Coordination through Authority vs Consensus

First Draft

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November 8, 2002

Abstract

One of the defining characteristics of organizations is the presence of a managerial hierarchy which coordinates economic activity by use of authority. Organizations, however, also frequently delegate decisions to groups of agents - committees, cross-functional teams - as opposed to managers. This paper proposes a model of organizational decision-making with endogenous communication costs and puts forward a theory of why and when authority is a superior coordination device relative to some form of consensus (that is, majority rule or unanimity). We argue that coordination by authority results in faster decision-making and a less distorted aggregation of information. This, however, comes at the expense of a narrowness in decision-making, where the agent in control is biased in favor of her own ideas. Authoritative coordination tends to be indicated for problems which are urgent or complex, or where the variance in the quality of potential solutions is limited. The magnitude of the incentive conflict among agents has a non-monotonic impact on the trade-off between authority and consensus, with the latter being optimal for small and large conflicts of interest. We finally show how imposing a unanimity rule as opposed to a majority rule can alleviate some of the drawbacks of consensus.

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"Hereby it is manifest that during the time men live without a common power to keep them all in awe, they are in that condition which is called war; and such a war as is of every man against every man"

Hobbes, *Leviathan I 13*

1 Introduction

One of the defining characteristics of organizations is the prevalence of authoritative coordination. Thus, whereas in markets, independent businesses need to achieve coordination through the price-system or - if the latter fails - by *agreeing* on a course of action, a key feature of the modern business enterprise is the presence of a managerial hierarchy, which coordinates the activities of different operating units using administrative *authority*. As a result, economists typically model firms as clusters of authority in general, or control rights over assets in particular. Nevertheless, we frequently observe that in organizations, decisions are delegated to committees or teams, which then decide by some form of consensus. In firms, for example, many decisions are delegated to division heads or managers of functional units, but in order to resolve other problems, cross-functional or cross-divisional committees are created. In universities, committees are set up to deal with such issues as hiring, promotion decisions and curriculum changes. In government institutions, finally, many decisions are taken by councils or committees representing a number of constituencies. For other matters, elected officials or appointed bureaucrats are granted wide powers.

In this paper, we study when and why coordination through *authority* is superior to coordination by some form of *consensus.* Our interest is two-fold. First, taking the boundaries of the firm as given, we want to explain why authority is a predominant decision-mechanism, but also point out when and what kind of decisions may be optimally delegated to committees. Secondly, since by definition, independent businesses cannot use authority to coordinate their activities, our model puts forward a theory of why and when firms arise in settings where production is complementary and the price system fails. Our rationale for authoritative coordination is related to an old idea, put forward informally by Arrow (1974), Williamson (1975), Chandler (1977) and more recently, Milgrom and Roberts (1992), that authority is an efficient way to coordinate the activities of many persons in complex environments. In particular, we argue that the benefit of coordination by authority is that, relative to consensus, it results in faster decision-making and a less distorted aggregation of dispersed information. This however, comes at the expense of a 'narrowness' in decision-making, where the agent in control is biased in favor of her own ideas. When the information generation process is endogenous, we also highlight the benefits of decision-making by unanimity as opposed to consensus with simple majority voting.

Consider a group of agents (individual firms, business units, specialized divisions, account managers, workers,...) who face a problem or opportunity and need to agree on a course of action (product design, standard, code of conduct, procedure, access rule, transfer price,...). Because of complementarities in production, a joint decision is superior to separate decisions, hence the need for coordination. Finally, information is dispersed in the sense that each agent may come up with a solution whose existence and value are unknown to its peers. One way to resolve the coordination problem is to delegate the decision-making authority to one of the agents, who then decides on a joint action, perhaps after having consulted with the other agents. Alternatively, the agents could decide by some form of *consensus.* In most of the paper, we will equate consensus with decisions taking by majority rule.[1] Decision-making by unanimity rule is discussed in section 4.

