented with probability $Q = 1$.*

The committee is reduced to a mere rubberstamping function even though moderate allies ($p_0 \leq p_i < p_+$) would prefer to have a closer look at the project if given the chance to. But S does not give them the option since this could only trigger some opposition to the project. This outcome is similar to the one obtained in the dictator case.

Another simple case arises when the committee consists of two hard-core opponents, that is when $p_2 \leq p_1 < p_-$. In this case, $u^R(P) \leq u^R(p_i) < u^I(p_i) < 0$ for $i = 1, 2$. A hard-core opponent neither approves without further information than her prior nor investigates, and so the project is turned down.

Proposition 3. *If both committee members are hard-core opponents to the project, i.e. if* $p_2 \leq p_1 < p_-$*, the project is never implemented.*

We therefore restrict attention to the constellation of parameters such that at least one member is not an ally ($p_2 \leq p_0$), and at least one member is not a hard-core opponent ($p_1 \geq p_-$).

We focus first on the case where R_1 is a champion for the project ($p_1 > p_+$), while R_2 is an opponent ($p_2 < p_0$). From the definition of p_+, $u^R(p_1) > u^I(p_1)$. A fortiori $u^R(\widehat{p}_1) > u^I(\widehat{p}_1)$. And so there is no way to induce the champion to investigate; she always prefers to rubberstamp and avoid paying the cost of examining the report. Referring to S's pecking order, the only possible way to get the project approved is to let R_2 investigate and decide.

Proposition 4. *If* R_1 *is a champion* ($p_1 > p_+$)*, while* R_2 *is a mellow opponent* ($p_- \leq p_2 < p_0$)*, the project is implemented with ex ante probability* $Q = p_2$*; the sponsor lets the mellow opponent investigate and decide according to the value of* r_2*, while the champion rubberstamps. If however* R_1 *is a champion while* R_2 *is a hard-core opponent, there is no way to have the project approved* ($Q = 0$)

The proposition formalizes the idea that *too strong a support is no useful support.* S's problem here is to convince the opponent R_2. Without any further information, this opponent will simply reject the proposal. To get R_2's approval, it is therefore necessary to gather good news about the project. Investigation by R_1 is likely to deliver such good news, but committee member R_1 is so enthusiastic about the project that she will never bother to investigate. The sponsor has no choice but to let the opponent investigate herself. R_2 de facto is a dictator and R_1 is of no use for the sponsor's cause.

We complete our analysis by focusing on the region of parameters such that $p_- \leq p_1 \leq p_+$ and $p_2 < p_0$. In this region, we move down S's pecking order, given that having both members rubberstamp cannot be incentive compatible. The following proposition characterizes the optimal scheme.

Proposition 5. *Suppose the committee consists of a moderate and an opponent, i.e.* R_1 *is a moderate with* $p_- \leq p_1 \leq p_+$ *and* R_2 *is an opponent with* $p_2 < p_0$*;*

- *if* $\hat{p}_2 \geq p_0$ *(*R_2 *is willing to rubberstamp if she knows that* R_1 *benefits from the project), the optimal mechanism is to let the most favorable member* R_1 *investigate and decide: the project is implemented with probability* $Q = p_1$*;*

- *if* $\hat{p}_2 < p_0$ *and* $\hat{p}_1 \geq p_0$*, the optimal mechanism is to let* R_2 *investigate and decide (in which case the project is implemented with probability* $Q = p_2$*) if* $p_2 \geq p_-$*; the project cannot be implemented if* $p_2 < p_-$*;*

- *if* $\hat{p}_i < p_0$ *for* $i = 1, 2$*, the optimal mechanism is to let both members investigate provided* $P \geq p_-$*, in which case* $Q = P$*; the status quo must prevail if* $P < p_-$*.*

Proof. The proof simply follows S's pecking order. $\theta_1 = 1$ is incentive compatible if and only if:

$$
\begin{aligned}
u^I(p_1) &\geq u^R(p_1) \\
u^I(p_1) &\geq 0 \\
u^R(\hat{p}_2) &\geq 0.
\end{aligned}
$$

The first two conditions are equivalent to $p_- \leq p_1 < p_+$, and hence are satisfied; the last condition is equivalent to $\hat{p}_2 \geq p_0$.

If $\hat{p}_2 < p_0$, $\theta_1 = 1$ violates incentive compatibility and the next best choice is $\theta_2 = 1$. The latter is incentive compatible if and only if:

$$\begin{aligned} u^I(p_2) &\geq u^R(p_2) \\ u^I(p_2) &\geq 0 \\ u^R(\hat{p}_1) &\geq 0. \end{aligned}$$

In the sub-region $\hat{p}_2 < p_0$, the first two conditions are equivalent to $p_2 \geq p_-$, and the last one is equivalent to $\hat{p}_1 \geq p_0$.

Finally, the next best choice would be to have $\lambda_i = 1$ for some i. (2) then imposes that $u^I(P) \geq 0$, i.e. that $P \geq p_-$. So, if $p_2 < p_-$, $\lambda_i = 1$ cannot be implementable since $P \leq p_2$. Therefore $\lambda_i = 1$ can only be optimal within the region such that $p_- \leq p_2$, $\hat{p}_2 < p_0$ and $\hat{p}_1 < p_0$. There, the incentive compatibility constraints are:

$$\begin{aligned} u^I(P) &\geq p_j u^R(\hat{p}_i) \\ u^I(\hat{p}_i) &\geq u^R(\hat{p}_i) \\ u^I(P) &\geq 0 \\ u^I(\hat{p}_j) &\geq 0. \end{aligned}$$

$\hat{p}_i < p_0$ implies $u^R(\hat{p}_i) < 0$ so that the first constraint is implied by the third, the second and the fourth constraint are satisfied since $\hat{p}_i \geq p_2 \geq p_-$. So, $\lambda_i = 1$ is optimal whenever $\hat{p}_2 < p_0$, $\hat{p}_1 < p_0$ and $P \geq p_-$. $\blacksquare$

Like Proposition 4, Proposition 5 shows that for committees that consist neither of two hard-core opponents nor of two allies, communication is required to get the project adopted. More importantly, Proposition 5 relies on the existence of *persuasion cascades*. Although a committee member R_i is a priori an opponent to the project ($p_i < p_0$), she may be induced to give her approval without investigation if she can trust her fellow committee member R_j's informed decision. In some sense, R_i is ready to delegate authority about the decision to R_j, knowing that R_j will endorse the project only after investigating and learning that her benefit is positive ($r_j = G$). R_j is reliable for R_i because the information that $r_j = G$ is sufficiently *good news* about r_i that the updated beliefs $\Pr\{r_i = G \mid r_j = G\}$ turn R_i into an ex post ally, that is $\hat{p}_i \geq p_0$, who is now willing to rubberstamp R_j's decision without further investigation.

Of course, the sponsor prefers to rely on a persuasion cascade triggered by the most favorable committee member R_1, since the probability that this member benefits from the project is larger than the corresponding probability for the other member. But this strategy is optimal only if R_1 is reliable for R_2, that is if news about $r_1 > 0$ carries enough information to induce R_2 to rubberstamp. If R_1 is not reliable for R_2, then the next best strategy is to rely on a persuasion cascade triggered by the less favorable committee member R_2. Even though this implies a smaller probability of having the project adopted, this strategy is still better than having both members investigate, which leads to approval with probability P.

It is worth noting that the choice of the optimal persuasion strategy by the sponsor does not depend only on the *external congruence* of the committee, that is on the prior probabilities p_i that the members' benefits are aligned with the sponsor's benefit; this choice also depends on the degree of *internal congruence* among committee members, that is on the posteriors $\hat{p}_i$. The sponsor will find it optimal to trigger a targeted persuasion cascade when facing a committee with high internal congruence, while he must convince both members of a committee with poor internal congruence.

It is straightforward to find implementation procedures for the optimal mechanism. Persuasion cascades amount to presenting the project to one committee member through private communication, letting her endorse or reject the project, and asking the other member to rubberstamp. When both committee members need be convinced, one of them is asked to investigate, followed by the other if the first investigator endorses the project.

Finally persuasion cascades may be viewed as "bottom-up" or "top-down", depending upon whether S convinces first the committee member with interests closer to his (the more externally congruent) or the committee member with interests that are the more conflictual with his (the less externally congruent member).

An illustrative example: the case of nested preferences.

Assume that a project that benefits committee member R_2 necessarily also benefits R_1: $P = p_2$. Committee members are then ranked unambiguously in terms of how aligned their objectives are with the sponsor's. Internal congruence within the committee is captured by the updated beliefs: $\hat{p}_1 = 1$ and $\hat{p}_2 = p_2/p_1$.

Note that R_1 will always rubberstamp R_2's informed decision and so persuasion cascades triggered by R_2 are possible provided $p_2 \geq p_-$. Persuasion cascades triggered by R_1 if feasible are preferred by S since R_1 has more external congruence with him. But R_1's external congruence with S comes in direct conflict with internal congruence within the committee: indeed, keeping p_2 fixed, the larger p_1, the less reliable R_1 is as a sole investigator for R_2 and the less R_2 is willing to follow a persuasion cascade triggered by R_1.

The optimal mechanism in this nested case can be straightforwardly computed from previous propositions using the fact that $\hat{p}_2 \geq p_0 \Leftrightarrow p_2 \geq p_0 p_1$. It is depicted in Figure 2.

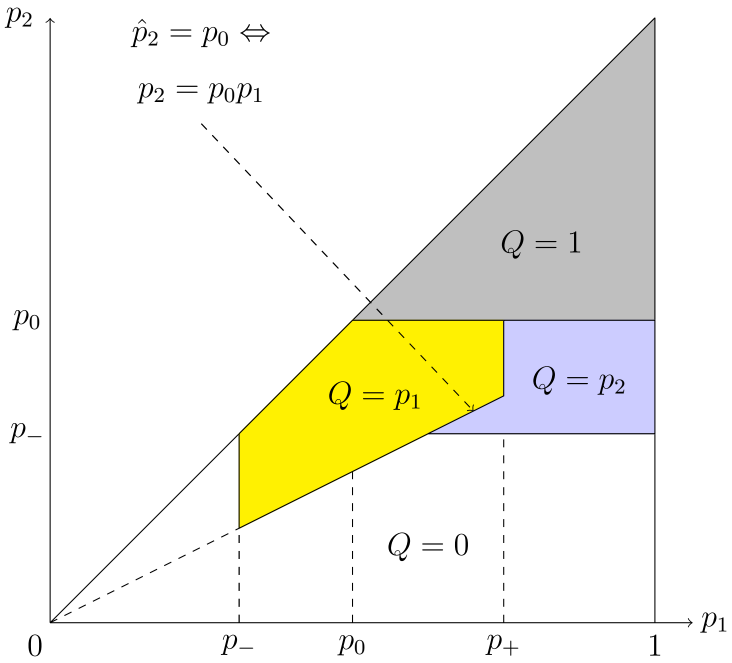


FIGURE 2

Internal dissonance.

Persuasion cascades rely on the fact that it is good news for one committee member to learn that the other benefits from the project. If committee members' benefits are stochastically independent, then $\hat{p}_i = p_i$ for each i: No bandwagon effect can be generated and no persuasion cascade can exist; each committee member is de facto a dictator and the sponsor has no sophisticated persuasion strategy relying on group effects.

When the members' benefits are negatively correlated, $r_i = G$ is bad news for R_j and therefore $\hat{p}_i < p_i$: there is internal *dissonance* within this committee. In this case, Propositions 2 and 3 continue to hold. Focusing on the non-trivial case in which $p_2 < p_0$, $\hat{p}_2 < p_2 < p_0$ implies that no persuasion cascade can be initiated with R_1 investigating and R_2 rubberstamping. So, whenever $p_2 < p_0$, R_2 must investigate for the project to have a chance of being approved. Then, R_1 knows that the project can be adopted only if $r_2 = G$. In the optimal mechanism, R_1 acts as a dictator conditionnal on $r_2 = G$ and decides to rubberstamp, investigate or reject the project based on the posterior $\hat{p}_1$. Since $\hat{p}_1 < p_1$, it is more difficult to get R_1's approval when she is part of a committee with internal *dissonance*. Following similar steps as in the proof of Proposition 5, it is easy to characterize the optimal mechanism under internal dissonance; the results are summarized in the following proposition.

Proposition 6. (Internal dissonance) *Assume the committee is characterized by internal dissonance, i.e. $\hat{p}_i \leq p_i$ for $i = 1, 2$, and that $p_2 < p_0$ and $p_1 > p_-$:*

- *if $p_2 < p_-$, the project cannot be implemented;*
- *if $p_2 \geq p_-$ and $\hat{p}_1 \geq p_0$, the optimal mechanism is to let R_2 investigate and R_1 rubberstamp: $Q = p_2$;*
- *if $p_2 \geq p_-$ and $\hat{p}_1 < p_0$, the optimal mechanism is to let both members investigate whenever $P \geq p_-$, in which case the project is implemented with probability $Q = P$; if $P < p_-$ however, the status quo prevails.*

Note that the second bullet point in this proposition does not describe a persuasion cascade: R_1 would be willing to rubberstamp based on her prior and the mechanism exploits the fact that she is still willing to rubberstamp *despite* the bad news $r_2 = G$.

5 Comparative statics and robustness

This section discusses the properties of the optimal deterministic mechanism.

Stochastic structure.

The comparative statics analysis with respect to priors in the general model is slightly more delicate than in the nested example since the following equality must always hold: $\hat{p}_2 p_1 = \hat{p}_1 p_2 = P$. Several types of analysis can be considered: increasing $\hat{p}_i$ while keeping p_i fixed (hence increasing P), increasing p_i while keeping P fixed (hence decreasing $\hat{p}_j$), increasing p_i while keeping $\hat{p}_j$ and p_j fixed (hence increasing P and $\hat{p}_i$).

The first type of analysis is straightforward and a mere examination of Proposition 5 delivers the following corollary.

Corollary 1. (Benefits from internal congruence) *Fixing priors p_i, the probability of having the project implemented is (weakly) increasing in $\hat{p}_1$ and $\hat{p}_2$.*

The sponsor unambiguously benefits from higher internal congruence within the committee. It should be noted that this holds even when only one member investigates (when both members investigate, an increase in internal congruence mechanistically raises the probability P that both favor the project). Note further that Proposition 6 implies that less internal dissonance also benefits the sponsor under negative correlation.

The next corollary shows that an increase in member i's external congruence with S may hurt S for two reasons: First, if R_i investigates, her endorsement may no longer be credible enough for R_j ($\widehat{p}_j$ falls below p_0); second she may even no longer investigate (p_1 becomes greater than p_+). In either case, an increase in R_i's congruence with S prevents a persuasion cascade.

Corollary 2. (Potential costs of external congruence) *(i) Fixing P, an increase in either p_1 or p_2 may lead to a smaller probability of having the project approved.*
(ii) Fixing p_2 and $\hat{p}_2$, an increase in p_1 (and therefore also in $\hat{p}_1$) may lead to a smaller probability of having the project approved.[9]

[9] However, fixing p_1 and $\hat{p}_1$, an increase in p_2 unambiguously increases Q.

Payoffs.

First, although R_1's prior payoff distribution first-order stochastically dominates R_2's, R_1's expected benefit may be smaller than R_2's. The reason is that R_1, but not R_2, may incur the investigation cost.[10] The sponsor's reliance on the member with highest external congruence to win the committee's adhesion imposes an additional burden on this member and she may be worse off than her fellow committee member.[11]

Second, suppose that the sponsor can modify project characteristics so as to raise the members' benefits or reduce their losses. Such manipulations do not necessarily make it easier to get the project adopted, as the next result shows.[12]

Corollary 3. *If $G_1 = G_2 = G$ and $L_1 < L_2 = L$, the probability of having the project approved may be smaller than when $L_1 = L$.*[13]

As in Corollary 2, too strong an ally is useless, and so raising an ally's external congruence may decrease the chances of the project being approved.

Do more veto powers jeopardize project adoption?

Intuition suggests that under the unanimity rule, the larger the committee the stronger the status-quo bias. Although our model so far deals only with one- and two-member

[10] In particular, when p_1 is slightly above p_- (while $\hat{p}_2 \geq p_0$), R_1's expected benefit is almost null.

[11] This point is to be contrasted with one in Dewatripont-Tirole (2005), according to which a dictator may be made worse off by an increase in her congruence with the sponsor because she is no longer given the opportunity to investigate. It also suggests that if the a priori support of committee members were unknown to the sponsor, the latter could not rely on voluntary revelation of priors by committee members (the same point also applies to the dictator case).

[12] More generally, the sponsor could raise G_i and lower L_i. Proposition 3 focuses on the interesting case. For completeness, let us state the other results:

(i) If $G_i > G = G_2$ and $L_1 = L_2 = L$, the probability of having the project approved unambiguously increases compared with the case where $G_1 = G$. (ii) If $G_1 = G_2 = G$ and $L_2 < L_1 = L$, the probability of having the project approved unambiguously increases compared with the case where $L_2 = L$.