Obviously, if one were to assume a sufficiently large cost of 'sending a message', authoritative coordination would always prevail as an efficient institution. We argue, however, that any non-negligible *communication costs are the endogenous result of a conflict of interest among the agents.* Indeed, if interests were perfectly congruent, each of the agents could simply (truthfully) announce the value of his solution. A group deciding by consensus then simply would agree to implement the highest value solution. Arguable, the communication costs of such statements are negligible, from which consensus achieves the first best. Similarly, an agent with decision-making authority could simply ask the other agents about the value of their idea and then pick the best one. Once agents do have different preferences, however, they have an incentive to *misrepresent*

[1] One may wonder whether majority rule is an appropriate assumption if one thinks of independent firms which need to agree on a course of action. Given that in our model, acting unilaterly is strictly dominated for each agent, majority decision-making always constitutes an equilibrium for appropriate beliefs.

the value of their idea, inducing the group - or the agent with decision-making authority - to *investigate* the proposal in greater detail. In contrast to a simple announcement of the value of an idea, an investigation - that is an assessment of its true value by the group or decision-maker - is likely to be time-consuming and costly. These costs reflect, for example, the costs due to the delay in the solution or the opportunity cost of time of the group.[2] In the latter case, one might conjecture that consensus will always dominate authoritative coordination. Indeed, a group deciding by *consensus* has the 'right' incentives to pick out the 'best' idea, whereas an agent with control is biased in favor of his own idea. If the incentive conflict is very large, for example, the biased principal will always implement his own pet-solution. A group deciding by consensus, can always achieve the latter outcome by selecting a proposed solution without further investigating or discussing it. As long as communication costs are not too large, however, the group will be able to improve upon this outcome by investigating at least some proposals. How, then, can authority result in a better information aggregation than consensus?

We provide a two-pronged answer:

First of all, in the presence of incentive conflicts, consensus is particularly vulnerable to *politicking:* agents argue their case strenuously, even when its merits are limited. Thus, we show that decision-making under consensus is often characterized by an *information overload* in which agents with mediocre ideas excessively seek the attention of the group, encumbering the discussion and investigation process. Not only does the group then need to launch extensive investigations (engage in prolonged discussions) in order to select the best idea, mediocre ideas are sometimes implemented as investigations are inherently imperfect.

Such politicking is prevented to a large extent by assigning the authority to one of the agents. Intuitively, the latter will apply a *higher standard for adoption* to alternative proposals: unless the controlling agent is very convinced of the merits of an alternative proposal, she will implement her own idea. Such a high standard discourages advising agents with mediocre ideas to 'argue their case' excessively. Indeed, proposing a mediocre idea then mainly results in delays, but the probability that the idea will be implemented is limited. It follows that the average quality of proposals which 'seek attention' under authoritative decision-making is much higher than under consensus. This reduces communication costs

[2] As long as a particular problem is not solved, other problems or opportunities lack attention.

and yields a better information aggregation. In addition to this advantage in screening out mediocre proposals, authoritative coordination has the obvious advantage that the controlling agent can implement his own high-quality idea without needing to convince the group of its merits. Communication savings are again obtained. This improved information aggregation, however, comes at the expense of ex post biased decision-making: the controlling agent will also turn down high-quality proposals unless there is sufficiently evidence that they are truly better than her own mediocre idea. Finally, if the controlling agent is very biased in favor of her own ideas, she may refrain from consulting other agents altogether. Thus, alternative proposals may not be accorded the required attention under authoritative coordination.

A trade-off then obtains between faster decision-making and a better information aggregation under authority, and a less biased decision-making under consensus. For intermediate incentive conflicts, coordination by authority is indicated whenever the cost of investigating the quality of an idea exceeds a threshold which is increasing in the variance in the quality of ideas. Since the cost of an investigation depends on the urgency of a problem or the complexity of its potential solutions, our model thus predicts that authoritative coordination is more likely for *complex* or *urgent* problems. Finally, authoritative coordination is not indicated for large incentive conflicts, as the controlling agent then always implements her own idea. For very small incentive conflicts, both decision-mechanisms select the idea with the highest quality, though this feature is due to the discrete nature of our model. Nevertheless, consensus is sometimes strictly preferred, as a controlling agent with a mediocre idea may engage in excessive 'checks' before accepting an alternative proposal

In the second part of the paper, we endogenize the information structure by assuming that each agent may have several 'rough' ideas - intuitions - as how to solve the problem at hand, and needs to choose one of these intuitions for further development and potential implementation. To the extent that some of these potential ideas are more complex or more difficult to be evaluated by a group than others, decision-making under consensus may push the agent to develop 'superficial', 'good-looking' solutions which can easily 'convince' other agents, at the expense of better, but more complex solutions. In contrast, under coordination by authority, a superior has no distorted incentive and will seek to develop and implement his best idea. As in the model with exogenous information, however, the superior also tends to be too 'narrow', that is he will not listen enough to his subordinates. A trade-off then obtains between quantity and quality, that is the variety of ideas which are brought to bear on a problem and how 'deep' these ideas are. Coordination by authority is again indicated whenever the complexity of the solutions exceeds a threshold value.