[13] If $L_1 < L$, the thresholds $p_{0,1} = \frac{L_1}{G+L_1}$ and $p_{+,1} = 1 - \frac{c}{L_1}$ become member-specific and smaller than their counterparts p_0 and p_+. A decrease in L_1 below L may then turn R_1 into a champion, which prevents a persuasion cascade initiated by R_1.

committees, it may shed a new light on this idea and enrich our understanding of bureaucracies. The conjecture that larger communities are less likely to vote against change misses the main point about the use of persuasion cascades to persuade a group. When internal congruence within the committee is high enough so that $\hat{p}_2 \geq p_0$, it is possible to win R_2's adhesion to the project even though she started as an hard-core opponent ($p_2 < p_-$). Adoption would not be possible with a hard-core opponent dictator.

Suppose that committees are formed by randomly selecting members within a given population of potential members with ex ante unknown support for S's project. For a one-member committee (a dictator) the probability of implementing the project is based merely on external congruence with S; two-member committees may compensate poor external congruence of some of its members by high internal congruence among its members and therefore lead, ex ante, to a higher probability of implementing S's project.

Proposition 7. *A randomly drawn two-member committee may implement projects more often than a randomly drawn dictator: a two-member committee is not necessarily more prone to the status-quo bias than a one-member committee.*

Proof. The proof is by way of an example. A randomly-drawn member is a mellow opponent with probability β (has congruence $p = p_H$, where $p_- < p_H < p_0$), and a hard-core opponent with probability $1 - \beta$ (has congruence $p_L < p_-$). Assume that the hard-core opponent rubberstamps if the mellow opponent investigates and favors the project. The optimal organization of a two-member committee that turns out to be composed of at least one mellow opponent is to let a mellow opponent investigate and the other rubberstamp. The ex ante probability that a randomly drawn two-member committee approves the project is larger than for a random dictator:

$$\mathbf{E}[Q] = \beta^2 p_H + 2\beta(1-\beta)p_H = \beta(2-\beta)p_H > \beta p_H. \qquad \blacksquare$$

Side communication.

We have assumed that communication can only take place between the sponsor and committee members. There may be uncontrolled channels of communication among members, though. First, members may exchange soft information about their preferences and about whether they have been asked to investigate. Second, an investigator may, in the absence of confidentiality requirement imposed by the sponsor, forward the file to the other committee member. It is therefore interesting to question the robustness of our results to the possibility of side communication between committee members. To this purpose, we exhibit implementation procedures in which the equilibrium that delivers the optimal outcome is robust to the possibility of side communication, whether the latter involves cheap talk or file transfer among members.[14]

Obviously, side communication has no impact when both members rubberstamp, as they then have no information. Intuitively, it also does not matter under sequential investigation, because the sponsor both reveals the first investigator's preferences and hands over the file to the second investigator. Under a single investigation and rubberstamping, the member who rubberstamps can as well presume that the investigator liked the project (otherwise her vote is irrelevant); furthermore, conditional on liking the project, the investigator is perfectly congruent with the sponsor and has no more interest than he does in having the second member investigate rather than rubberstamp. Appendix 2 makes this reasoning more rigorous and also looks at side communication following out-of-equilibrium moves.

Proposition 8. (Robustness to side communication) *The sponsor can obtain the same expected utility even when he does not control communication channels among members.*

[14]So, we focus on a weak form of robustness; there exist other equilibria that do not implement the optimal outcome, if only because of the voting procedure.

6 Informational and voting pivots in N-member committees

We now turn to N-member committees. In this richer framework, we discuss selective communication (who should be presented with a report) and the role of the committee's decision rule. To present the main intuition, we focus on a case that generalizes the example provided at the end of section 4: committee members' preferences are nested. Moreover, we restrict the analysis to deterministic sequential mechanisms, defined below.

Let R_i, $i = 1, 2, ..., N$ denote the members of the committee, with benefits $r_i \in \{-L, G\}$ and $p_i = \Pr\{r_i = G\}$. Committee members are ranked with respect to their degree of external congruence with the sponsor, R_1 being the most supportive and R_N the most radical opponent:

$$p_{N+1} \equiv 0 \leq p_N \leq p_{N-1} \leq ... \leq p_2 \leq p_1 \leq 1.$$

We assume the following nested stochastic structure: projects that benefit a given member also benefit all members who are a priori more supportive of (or less opposed to) the project: for any j, k such that $j > k$,

$$r_j = G \Longrightarrow r_k = G.$$

The committee makes its decision according to a K-majority rule, with $K \leq N$ ($K = N$ corresponds to the unanimity rule). So, S needs to build a consensus among (at least) K members of the committee to get the project approved. If $p_K \geq p_0$, then for all $j \in \{1, 2, ...K\}$, $p_j \geq p_0$, and the K members who are the most externally congruent with the sponsor are willing to approve the project without investigation. From now on, we focus on the more interesting case in which general rubberstamping is not feasible ($p_K < p_0$).

If the *voting pivot* R_K is not a priori willing to rubberstamp ($p_K < p_0$), some information must be passed on inside the committee to obtain approval. Let us define the *informational pivot* R_{i^*} as the member who is the most externally congruent member within the set of committee members R_j who are not champion and whose internal congruence with R_K is sufficiently high to sway the voting pivot's opinion: $\Pr\{r_K = G \mid r_j = G\} \geq p_0$. Formally, in the nested structure:

$$i^* = \min\{j \text{ such that } p_0 p_j \leq p_K \text{ and } p_j \leq p_+\}.$$

Clearly, i^* exists and $i^* \leq K$.

A deterministic mechanism is a mapping $(I(.), d(.))$ from the set of states of nature to the set of subsets of $\{1, 2, ..., N\} \times \{0, 1\}$, where $I(\omega)$ denotes the set of committee members who investigate and $d(\omega)$ denotes the final decision in state of nature ω. In the rest of this section, we discuss the optimal deterministic mechanism in the nested case, first under the unanimity rule, and then under a more general K-majority rule.

Unanimity rule ($K = N$)

When general rubberstamping is infeasible, the sponsor has to let at least one committee member investigate. The sponsor has an obvious pecking order if he chooses to let exactly one member investigate: he prefers to approach the most favorable member among those who have the right incentives to investigate and whose endorsement convinces all other members in particular the voting pivot R_N to rubberstamp. The informational pivot is then a natural target for selective communication of the report by S. The next proposition formalizes this intuition and shows that selective communication with the informational pivot is optimal within the set of all deterministic mechanisms, even those involving multiple investigations.[15]

[15]Both propositions in this section are proved in Appendix 3.

Proposition 9. (Informational pivot under unanimity) *Suppose that $p_K < p_0$ and $K = N$;*

- *if $p_- \leq p_{i^*}$, the optimal deterministic mechanism consists in letting R_{i^*} investigate and all other members rubberstamp; the project is then approved with probability $Q = p_{i^*}$;*
- *if $p_{i^*} < p_-$, the project cannot be approved using a deterministic mechanism.*

The proposition characterizes which committee member the sponsor should try to convince. Investigation revealing that $r_{i^*} = G$ can generate a strong enough persuasion cascade that member R_N, and a fortiori all others, approve the project without further investigation. In general, the informational pivot differs from the voting pivot (R_N here). That is, the best strategy of persuasion is not necessarily to convince the least enthusiastic member. A better approach is to generate a persuasion cascade that reaches R_N. The choice of the informational pivot reflects the trade-off between internal congruence with R_N and external congruence with S.

Majority rule ($K < N$)

Since $p_K < p_0$, the sponsor has again to let at least one member investigate. If he chooses to let exactly one member investigate, he should again target a member j who has the right incentives to investigate and one whose endorsement induces at least K members (including herself) to rubberstamp. Given the nested structure, the latter property amounts to convincing R_K to rubberstamp.

Proving that this one-investigation mechanism is optimal among all deterministic mechanisms is however more difficult than under the unanimity rule, because an investigation revealing that $r_j = -L$ is still compatible with the project being approved. We were able to obtain this result only under the additional assumption of *vote trans-*

parency: under vote transparency, before being asked to vote, all committee members observe which members have investigated and the results of their investigation.[16]

Proposition 10. *Suppose that $p_K < p_0 p_+$, $K < N$, and vote transparency holds; if $p_- \leq p_{i^*}$, the optimal deterministic mechanism consists in letting R_{i^*} investigate and all other members rubberstamp, the project being approved with probability $Q = p_{i^*}$.*

Note that the larger the required majority (K grows), the less sympathetic to the sponsor's cause the informational pivot is, and the lower the probability of adoption. Unlike an increase in the committee size under a given voting rule, an increase in the required majority for a given committee size can never benefit the sponsor under the conditions of Proposition 10.

Both propositions proves that selective communication is a key dimension in the sponsor's optimal strategy; irrespective of the rules governing decision-making in the committee, it leads to a strong distinction between the voting and the informational pivot.[17]

7 Stochastic mechanisms

The restriction to deterministic mechanisms involves some loss of generality, as we now show. In this section, we consider a symmetric two-member committee ($p_1 = p_2 = p$, $\hat{p}_1 = \hat{p}_2 = \hat{p}$), and we investigate the possibility for S to increase the probability of getting the project approved using (symmetric) stochastic mechanisms.

[16]Although it is restrictive, this assumption may be motivated as follows. If all members know who has investigated but not necessarily the results of their investigation, it would be a dominant strategy for informed members to publicly and truthfully disclose the value of their benefits if a stage of public communication were introduced before the final vote. Note also that it might be difficult for the sponsor to secretly approach a committee member without the others noticing.

So, the important assumption is that investigation by a member who is presented with a report is observable by other members, or else that it is costless.

[17]Interestingly, the Democracy Center's website makes a similar distinction between "decision-influencer" and "decision-maker".

Assume that $p_- < p < p_0 < \hat{p}$, so that the optimal deterministic mechanism consists in a persuasion cascade where R_1, say, investigates and R_2 rubberstamps. In this deterministic mechanism, R_2 knows that R_1 investigates and, given this, she has strict incentives to rubberstamp rather than to reject the project: $u^R(\hat{p}) > 0 = u^R(p_0)$. If R_2 knew that R_1 does not investigate, however, she would not rubberstamp since $u^R(p) < 0$. Suppose now that R_1 may or may not investigate; R_2 is then willing to rubberstamp provided she is confident enough that R_1 investigates. So, when $p < p_0 < \hat{p}$, it is not necessary to have R_1 investigate with probability 1 to get R_2's approval.

Intuitively, the incentive constraint corresponding to rubberstamping is slack in the deterministic mechanism. Stochastic mechanisms may be designed so as to induce appropriate beliefs from the committee members: we say that stochastic mechanisms exhibit *constructive ambiguity*. Constructive ambiguity enables S to reduce the risk that one member gets evidence that she would lose from the project, and thereby increases the overall probability of having the project adopted.

To make this intuition more precise, suppose S mixes among three deterministic mechanisms and committee members do not directly observe the realization of this lottery: with probability $\theta \in [0, \frac{1}{2}]$, S asks R_1 to investigate and R_2 to rubberstamp, with probability θ, S asks R_2 to investigate and R_1 to rubberstamp, and with probability $1 - 2\theta$, S asks both committee members to rubberstamp. When asked to rubberstamp, R_i does not know whether R_j is asked to investigate. R_i rubberstamps whenever (3) holds, that is whenever:

$$(1 - 2\theta)u^R(p) + \theta p u^R(\hat{p}) \geq 0 \Longleftrightarrow \theta \geq \frac{u^R(p)}{2u^R(p) - pu^R(\hat{p})}.$$

Note that $\frac{u^R(p)}{2u^R(p) - pu^R(\hat{p})} \in (0, \frac{1}{2})$ because $u^R(p) < 0$, so that it is possible to find appropriate values of θ. Moreover, when being asked to investigate, a committee member perfectly knows the realization of the mechanism lottery and she has incentives to comply, just like in a deterministic mechanism (since $p > p_-$). This stochastic mechanism is therefore implementable and it leads to an overall probability of implementing the project equal to $Q = (1 - 2\theta) + 2\theta p > p$, hence higher than for the optimal deterministic mechanism.

We summarize this discussion as follows.

Proposition 11. *In the symmetric two-member committee, when $p_- < p < p_0 < \hat{p}$, stochastic mechanisms strictly dominate the optimal deterministic (persuasion cascade) mechanism; constructive ambiguity allows the sponsor to reduce investigation and to elicit rubberstamping more often.*

Stochastic mechanisms and the role of constructive ambiguity may also help S get a project approved even when facing two hard-core opponents. The intuition for this particularly striking result is quite similar to that for the previous result. Suppose the committee consists of two hard-core opponents ($p < p_-$) whose distributions of payoffs are highly correlated: $\hat{p} > p_0$, i.e. there is strong internal congruence within this committee. S's problem is to induce one member to investigate. If a committee member thought with sufficiently high probability that she is asked to investigate after her fellow committee member has investigated and discovered that her own benefits are positive, she would be willing to investigate herself, and even to rubberstamp. Hence, there is room again for constructive ambiguity: S can simply randomize the order in which he asks members to investigate, without revealing the order that is actually followed.[18]

Proposition 12. *When $p_0 > \frac{1+p_-}{2}$, there exists a subset of parameter values $(p, \hat{p})$ under which the sponsor can use a stochastic mechanism to get approval from a committee consisting of two hard-core opponents by using a stochastic mechanism.*

The previous two propositions demonstrate the power of constructive ambiguity. Stochastic mechanisms enable S to manipulate committee members' information when they de-

[18]The proof of Proposition 12 can be found in Appendix 4.

cide upon their action, thereby enlarging the set of available persuasion strategies. This approach is very similar to the practice that consists in getting two major speakers interested in attending a conference by mentionning the fact that the other speaker will likely attend the conference herself. If each is sufficiently confident that the other one is seriously considering to attend, she might indeed be induced to look closely at the program of the conference and investigate whether she can move her other commitments.

The one-investigation stochastic mechanism discussed in Proposition 11 can be easily implemented; the sponsor simply commits to secretly approach one of the members before the final vote. Implementing the random sequential investigation mechanism discussed in Proposition 12 may however be rather involved if S can approach only one committee member at a time and communication requires time. To illustrate the difficulty, suppose that with probability $\frac{1}{2}$ the sponsor presents R_1 with a detailed report at time $t = 1$ and, if $r_1 = G$, he transfers the report to R_2 at time $t = 2$; with probability $\frac{1}{2}$ the order is reversed. When being approached at $t = 1$, R_i then knows for sure that she is the first to investigate and constructive ambiguity collapses. Implementing constructive ambiguity requires a more elaborate type of commitment.[19] Stochastic mechanisms may therefore come at a cost in terms of realism.

Finally, let us discuss the robustness of stochastic mechanisms to side communication. While the mechanism exhibited in Proposition 11 is robust to file transfers (for the now-usual reason that a member who knows she will benefit from the project does not want to jeopardize the other member's assent), it does not seem robust to soft communication before voting. Indeed it is Pareto optimal and incentive compatible for the members to

[19]Suppose there is a date $t = 1$ at which the committee must vote. In addition to randomizing the order, the project sponsor must also commit to draw a random time $t \in (0, 1)$, according to some probability distribution, at which he will present the first member with a report; if presenting the report lasts Δ, at $t + \Delta$ he should (conditionally) presents the other member with the report. The distribution of t must be fixed so that when being approached, a committee member draws a asymptotically zero-power test on the hypothesis that she is the first to be approached, when Δ goes to 0.

communicate to each other when they have been asked to rubberstamp. This prevents them from foolishly engaging in collective rubberstamping.

By contrast, it can be argued that the random sequential investigation mechanism in Proposition 12 is robust to side communication. It is obviously robust to soft communication before voting as both know that they benefit from the project when they actually end up adopting it. Similarly, file transfers are irrelevant. Furthermore the equilibrium outcome is under some conditions Pareto optimal for the members and remains an equilibrium under soft communication as to the order of investigation (see footnote 19 for an example of implementation).

8 Conclusion

Many decisions in private and public organizations are made by groups. The economic literature on organizations has devoted surprisingly little attention to how sponsors of ideas or projects should design their strategies to obtain favorable group decisions. This paper has attempted to start filling this gap. Taking a mechanism design approach to communication, it shows that the sponsor should distill information selectively to key members of the group and engineer persuasion cascades in which members who are brought on board sway the opinion of others. The paper unveils the factors, such as the extent of congruence among group members ("internal congruence") and between them and the sponsor ("external congruence"), and the size and governance of the group, that condition the sponsor's ability to maneuver and get his project approved. While external congruence has received much attention in the literature on a single decision-maker, the key role of internal congruence and its beneficial effect for the sponsor (for a given external congruence) is novel.

This work gives content not only to the pro-active role played by sponsors in group decision-making, but also to the notion of "key member", whose endorsement is look after. A key member turns out to be an "informational pivot", namely the member who is most aligned with the sponsor while having enough credibility within the group to sway the vote of (a qualified majority of) other members; a key member in general is not voting-pivotal and may initially oppose the project.

Even in the bare-bones model of this paper, the study of group persuasion unveils a rich set of insights, confirming some intuitions and infirming others. On the latter front, we showed that adding veto powers may actually help the sponsor while an increase in external congruence may hurt him; that a more congruent group member may be worse off than an a priori more dissonant member; and that, provided that he can control channels of communication, the sponsor may gain from creating ambiguity as to whether other members really are on board. Finally, an increase in internal congruence always benefits the sponsor.