We conclude by arguing that above default of consensus can be alleviated by imposing decision-making by *unanimity* - at the cost of higher communication costs. Assume that a group can quickly obtain a rough assessment of the value of a proposal, but too fully understand the quality of a solution, an extensive discussion or investigation is necessary. Intuitively, if one proposal 'looks' sufficiently better than another proposal, then if these investigation costs are somewhat large, a group deciding by consensus will directly implement the best-looking proposal. As pointed out above, this induces agents to develop their best-looking ideas as opposed to their best ideas. Consider now coordination by unanimity, where each agent has the option to veto any decision until all proposals have been fully investigated.[3] While this may result in excessive communication costs ex post, ex ante this provides agents with the correct incentives to develop and propose their best idea. As a result, unanimity achieves a better allocative efficiency than both authority and consensus. For intermediate communication-costs, unanimity may then pareto-dominate both authority and consensus.

In addition to some organizational classics, such as Williamson (1975), our arguments in favor of authoritative coordination are reminiscent of the influence cost literature (Milgrom (1988)) and Stein (2002)'s argument in favor of decentralization. A full discussion of the related literature is deferred to section 5. The remainder of the paper proceeds as follows. The basic model is presented in Section 2. Section 3 develops our first rationale for authoritative coordination. Section 4.1 presents a variation of our basic model in which information is endogenous, and develops our second rationale for authority. Section 4.2., finally, provides a rationale for decision-making by unanimity. We conclude with a discussion of the related literature.

[3] Once, all the uncertainty has been resolved, we assume that under unanimity, the group coordinates on the most efficient Nash-equilibrium, that is the one in which the best best available solution is selected.

2 The Model

2.1 Basic Structure

The model considers three divisions or operating units, L, R and M, who face an opportunity or problem which requires a coordinated response. Each unit is managed by a different agent who, by virtue of his activities of managing the unit, may have an idea as how to solve the problem or exploit the opportunity. All agents, however, need to coordinate on the same solution: unilateralism is strictly dominated by coordination.

Payoffs – Each solution or idea has both *efficiency* consequences and *distributional* consequences. With a probability α, a particular idea is *'high-quality'*, in which case in it provides benefits v_H to all agents. With a probability $1 - \alpha$, it is '*mediocre*', providing benefits $v_L < v_H$. To reduce notation, we denote $v \equiv v_H - v_L$ and normalize $v_L = 0$.
In addition to these general benefits, the 'owner' or 'developer' of the idea also derives some private benefits $b > 0$ from his idea being implemented. This assumption is realistic: First, each agent will tend to focus on solutions which have positive distributional consequences for himself or his division.[4] Secondly, an agent will tend to come up with solutions which exploit his human capital, skills or specific knowledge. Therefore, if adopted, he - or his division - will probably play a leading role in the implementation of this solution or idea, resulting in additional opportunities for rent extraction, skill development, organizational influence and benefits of control. The larger is b, the larger are the distributional consequences of decisions. Hence, b will be a measure of the conflict of interest among the agents. The larger is v, the larger are the efficiency consequences of decisions.

Communication and Information Structure – For simplicity, we assume that only L and R have an idea as how to resolve the problem. Agent M never has an idea, but may take part in the decision process. Equivalently, one could assume that M only has mediocre ideas. In both cases, M will always be the 'median voter' under majority voting. The quality of an idea is privately known by its developer, L or R. This private information can be revealed in two ways: (i) Both L and R can describe their idea and make a 'cheap talk' statement about its quality. This cheap talk stage if 'free': the agents or organization

[4] The latter assumes that an agent is subject to an (implicit or explict) incentive scheme which rewards positive performance by the division.

incurs no direct costs by listening to these statements.
(ii) In order to assess the true value of a proposed idea, however, the group needs to launch a costly and time-consuming investigation: hold a long discussion, read numerous reports,... These investigation costs, whose magnitude we denote by c, reflect the delay in the implementation of a solution and the opportunity cost of time of the group: as long as a particular problem is not solved, other problems or opportunities lack attention. It follows that c is best interpreted as a measure for the *urgency* or *complexity* of the problem, and henceforth, its solutions. Since all agents loose valuable time or suffer from a delay in the resolution of a problem, c is incurred by everybody.
Even after a careful investigation has taken place, the merits of an idea may remain ambiguous. In particular, we assume that with a probability s, an investigation reveals the true value of an idea, whereas with a probability $1 - s$, no additional information is learned.[5] An idea is never investigated more than once: a second investigation yields no additional information.