Needless to say, our work leaves many questions open. Let us just mention three obvious ones:

Multiple sponsors: Sponsors of alternative projects or mere opponents of the existing one may also be endowed with information, and themselves engage in targeted lobbying and the building of persuasion cascades. Developing such a theory of competing advocates faces the serious challenge of building an equilibrium mechanism design methodology for studying the pro-active role of the sponsors.

Size and composition of groups: We have taken group composition and size as given (although we performed comparative static exercises on these variables). Although this is perhaps a fine assumption in groups like families or departments, the size and composition of committees, boards and most other groups in work environments are primarily driven by the executive function that they exert. As committees and boards are meant to serve organizational goals rather than lobbyists' interests, it would thus make sense to move one step back and use the results of analyses such as the one proposed here to answer the more normative question of group size and composition.

Two-tier persuasion cascades: even though their informational superiority and gate-keeping privileges endow them with substantial influence on the final decision, committees in departments, Congress or boards must still defer to a "higher principal" or "ultimate decision-maker" (department; full House or, because of pandering concerns, the public at large; general assembly). Sponsors must then use selective communication and persuasion building at two levels. For example, lobbying manuals discuss both "inside lobbying" and "outside lobbying" (meetings with and provision of analysis to legislators, selective media and grassroot activities).

We leave these and many other fascinating questions related to group persuasion for future research.

References

Aghion, P. and J. Tirole (1997) "Formal and Real Authority in Organizations," *Journal of Political Economy*, 105: 1–29.

Austen-Smith, D. (1990) "Information Transmission in Debate", *American Journal of Political Science*, 34(1), 124-152.

——— (1993a) "Information and Influence: Lobbying for Agendas and Votes", *American Journal of Political Science*, 37(3), 799-833.

——— (1993b) "Interested Experts and Policy Advice: Multiple Referrals under Open Rule", *Games and Economic Behavior*, 5, 3-44.

Austen-Smith, D. and W.H. Riker, (1987) "Asymmetric Information and the Coherence of Legislation," *American Political Science Review,* 81(3): 897–918.

Battaglini, M. (2002) "Multiple Referrals and Multidimensional Cheap Talk," *Econometrica*, 70(4): 1379–1401

Battaglini, M. and R. Bénabou (2003) "Trust, Coordination and the Industrial Organisation of Political Activism," *Journal of the European Economic Review*, 1(4): 851–889.

Beniers, K. and O. Swanks (2004) "On the Composition of Committee," *Journal of Law, Economics and Organizations,* 20(2): 353–79.

Crawford, V. and J. Sobel (1982) "Strategic Information Transmission," *Econometrica*, 50(6): 1431–1451.

Dewatripont, M. and J. Tirole (1999) "Advocates," *Journal of Political Economy,* 107(1): 1–39.

——— (2005) "Modes of Communication," *Journal of Political Economy,* 113(6): 1217–1238.

Farrell, J. and R.Gibbons (1989) "Cheap Talk with Two Audiences", *American Economic Review,* 79, 1214-1223.

Federsen, T. and W.Pesendorfer (1996) "The Swing Voter's Curse," *American Economic Review,* 86(3): 408–424.

Gilligan, T., and K. Krehbiel (1989) "Asymmetric Information and Legislative Rules with A Heterogenous Committee," *American Journal of Political Science,* 33, 459-490.

Glazer, J. and A. Rubinstein (1998) "Motives and Implementation: on the Design of Mechanisms to Elicit Opinions," *Journal of Economic Theory*, 79(2): 157-173.

Glazer, J. and A. Rubinstein (2001) "Debates and Decisions, On a Rationale of Argumentation Rules," *Games and Economic Behavior*, 36: 158–173.

Groseclose, T. and D. King (1997) "Committee Theories and Committee Institutions," working paper, http://www.ksg.harvard.edu/prg/king/committ.htm.

Groseclose, T. and D. King (2000) "Committee Theories Reconsidered," in Lawrence C. Dodd and Bruce I. Oppenheimer, editors, *Congress Reconsidered*, 7th Edition.

Groseclose, T. and J. Snyder (1996) "Buying Supermajorities," *American Political Science Review*, 90: 303–315.

Grossman, S. (1980) "The Role of Warranties and Private Disclosure about Product Quality," *Journal of Law and Economics*, 24: 461–483.

Grossman, S. and O. Hart (1980) "Disclosure Laws and Take over Bids," *Journal of Finance*, 35: 323–334.

Krehbiel, K. (1990) "Are Congressional Committees composed of Preference Outliers," *American Political Science Review,* 84(1): 149–163.

Krishna, V. and J. Morgan (2001) "A Model of Expertise," *Quarterly Journal of Economics*, 747–775.

Li, H., Rosen, S. and W. Suen (2001) "Conflicts and Common Interests in Committees," *American Economic Review*, 91(5): 1478–1497.

Lindbeck, A., and J. Weibull (1987) "Balanced-Budget Redistribution as the Outcome of Political Competition," *Public Choice*, 52: 273–297.

Milgrom, P. (1981) "Good News and Bad News: Representation Theorems and Applications," *Bell Journal of Economics*, 12: 380–391.

Morris, S. (2001) "Political Correctness," *Journal of Political Economy*, 109(2): 231–265.

Myerson, R. (1982) "Optimal Coordination Mechanisms in Generalized Principal-Agent Problems," *Journal of Mathematical Economics* 10: 67–81.

Ottaviani, G. and S. Sorensen (2001) "Information Aggregation in Debate: Who Should Speak First?", *Journal of Public Economics*, 81, 393-421.

Spector, D. (2000) "Rationale Debate and One-Dimensional Conflict," *Quarterly Journal of Economics*, 115(1): 181–200.

Appendix 1: Proof of Lemma 2.

A payoff-relevant outcome consists of the list of members who investigate and whether the project is implemented or not. The set of states of nature is characterized by the possible values of r_1 and r_2; let ω_0 correspond to $r_1 = r_2 = -L$, ω_i to $r_i = G$ and $r_j = -L$, and ω_3 to $r_1 = r_2 = G$. Let $\pi(\omega)$ the probability of state ω. A (stochastic) direct mechanism is a mapping from the set of states of nature Ω to the set of probability distributions over the set of possible outcomes.

For each $\omega \in \Omega$, let us introduce the following notation:

- $\gamma(\omega) \geq 0$, the probability that no-one investigates and that the project is implemented in state ω;
- $\eta(\omega) \geq 0$, the probability that no-one investigates and that the project is NOT implemented in state ω;
- $\theta_i(\omega) \geq 0$, the probability that only R_i investigates and the project is implemented;
- $\mu_i(\omega) \geq 0$, the probability that only R_i investigates and the project is NOT implemented;
- $\lambda(\omega) \geq 0$, the probability that both investigate and the project is implemented;
- $\nu(\omega) \geq 0$, the probability that both investigate and the project is NOT implemented.

When no one investigates, the mechanism cannot depend upon ω; when only R_i investigates, the mechanism cannot depend upon the value of r_j. From this, the following measurability conditions must hold: $\gamma(\omega)$ and $\eta(\omega)$ are constant across ω, equal to γ and η; moreover, $\theta_i(\omega)$ and $\mu_i(\omega)$ can only depend on r_i and, using the restriction presented above, we define: $\theta_i(\omega_i) = \theta_i(\omega_3) \equiv \theta_i$, $\theta_i(\omega_j) = \theta_i(\omega_0) \equiv \theta_i^-$, $\mu_i(\omega_i) = \mu_i(\omega_3) \equiv \mu_i^+$ and $\mu_i(\omega_j) = \mu_i(\omega_0) \equiv \mu_i^-$.

Let us write the interim individual rationality constraints. Conditional on $r_i(\omega) = r_i$, R_i must prefer reporting r_i truthfully rather than vetoing the project:

$$\sum_{\{\omega | r_i(\omega) = r_i\}} \pi(\omega) \left[\theta_i(\omega) + \lambda(\omega)\right] r_i(\omega) \geq 0.$$

This constraint is trivially satisfied when $r_i = G$ and when $r_i = -L$, it boilds down to:

$$\pi(\omega_j) \left[\theta_i(\omega_j) + \lambda(\omega_j)\right] + \pi(\omega_0) \left[\theta_i(\omega_0) + \lambda(\omega_0)\right] = 0,$$

and therefore $\theta_i(\omega_j) = \theta_i(\omega_0) = 0$, $\lambda(\omega_0) = \lambda(\omega_1) = \lambda(\omega_2) = 0$. We let now λ denote $\lambda(\omega_3)$ and ν_h denote $\nu(\omega_h)$.