2.2 Collective Decision Making

Assume that the three units belong to the same organization, headed by a principal who has no time to be actively involved in the decision making for a particular problem. Two decision processes are considered:
(i) The principal gives the decision-making authority to one of the agents.
(ii) The principal delegates the decision to the group of agents, who then need to agree on a common action by some form of consensus. Throughout most of the paper, we will assume that the group decides by majority voting. Decision-making by unanimity is discussed in section 4.

We discuss the theoretical foundations for restricting ourselves to these two decision processes at the end of this section. While realistic in a great deal of situations,[6] our assumption that the principal has no time to be actively

[5] Assuming that an investigation yields a noisy signal as to whether the idea is high-quality or mediocre, would yield similar results, but substantially complicate the calculations. Assuming that an investigation *perfectly* reveals the quality of an idea, in contrast, would bias our results too much in favor of coordination by authority. Indeed, as long as $b < v$, an agent with control then always implements the best available idea after an investigation. This result, however, would not generalize to a continuous distribution of the quality of ideas. Assuming an imperfect investigation technology re-introduces inefficiencies in ex post decision making under authority, even in a model where the quality of ideas only takes two values.

[6] For many organizational problems, the opportunity cost of the principal's time is likely to be very high relative to the importance of the problem. Furthermore, the principal may not

involved, can easily be relaxed. Indeed, allowing the principal to participate in the decision process would be equivalent to *coordination through authority* if the principal is a 'visionary manager': he has ideas of his own, but is also biased in favor of them. In order to achieve the benefits of consensus, the business units should then be made independent. In contrast, if the principal is unbiased but also uninformed, allowing the latter to participate would be equivalent to *coordination through majority voting,* as we will show further. If coordination through authority is optimal, this uninformed principal then optimally delegates the decision-making authority to one of the agents. The case where the principal is informed and unbiased is trivial and will not be discussed in this paper.

The above discussion presumes that, for some exogenous reason, the three units belong to the same organization. An alternative interpretation of our model is that the units are initially independent, but they bargain ex ante - that is before L and R learn the quality of their idea - whether or not to integrate. If they integrate, one agent controls all the decision rights. If they decide to remain independent, all decisions must be taken by consensus. Given that unilateral actions are always dominated, majority decision-making is then an equilibrium for appropriate beliefs.

Coordination through Authority – Figure 1 illustrates the decision process under Authority. For concreteness, we assume that L is allocated authority. L then can either directly implement his own idea or first consult R. If player R proposes an idea upon being consulted, L can either directly implement $R's$ idea, or first investigate it, delaying the implementation.[7] At each decision point, L maximizes his expected utility. No commitment as to future actions is possible.

Coordination through Consensus – Figure 2 illustrates the decision process under consensus. We assume that L and R simultaneously decide whether or not to propose their idea. Given monotone beliefs,[8] an agent with a high-quality idea will always propose this idea, implying that if an agent does not propose his idea, it must be mediocre. It follows that if only one agent proposes an idea, this idea is always implemented and no communication costs are incurred. Similarly, if

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be a physical person, but a board of directors or trustees, the share-holders, an electorate,...

[7] By proposing an idea, Y makes a statement about its value. We restrict the beliefs of X to be monotone, that is when Y proposes an idea, the probability which X assigns to the event that $Y's$ idea is high-quality must be equal or higher than when Y would not have proposed an idea.

[8] Beliefs are monontone when the probability which agents R and M assign to $L's$ idea being high quality, does not decrease when L proposes his idea.

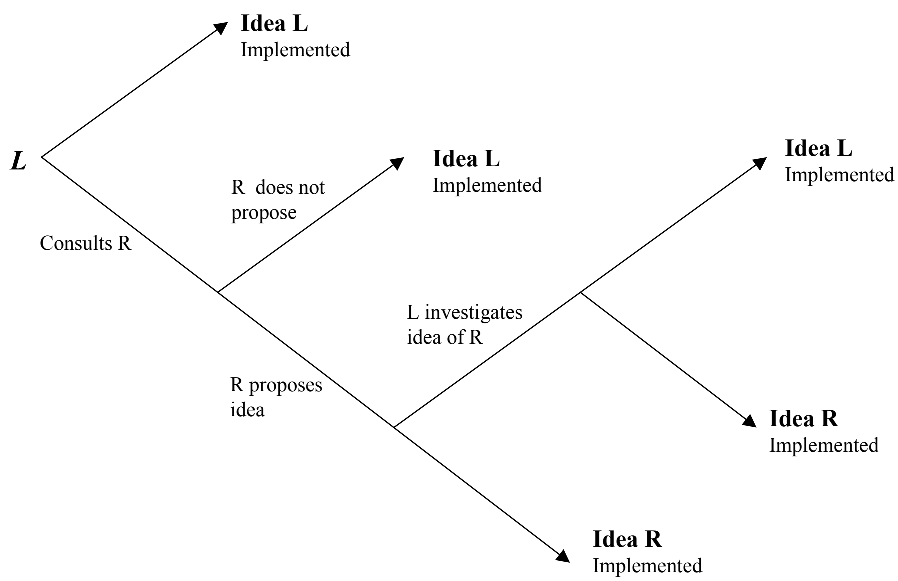


Figure 1: Coordination through Authority

neither L or R propose their idea, one of the ideas is implemented at random and no communication costs are incurred. In contrast, if both L and R propose an idea, the group randomly selects one idea and decides whether to accept or investigate it. If an investigation of this first idea took place, the group subsequently decides whether to accept it, whether to accept the second idea or whether to investigate the second idea. At each decision point, the group votes by majority, anticipating the subsequent game. No commitment as to future decisions is possible.

Note that since M is always be the 'median voter' and M only cares about the efficiency consequences of $L's$ and $R's$ solutions, decision-making by consensus is equivalent to allocating control to an uninformed and unbiased principal.[9] More generally, M could be seen as a proxy for a large number of uninformed agents which take part in the decision process. Indeed, our model would be unaffected if there were $N \geq 3$ agents, but only two of them are 'inspired'.[10]

[9] Allocating control to M, however, will be different from deciding by consensus if M only has mediocre ideas (and derives a private benefits from these ideas). In the latter case, the group will never adopt and idea from M, but M may adopt his own idea if he is not convinced by $L's$ or $R's$ idea.

[10] It should further be noted that in large committees, typically only a few members take an active role, as it is inefficient for all agents to collect information about potential solutions.

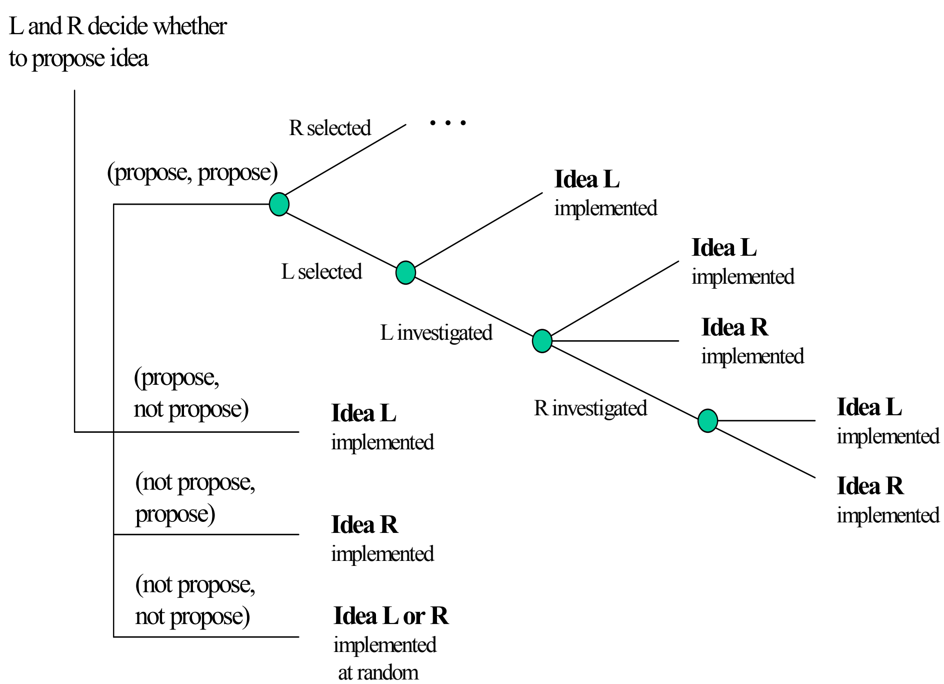


Figure 2: Coordination through Consensus

Theoretical Foundations: The above collective decision processes, consensus versus authority, arise naturally if, following Grossman and Hart (1985) and Hart and Moore (1990), one posits that actions (solutions) are not contractible, but the authority over who decides over a particular action (solution) is.[11] No contracts in which one party agrees to implement an idea in return for a side-payment can then be enforced. In addition, our model presumes that during the communication stage, bargaining over decision-rights is impractical . This assumption is realistic if decision rights must be institutionalized *ex ante* (through company charters and procedures, allocated budgets, access to information and critical resources, reporting relationships with subordinates, ownership or control over assets) and cannot be easily or credibly transferred 'on the spot'.