The feasibility constraints impose that probability add up to 1 in each state of nature:

$$\begin{aligned}
\gamma + \eta + \theta_1 + \theta_2 + \mu_1^+ + \mu_2^+ + \lambda + \nu_3 &= 1, \\
\gamma + \eta + \theta_1 + \mu_1^+ + \mu_2^- + \nu_1 &= 1, \\
\gamma + \eta + \theta_2 + \mu_1^- + \mu_2^+ + \nu_2 &= 1, \\
\gamma + \eta + \mu_1^- + \mu_2^- + \nu_0 &= 1,
\end{aligned}$$

Alternatively, a mechanism is given by $(\gamma, \theta_i, \mu_i^+, \mu_i^-, \nu_0, \nu_3)$ and:

$$\lambda = \nu_0 - \theta_1 - \theta_2 - \mu_1^+ - \mu_2^+ + \mu_1^- + \mu_2^- - \nu_3 \geq 0, \tag{4}$$

$$\nu_1 = \nu_0 - \theta_1 - \mu_1^+ + \mu_1^- \geq 0, \tag{5}$$

$$\nu_2 = \nu_0 - \theta_2 - \mu_2^+ + \mu_2^- \geq 0, \tag{6}$$

$$\eta = 1 - \gamma - \mu_1^- - \mu_2^- - \nu_0 \geq 0. \tag{7}$$

The expected probability that the project is implemented is given by:

$$\begin{aligned}
Q &= \sum_{\omega} \pi(\omega) \left[\gamma(\omega) + \theta_1(\omega) + \theta_2(\omega) + \lambda(\omega)\right] \\
&= \gamma + p_1\theta_1 + p_2\theta_2 + P\lambda.
\end{aligned}$$

Plugging in the value of λ from (4), we find:

$$Q = \gamma + (p_1 - P)\theta_1 + (p_2 - P)\theta_2 + P\nu_0 - P\mu_1^+ - P\mu_2^+ + P\mu_1^- + P\mu_2^- - P\nu_3. \quad (8)$$

Let us now write the incentive constraints. When R_i is supposed to investigate, not investigating and playing as if $r_i = G$ must be an unprofitable deviation:

$$\begin{aligned} & \sum_\omega \pi(\omega)\{[\theta_i(\omega) + \lambda(\omega)]\,(r_i(\omega) - c) - c\,[\mu_i(\omega) + \nu(\omega)]\} \\ \geq & \sum_\omega \pi(\omega)\{[\theta_i(\tilde{\omega}) + \lambda(\tilde{\omega})]\,r_i(\omega), \end{aligned}$$

where $\tilde{\omega}$ results from changing r_i to G in ω. Given previous results and using the expressions for λ and ν_i, this constraint can be written as:

$$\begin{aligned} & \theta_1(1 - p_1)L + \left(\nu_0 - \theta_1 - \theta_2 - \mu_1^+ - \mu_2^+ + \mu_1^- + \mu_2^- - \nu_3\right)(p_2 - P)L \\ \geq & \; c[\nu_0 + \mu_1^- + p_2\left(\mu_2^- - \theta_2 - \mu_2^+\right)], \end{aligned} \quad (9)$$

$$\begin{aligned} & \theta_2(1 - p_2)L + \left(\nu_0 - \theta_1 - \theta_2 - \mu_1^+ - \mu_2^+ + \mu_1^- + \mu_2^- - \nu_3\right)(p_1 - P)L \\ \geq & \; c[\nu_0 + \mu_2^- + p_1\left(\mu_1^- - \theta_1 - \mu_1^+\right)]. \end{aligned} \quad (10)$$

R_i must also not prefer to reject the project (an ex ante individual rationality constraint):

$$\sum_\omega \pi(\omega)\{[\theta_i(\omega) + \lambda(\omega)]\,(r_i(\omega) - c) - c\,[\mu_i(\omega) + \nu(\omega)]\} \geq 0.$$

Using the same manipulations as above, the latter inequality becomes:

$$\begin{aligned} & \theta_1 p_1 G + \left(\nu_0 - \theta_1 - \theta_2 - \mu_1^+ - \mu_2^+ + \mu_1^- + \mu_2^- - \nu_3\right) PG \\ \geq & \; c[\nu_0 + \mu_1^- + p_2\left(\mu_2^- - \theta_2 - \mu_2^+\right)], \end{aligned} \quad (11)$$

$$\begin{aligned} & \theta_2 p_2 G + \left(\nu_0 - \theta_1 - \theta_2 - \mu_1^+ - \mu_2^+ + \mu_1^- + \mu_2^- - \nu_3\right) PG \\ \geq & \; c[\nu_0 + \mu_2^- + p_1\left(\mu_1^- - \theta_1 - \mu_1^+\right)]. \end{aligned} \quad (12)$$

Finally, when the project is supposed to be implemented without R_i's investigation, R_i must not prefer vetoing the project (another ex ante individual rationality constraint):

$$\sum_{\omega} \pi(\omega) \left[\gamma(\omega) + \theta_j(\omega)\right] r_i(\omega) \geq 0.$$

Rearranging,

$$\gamma u^R(p_1) + \theta_2 p_2 u^R(\hat{p}_1) \geq 0, \tag{13}$$

$$\gamma u^R(p_2) + \theta_1 p_1 u^R(\hat{p}_2) \geq 0. \tag{14}$$

The program is to maximize (8) under the feasibility and incentive constraints. With $(A_1, A_2, B_1, B_2, C_1, C_2)$ the multipliers associated with constraints (9)-(10)-(11)-(12)-(13)-(14), and D, E_1, E_2 and F the multipliers associated with (4)-(5)-(6)-(7), one can compute the derivatives of the Lagrangian with respect to $(\gamma, \theta_1, \theta_2, \mu_1^+, \mu_2^+, \mu_1^-, \mu_2^-, \nu_0, \nu_3)$ (omitting the constraints that each of these must lie within $[0, 1]$):

$$\frac{\partial \mathcal{L}}{\partial \gamma} = 1 + C_1 u^R(p_1) + C_2 u^R(p_2) - F$$

$$\begin{aligned} \frac{\partial \mathcal{L}}{\partial \nu_0} &= P + A_1(p_2 - P)L - cA_1 + A_2(p_1 - P)L - cA_2 \\ &\quad + B_1 PG - cB_1 + B_2 PG - cB_2 + (D + E_1 + E_2) - F \end{aligned}$$

$$\begin{aligned} \frac{\partial \mathcal{L}}{\partial \theta_i} &= p_i - P + A_i(1 - p_i)L - A_i(p_j - P)L - A_j(p_i - P)L + A_j c p_i \\ &\quad + B_i(p_i - P)G - B_j PG + B_j c p_i + C_j p_i u^R(\hat{p}_j) - (D + E_i) \end{aligned}$$

$$\begin{aligned} \frac{\partial \mathcal{L}}{\partial \mu_i^+} &= -P - A_i(p_j - P)L - A_j(p_i - P)L + A_j c p_i \\ &\quad - B_i PG - B_j PG + B_j c p_i - (D + E_i) \end{aligned}$$

$$\begin{aligned} \frac{\partial \mathcal{L}}{\partial \mu_i^-} &= P + A_i(p_j - P)L + A_j(p_i - P)L - A_j c p_i \\ &\quad + B_i PG + B_j PG - B_j c p_i + (D + E_i) - F \end{aligned}$$

$$\frac{\partial \mathcal{L}}{\partial \nu_3} = -P - A_1(p_2 - P)L - A_2(p_1 - P)L - PGB_1 - PGB_2 - D$$

Note first that $\frac{\partial \mathcal{L}}{\partial \nu_3} < 0$ and so $\nu_3 = 0$.