While actions may not be contractible, the attentive reader may notice that it may be worthwhile to punish agents who 'propose' ideas. Proposing an idea, however, can be done in many different ways. As a result, such contracts may be extremely difficult to enforce. Perhaps as important, such contracts would also punish agents who exert effort in order to develop high-quality ideas. Therefore, in a more general model with endogenous information acquisitions, such contracts, if enforceable, would loose a lot of their appeal.

3 Authority versus consensus

As long as members can be trusted to tell what is on their mind, group decision-making is likely to be a relative smooth process. Discussions are prone to become much more laborious, however, once agents' preferences differ enough such that members cannot be trusted to reveal their information truthfully. In our two-type model, communication will be strategic whenever $b > \alpha v$. Sections 3.1, 3.2 and 3.3, will focus on the latter, more interesting case. Sections 3.1 and 3.2 characterize equilibrium behavior under consensus and authoritative decision-making respectively. Section 3.3 then shows that as long as the incentive conflict is not too large, authority is a more efficient way of coordinating the activities of the group whenever the complexity or urgency of the problem is larger than some threshold which is increasing in the variance of the quality of ideas. In contrast, for extreme biases, consensus does always at least as good as authority. Section 3.4 briefly discusses settings in which non-strategic com-

The endogenization of the number of 'agents with ideas' is an exciting topic for futur research.

[11] Authority, for example, could stem from controlling some of the critical assets which are needed to implement a particular solution.

munication is feasible. The fact that non-strategic communication is feasible for small incentive conflicts, however, depends on the discrete nature of our model. If the quality of ideas were to be continuously distributed, communication would always be strategic.

3.1 Coordination through consensus

Consider first the case where L, R and M decide by consensus (majority voting). As discussed above, the decision-making process then starts with L and R making a 'cheap talk' statement about the value of their idea. We will say that an agent 'proposes' an idea if it claims to have a high-quality idea.

Given monotone beliefs, it is straightforward to see that an agent with a high-quality idea will always propose this idea, implying that if an idea is *not* proposed, it must be mediocre. Hence, if only one idea is proposed, the group will implement this idea without further investigation. Similarly, if no ideas are proposed, the group will ask L or R (chosen at random) to describe his mediocre idea and implement it without further investigation.

What happens if both L and R propose an idea? For the sake of the exposition, we will only consider symmetric equilibria in which L and R exhibit the same behavior. In the Appendix, we prove that no asymmetric equilibria exist. Denoting by $\rho \in [0,1]$ the probability with which an agent with a mediocre solution proposes this solution and by $\beta(\rho)$ the expected quality of a proposed solution,

$$\beta(\rho) \equiv \frac{\alpha}{\alpha + (1-\alpha)\rho} \in [\alpha, 1],$$

the group will launch an investigation of one of the proposals (chosen at random) if and only if

$$c \leq s(1-\beta(\rho))\beta(\rho)v \tag{1}$$

Indeed, if an investigation is informative, the group will implement the investigated proposal if it is high-quality, but implement the rival proposal if it is mediocre. It follows that the RHS of (1) equals the expected gain of launching an investigation relative to randomly selecting a proposal. If the investigation is uninformative, (1) implies that it will also be optimal to investigate the second proposal. If also this investigation is uninformative or if (1) does not hold, a proposal will be selected at random.

What determines ρ? The incentives of an agent with a mediocre idea to actually propose this idea depend on three considerations: (i) the probability that his proposal may prevent another mediocre idea from being implemented, (ii) the probability that his proposal may prevent a high-quality idea from being implemented, and (iii) the delay his proposal may cause in the decision-making process. Denoting by $p(\rho)$ the probability that the group will launch an investigation if two proposals are made, the value of proposing a mediocre idea is given by

$$\begin{aligned} V(\rho) \quad \equiv \quad & \frac{1}{2}(1-\alpha)b - \frac{1}{2}\alpha\left[1 - p(\rho) + p(\rho)(1-s)^2\right](v-b) \\ & -p(\rho)\left[\alpha + (1-\alpha)\rho\right][2-s]\,c \end{aligned} \tag{2}$$