From the derivatives of the Lagrangian, one can derive useful relationships:

$$\frac{\partial \mathcal{L}}{\partial \mu_i^+} + \frac{\partial \mathcal{L}}{\partial \mu_i^-} = -F \leq 0.$$

$$\begin{aligned} \frac{\partial \mathcal{L}}{\partial \mu_1^-} + A_2 p_1 c + B_2 p_1 c - E_1 &= \frac{\partial \mathcal{L}}{\partial \mu_2^-} + A_1 p_2 c + B_1 p_2 c - E_2 \\ &= \frac{\partial \mathcal{L}}{\partial \nu_0} + c(A_1 + A_2 + B_1 + B_2) - E_1 - E_2. \end{aligned}$$

$$\theta_i \frac{\partial \mathcal{L}}{\partial \theta_i} = \theta_i \left[\frac{\partial \mathcal{L}}{\partial \mu_i^+} + p_i + A_i(1 - p_i)L + B_i p_i G \right] + C_j \theta_i p_i u^R(\hat{p}_j).$$

Claim 1. *The optimum cannot be such that there exists i with $\nu_0 > 0$ and $\mu_i^+ > 0$.*

Proof. Suppose $\nu_0 > 0$ and $\mu_1^+ > 0$. It must be that $\frac{\partial \mathcal{L}}{\partial \nu_0} \geq 0$, $\frac{\partial \mathcal{L}}{\partial \mu_1^+} \geq 0$, $\frac{\partial \mathcal{L}}{\partial \mu_1^-} \leq 0$ and $A_2 + B_2 > 0$. Moreover:

$$\frac{\partial \mathcal{L}}{\partial \mu_1^-} + E_2 = \frac{\partial \mathcal{L}}{\partial \nu_0} + c(A_1 + A_2(1 - p_1) + B_1 + B_2(1 - p_1)) > 0.$$

So $E_2 > 0$, which implies $\nu_2 = 0$. We also have:

$$\begin{aligned} \lambda &= \nu_0 - \theta_1 - \theta_2 - \mu_1^+ - \mu_2^+ + \mu_1^- + \mu_2^- \\ &= \nu_2 - \theta_1 - \mu_1^+ + \mu_1^- = -\theta_1 - \mu_1^+ + \mu_1^- \geq 0. \end{aligned}$$

Hence, $\nu_1 = \nu_0 - \theta_1 - \mu_1^+ + \mu_1^- > 0$ et $E_1 = 0$. And so:

$$\frac{\partial \mathcal{L}}{\partial \mu_2^-} = \frac{\partial \mathcal{L}}{\partial \nu_0} + c(A_2 + A_1(1 - p_2) + B_2 + B_1(1 - p_2)) > 0.$$

This implies $\mu_2^- = 1$. This is not compatible with $\eta = 1 - \gamma - \mu_1^- - \mu_2^- - \nu_0 \geq 0$ and $\nu_0 > 0$. ■

Claim 2. *If $\nu_0 = 0$, the optimum is without loss of generality such that $\mu_i^+ = 0$ for all i.*

Proof. Suppose that $\nu_0 = 0$. Note first that since $p_2 \leq \hat{p}_2$, $C_2\theta_1 p_1 u^R(\hat{p}_2) \geq 0$. If $\frac{\partial \mathcal{L}}{\partial \mu_1^+} < 0$, then $\mu_1^+ = 0$. If $\frac{\partial \mathcal{L}}{\partial \mu_1^+} \geq 0$, one deduces that $\theta_1 \frac{\partial \mathcal{L}}{\partial \theta_1} \geq 0$ and if $\theta_i > 0$ then $\frac{\partial \mathcal{L}}{\partial \theta_1} > 0$. So, either $\theta_1 = 1$ or $\theta_1 = 0$.

$\theta_1 = 1$ and $\nu_1 = \nu_0 - \theta_1 - \mu_1^+ + \mu_1^- \geq 0$ impose that $\mu_1^+ = 0$.

If $\theta_1 = \nu_0 = 0$, consider the optimization program with $\theta_1 = \nu_0 = 0$ and consider the impact of the following marginal change: $d\mu_1^- = d\mu_1^+ = -\varepsilon < 0$. Since $\mu_1^- - \mu_1^+$ remains constant, the objective is unchanged, all incentive constraints are relaxed and the feasibility constraints are unchanged or relaxed (η increases). Therefore, one can impose $\mu_1^+ = 0$ without loss of generality. ■

Claim 3. *: If $\mu_1^+ = \mu_2^+ = 0$, the optimum is without loss of generality such that $\nu_0 = 0$.*

Proof. Suppose $\mu_1^+ = \mu_2^+ = 0$. If $\frac{\partial \mathcal{L}}{\partial \nu_0} < 0$, then $\nu_0 = 0$. If $\frac{\partial \mathcal{L}}{\partial \nu_0} \geq 0$,

$$\frac{\partial \mathcal{L}}{\partial \mu_i^-} + E_j = \frac{\partial \mathcal{L}}{\partial \nu_0} + c(A_i + A_j(1 - p_i) + B_i + B_j(1 - p_i)) > 0,$$

provided at least one of the multipliers A_1, A_2, B_1 or B_2 is strictly positive. Then either $\frac{\partial \mathcal{L}}{\partial \mu_i^-} > 0$, then $\mu_i^- = 1$, which is not compatible with $\nu_i \geq 0$, $\nu_0 > 0$ and $\mu_i^+ = 0$. Or, $E_j > 0$, in which case $\nu_j = 0$ which in turn implies that $E_i = 0$. Therefore, $\frac{\partial \mathcal{L}}{\partial \mu_j^-} > 0$ and $\mu_j^- = 1$, which again is not possible.

The last possibility is $A_1 = A_2 = B_1 = B_2 = 0$, $\frac{\partial \mathcal{L}}{\partial \nu_0} = \frac{\partial \mathcal{L}}{\partial \mu_i^-} = E_i = 0$. Then the simplified program only depends upon $\nu_0 + \mu_1^- + \mu_2^-$ and one can set $\nu_0 = 0$ without loss of generality. ■

To summarize, the optimal mechanism is without loss of generality such that $\nu_0 = \mu_1^+ = \mu_2^+ = 0$. It belongs to the class of no-wasteful-investigation mechanisms. In this class, a mechanism is characterized by $(\gamma, \theta_1, \theta_2, \mu_1^-, \mu_2^-)$. Defining $\lambda_i = \mu_i^- - \theta_i$, yields the final result.

Appendix 2: Proof of Proposition 8.

Side communication between committee members matters only if, during the implementation procedure, R_i has taken an unobservable action or has acquired some information. Such a situation can arise in a one-investigation mechanism or in a two-sequential-investigation mechanism.

Assume first, that $p_2 < p_0$, $p_- \leq p_1 \leq p_+$ and $\hat{p}_2 \geq p_0$, so that the optimal mechanism is let R_1 investigate and R_2 rubberstamp.[20] Consider the following game form Γ:

- S presents R_1 with a report; R_1 investigates (or not) and reports to r_1 publicly;
- R_1 may communicate with R_2, that is, she may send R_2 a message or transfer her the file, in which case R_2 may investigate;
- R_1 and R_2 can exchange information;
- finally members vote on the project.

Game form Γ has an equilibrium that implements the optimal mechanism and in which no side communication takes place on the equilibrium path: R_1 investigates in the first stage, does not transfer the file, and reports truthfully; R_2 approves the project, R_2 always believes that R_1 has investigated, regardless of whether R_1 hands over the file, and R_2 never investigates in case R_1 transfers the file (R_2's beliefs over the value of r_1 in case of file transfer are irrelevant). R_1 is a de facto dictator.

Let us now assume that $p_- \leq P < p_1 \leq p_+$ and for all $i = 1, 2$, $\hat{p}_i < p_0$, in which case the optimal mechanism is to have both members investigate, with say R_2 investigating conditionally on $r_1 = G$. Consider the following game form Γ':

- S presents R_1 with a report; R_1 investigates (or not), and reports publicly;

[20] The case where R_2 investigates and R_1 rubberstamps is similar.

- R_1 may send R_2 a message or transfer her the file;
- S presents R_2 with a report if R_1 has announced that $r_1 = G$;
- R_2 and R_1 may exchange information;
- finally members vote on the project.

Game form Γ' has an equilibrium that implements the optimal mechanism and in which no side communication takes place on the equilibrium path: R_1 investigates and reports truthfully; if R_1 reports she favors the project, R_2 investigates; if R_1 reports that $r_1 = -L$, R_2 does not investigate even if R_1 hands over the file; at the voting stage, both vote according to their benefit.

Appendix 3: Proof of Propositions 9 and 10.

Preliminaries: consequences of measurability

In this framework, there are $N+1$ states of nature: $\omega = 0$ by convention denotes the state in which no-one benefits from the project and, for $i \in \{1, 2, ...N\}$, $\omega = i$ denotes the state in which all $j \leq i$ benefit from the project and all $j > i$ suffer from it. The probability of state ω_i for $i \in \{1, 2, ...N\}$ is equal to $\pi(i) = p_i - p_{i+1}$, and the probability of state ω_0 is equal to $\pi(0) = 1 - p_1$.

Any deterministic mechanism must meet measurability conditions that the outcome cannot depend on the benefit r_j of a member who does not investigate. Consider two different states $\omega = i$ and $\omega = i'$; if $(I(i), d(i)) \neq (I(i'), d(i'))$, the outcome $(I(i), d(i))$ has probability 1 in state of nature $\omega = i$ and 0 in state of nature $\omega = i'$. Measurability implies that there exists $j \in I(i)$ such that $r_j(i) \neq r_j(i')$. This property has several implications.

First, suppose that $I(i) \neq I(i')$ and $d(i) = d(i') = 1$. There must exist a state $j \in I(i)$ such that $r_j(i) = G \neq r_j(i') = -L$, which implies that $i' < j \leq i$. Similarly, there exists k such that $i < k \leq i'$; hence a contradiction. Therefore, if $d(i) = d(i') = 1$, then the set of members who investigate must be the same in both states: $I(i) = I(i')$. So there exists a set I and $m = \max\{j \in I\}$, such that: $d(i) = 1 \Longrightarrow I(i) = I$ and $i \geq m$.