If $V(\rho) > 0$ ($V(\rho) < 0$), an agent with a mediocre idea always (never) proposes this idea. The three terms of $V(\rho)$ correspond to the three considerations mentioned above. First, if the other agent has a mediocre idea, proposing one's own mediocre idea always increases expected private benefits by $b/2$, regardless of ρ and $p(\rho)$. Indeed, if the other agent proposes, not proposing definitely implies that a rival mediocre solution is implemented, whereas proposing gives the agent a fifty-fifty chance. If the other agent does not propose, proposing definitely implies that one's own idea is implemented, whereas not proposing only gives you a fifty-fifty chance. Second, proposing a mediocre idea will prevent a high-quality idea from being implemented with a fifty-fifty chance if no investigation occurs or if two subsequent investigations are uninformative. Third, if $p(\rho) = 1$, then whenever two ideas are proposed, at least one investigation will take place, delaying the project. Moreover, with a probability $1 - s$, this investigation is uninformative, in which case also second investigation takes place.

Let us denote by c_p^{con} the threshold for c below which the group always investigates at least one proposal ($p = 1$), *given that there is complete pooling* ($\rho = 1$). From (1),

$$c_p^{con} \equiv s\alpha(1-\alpha)v$$

Similarly, let us define c_ρ as the threshold for c below which there is complete pooling ($\rho = 1$), *given that the group always investigates at least one idea* (($p =$ 1). From (2),

$$[2-s]\,c_\rho \equiv \frac{1}{2}(1-\alpha)b + \frac{1}{2}\alpha(1-s)^2\,(b-v)$$

Lemma 1 If $b > \alpha v$, then $c_p^{con} < c_\rho$

Proof. See Appendix A ■

From lemma 1 and the definitions of c_p^{con} and c_ρ, it follows that for $c < c_p^{con}$, there exists an equilibrium in which both players always propose an idea regardless of its quality ($\rho = 1$), and the group always investigates these ideas ($p = 1$). The following lemma states that for $c < c_p^{con}$, this is the unique equilibrium, whereas for $c > c_p^{con}$, the group randomly picks an idea without investigating it:

Lemma 2 *Given that $b > \alpha v$, then:*

- *If $c < s\alpha(1-\alpha)v$, there is a unique equilibrium in which both players always propose their idea, regardless of its quality, and the group always investigates these ideas.*
- *If $c > s\alpha(1-\alpha)v$, there is a unique equilibrium in which both players always propose their idea, and the group implements and idea at random*

Proof. See Appendix A ■

From lemma 2, decision-making under consensus is characterized by an *information overload*, as agents with mediocre ideas excessively seek to gain the attention of the group. No voluntary sorting occurs in which agents refrain from proposing a mediocre idea: the cheap-talk stage reveals no information. As a result, the only way in which the group can obtain valuable information about alternative proposals is by subjecting these proposals to costly investigations: long group discussions, extensive reports,... The group will do so as long as the associated investigation costs are not too large relative to the variance in the quality of ideas, $\alpha(1-\alpha)v$. In contrast, if $c > s\alpha(1-\alpha)v$,the group will pick a proposal at randomly and implement it without any further investigation. For future reference, we will refer to the latter equilibrium as the 'silent equilibrium' and to the former equilibrium as a 'communication equilibrium'.

The *expected communication costs* which are incurred in a communication equilibrium equal

$$(2-s)c,$$

as with a probability $1-s$, the group ends up investigating both proposals. It is important to note, however, that the cost of the information overload is not just these communication costs. As investigations are inherently imperfect, the group will sometimes implement a mediocre idea even when a high-quality idea is available. This will result in an *allocative efficiency loss*, whose expected value equals

$$\alpha(1-\alpha)(1-s)^2 v$$

Indeed, since both agents always propose their idea, with a probability $2\alpha(1-\alpha)$, one of these ideas is high-quality and the other is mediocre. With a probability $(1-s)^2$ the group will still be undecided after having investigated both ideas, in which case the mediocre idea is implemented in one in two cases.

3.2 Coordination through authority

Consider now the case in which one informed agent - which we will refer to as the '*superior*' is allocated full decision-making authority, but may still consult the other informed agent - referred to as the '*advisor*'. As for decision-making under consensus, we will distinguish between a communication equilibrium and a silent equilibrium. We will refer to equilibria in which the superior consults his advisor, and , with positive probability, implements a proposal made by his advisor, as *'communication equilibria'*, In contrast, we will refer to the equilibrium in which the superior always implements her own idea as the '*silent equilibrium*'. It is straightforward to see that a necessary condition for authority to outperform consensus is that a communication equilibria exist. Indeed, coordination by consensus can always mimic the 'silent equilibrium' outcome under authority by randomly selecting the solution of L or R without further investigating it.