As a second consequence of the above property, if $i' = i + 1$ and $d(i)$ and $d(i + 1)$ are different, then necessarily $j = i + 1$ must belong to $I(i) \cap I(i + 1)$. This has two consequences:

- Let $p = \min\{j \mid j \geq m, d(j) = 1\}$. Suppose $p > m$. Then $d(p) = 1 \neq d(p - 1) = 0$ and $p - 1 \geq m$. It follows that $p \in I(p) = I$ a contradiction with $m = \max\{j \in I\}$. Therefore, $d(m) = 1$.
- Suppose there exists $j \geq m$ such that $d(j) = 1$ and $d(j + 1) = 0$. Then again, $(j + 1) \in I$ and $j + 1 > m$; a contradiction.

One can then conclude that $d(i) = 1 \Longleftrightarrow i \geq m$.

As a third consequence of the previous property, suppose $i = m$ and $i' < m$ so that $d(i') = 0$. There exists $j \in I$ such that $r_j(m) \neq r_j(i')$; given the nested structure, this is possible only if $i' < j \leq m$. Since m is extremal in I, necessarily $j = m$. Therefore, for any i, $m \in I(i)$, provided $m < N + 1$.

Proof of Proposition 9

From the property that $d(i) = 1 \Longleftrightarrow i \geq m$, it follows that $Q = \sum_{i=0}^{N} \pi(i)d(i) = p_m$. If $N \in I$, then $Q = p_N \leq p_{i^*}$. If $N \notin I$, R_N never investigates in any state of nature where the project is implemented and R_N rubberstamps in states $\omega \in I$ if:

$$\sum_{i=0}^{N} \pi(i)d(i)r_N(i) \geq 0 \Longleftrightarrow d(N) = 1 \text{ and } p_N \geq p_0 \sum_{i=m}^{N} \pi(i)d(i) = p_0 p_m.$$

The probability of the project being adopted then satisfies: $Q = p_m \leq \frac{p_N}{p_0}$.

Since $m \in I(i)$ for all i, let us analyze R_m's incentive constraint. R_m's expected payoff from investigating when being asked equals:

$$\sum_{i=0}^{N} \pi(i)d(i)r_m(i) - \sum_{\{i|m \in I(i)\}} \pi(i)c = p_m G - c,$$

since for any i, $m \in I(i)$. If she deviates and rubberstamps, she obtains:

$$\begin{aligned}\sum_i \pi(i)d(\alpha(i))r_m(i) &= \sum_{i \geq m} \pi(i)G - \sum_{\{i|i<m, d(\alpha(i))=1\}} \pi(i)L \\ &\geq p_m G - (1-p_m)L,\end{aligned}$$

where $\alpha(i)$ is the state of nature obtained by substituting G in place of the true value of r_m; note that this may lead to a different decision $d(\alpha(i) \neq d(i)$ only if no other investigation reveals a loss for another member. R_m's incentive constraint then implies $p_m \leq p_+$.

Similarly, R_m's incentives to investigate instead of simply vetoing the project implies $p_m \geq p_-$.

Therefore, suppose the project can be implemented with positive probability using a deterministic mechanism, i.e. there exists $m < N + 1$. An overal upper bound on the probability that the project be implemented is therefore p_{i^*}. If $p_- \leq p_{i^*}$, this upper bound can be reached with the mechanism described in the text since then R_{i^*} is willing to act as sole investigator. If $p_{i^*} < p_-$, $Q = p_m < p_-$ would lead to a contradiction; so, in this case, the project cannot be implemented using a deterministic mechanism.

Proof of Proposition 10

We assume vote transparency that is, when deciding to vote on the project proposal, all members know who has investigated in the mechanism that is being implemented and what are their benefits.

Under a K-majority rule, let $m(i) = \max\{j \in I(i), \text{ such that } r_j(i) = G\}$. Member $R_{m(i)}$ is the less externally congruent investigator in state of nature $\omega = i$ that finds out she benefits from the project. Obviously, $m(i) \leq i$.

Suppose that $m(i) < i^*$. For $j \geq K$, let us analyze R_j's incentive constraints to vote in favor of the proposal. If $j \in I(i)$, since $j \geq K \geq i^* > m(i)$, then $r_j(i) = -L$ and j will vote against the project. If $j \notin I(i)$, she rubberstamps if all information $\mathfrak{I}$ she acquires enables her to update her beliefs so that $\Pr\{r_j = G \mid \mathfrak{I}\} \geq p_0$. By vote transparency, Information $\mathfrak{I}$ consists of the list $I = I(i)$ of members who have investigated and the values $r_k(i)$ for $k \in I(i)$ and m, the largest value of such k such that $r_k(i) = G$. Given affiliation and the nested information structure, the best news R_j can obtain is that there does not exist $k \in I$ such that $r_k(i) = -L$, that is $\mathfrak{I} = \{i \geq m\}$. Then $\Pr\{r_j = G \mid \mathfrak{I}\} = \frac{p_j}{p_{m(i)}}$.

$m(i) < i^*$ implies that $p_{m(i)} > \frac{p_K}{p_0}$ since $p_K \leq p_+ \cdot p_0$. Then

$$\Pr\{r_j = G \mid \mathfrak{I}\} = \frac{p_j}{p_{m(i)}} \leq \frac{p_K}{p_{m(i)}} < p_0.$$

That is, even with the best possible news, all $j \geq K$ vote against the project. Therefore, the project gets less than K favorable votes in every state of nature i such that $m(i) < i^*$. And so, the project is turned down if $i < i^*$. It follows that $Q \leq p_{i^*}$.

Under the assumption that $p_{i^*} \geq p_-$, the mechanism described in the proposition meets all incentive constraints and achives this upper bound; it is therefore optimal.

Appendix 4: Proof of Proposition 12.

Suppose $p < p_-$. Consider the following symmetric stochastic mechanism. S commits to draw randomly between two deterministic mechanisms with equal probabilities, without revealing the realization of this lottery to committee members: with probability $\frac{1}{2}$, he asks R_1 to investigate and then, if $r_1 = G$, he asks R_2 to investigate, and with probability $\frac{1}{2}$, she follows the symmetric scheme.

Proof. This mechanism is incentive compatible if it induces R_i to investigate, that is if (2) and (1) hold:

$$u^I(P) + pu^I(\hat{p}) \geq 0, \tag{15}$$

$$\frac{u^I(P) + pu^I(\hat{p})}{2} \geq pu^R(\hat{p}). \tag{16}$$

If $\widehat{p} > p_0$, $u^R(\widehat{p}) > 0$ and (15) can be omitted. (16) is equivalent to:

$$PG - c + p\left(\hat{p}G - c\right) \geq 2p\left(\hat{p}G - (1-\hat{p})L\right),$$

and, using $\frac{c}{G} = p_-$ and $\frac{c}{L} = \frac{c}{G} \cdot \frac{G}{L} = p_- \cdot \frac{1-p_0}{p_0}$, this can be written as:

$$1 - \hat{p} \geq p_- \cdot \frac{1-p_0}{p_0} \cdot \frac{1+p}{2p}. \tag{17}$$

For $p \in (0, p_-)$, there exists $\hat{p} \in (p_0, 1)$ satisfying these two inequalities if and only if:

$$p_0 < 1 - p_- \cdot \frac{1-p_0}{p_0} \cdot \frac{1+p}{2p}.$$

The RHS being increasing in p, one can conclude that if this inequality holds for $p = p_-$, then for p in a left neighborhood of p_-, there exists $\hat{p} \in (p_0, 1)$ satisfying the incentive constraints. Finally, the above inequality holding for $p = p_-$ is equivalent to:

$$p_0 > \frac{1+p_-}{2}.$$

If $\widehat{p} < p_0$, (16) can be omitted and (15) can be written as:

$$\hat{p} \geq p_- \cdot \frac{1+p}{2p}. \tag{18}$$

For $p \in (0, p_-)$, there exists $\hat{p} \in (0, p_0)$ satisfying this inequality if and only if: $p_0 > p_- \cdot \frac{1+p}{2p}$. Therefore, if $p_0 > \frac{1+p_-}{2}$, (18) holds for p close enough to p_- and $\hat{p}$ in a left neighborhood of p_0.

So, if $p_0 > \frac{1+p_-}{2}$ and p is smaller but close to p_-, there exists an interval of values of $\hat{p}$ around p_0 such that the symmetric stochastic mechanism that we have analyzed is incentive compatible and yields a strictly positive probability of having the project approved. ■