Let us investigate the conditions which a candidate communication equilibrium must satisfy. Obviously, even in a communication equilibrium, the superior will always implement her own solution whenever it is high-quality. What happens if the superior has a mediocre idea? If she consults her advisor, it is staigthforward to show that the latter will always propose a high-quality idea. Abusing notation, we denote by $\rho \in [0,1]$ the probability with which an adviser with a mediocre idea proposes his solution. In the absence an investigation or if an investigation is uninformative, the superior then adopts a proposed idea only if

$$\beta(\rho)v \geq b \tag{3}$$

where $\beta(\rho)$, as above, denotes the average quality of a proposal. Obviously, if an investigation is informative, the superior will adopt a high-quality proposal is $b < v$, but reject a mediocre idea, preferring to adopt her own mediocre idea. It follows that it will be optimal for the superior to investigate a proposed solution whenever

$$c < \max\left\{s\beta(\rho)(v-b), s(1-\beta(\rho))b\right\} \tag{4}$$

The first term between hyphens is the value of an investigation whenever $\beta(\rho)v \leq b$, and the superior adopts her own idea in the absence of an investigation. The second term denotes the value of an investigation whenever $\beta(\rho)v \geq b$

What are the incentives of the advisor to propose a mediocre idea under authoritative coordination? The adviser will propose a mediocre idea if and only if the probability of getting this idea accepted, outweighs the investigation costs and the delay in the implementation which this causes. Let $p(\rho)$ be the probability with which the superior *investigates a proposal*, and $a(\rho)$ the probability with which she *accepts a proposal* in the absence of an investigation or if and investigation is uninformative, then the value of proposing a mediocre idea is given by

$$V(\rho) \equiv [1-p(\rho)] * a(\rho) * b + p(\rho) * [(1-s) * a(\rho) * b - c] \tag{5}$$

From lemma 2, we know that under consensus, an agent with a mediocre idea always proposes this idea, that is $\rho = 1$. From (5) and (3), this cannot be an equilibrium under authoritative coordination. Indeed, whereas under consensus, if $\rho = 1$, proposing a mediocre idea results in this idea being implemented with positive probability, under authoritative coordination, the superior then never accepts an idea unless an investigation shows that it is high-quality. By proposing a mediocre idea, the agent then only delays the decision process, but never sees his idea implemented. Indeed, from (3), $a(1) = 0$ from which $V(1) < 0$ whenever an investigation occurs with positive probability (that is $p > 0$). It follows that under authoritative communication, it must be that $\rho^* < 1$. The following proposition characterizes equilibria for $b > \alpha v$:

Lemma 3 *Under authority, if* $b > \alpha b$, *then*:

- *If* $c > s\frac{b}{v}\left(1-\frac{b}{v}\right)v$, *there exists a unique 'silent' equilibrium where the superior always implements her own idea.*
- *If* $c < s\frac{b}{v}\left(1-\frac{b}{v}\right)v$, *there exists a 'communication' equilibrium in which (i) the a superior implements her own idea if it is high-quality, (ii) the superior consults an advisor if her own idea is mediocre, and*
  - *If* $c < (1-s)b$, *an advisor with a mediocre idea proposes this idea*

with a probability $\rho = \rho_H^* < 1$ *given by*

$$\beta(\rho_H^*) = \frac{b}{v},$$

the superior always investigates a proposed idea ($p^* = 1$)*, and if an investigation is uninformative, she implements the idea with a probability*

$$a^* = \frac{c}{(1-s)b} \tag{6}$$

– *If* $c > (1-s)b$*, an advisor with a mediocre idea proposes this idea with a probability* $\rho = \rho_L^* < \rho_H^*$*, given by*

$$c = s(1 - \beta(\rho_L^*))b,$$

the superior investigates a proposed idea with a probability p^* *given by*

$$(1-p^*)b + p^*(1-s)b = c,$$

and she always accepts a proposed idea in the absence of an investigation or if an investigation is uninformative ($a^* = 1$).

If $c < s\alpha\left(1 - \frac{b}{v}\right)v$*, the above equilibrium is unique. If* $s\alpha\left(1 - \frac{b}{v}\right) < \frac{c}{v} < s\frac{b}{v}\left(1 - \frac{b}{v}\right)$*, the only other equilibrium is the 'silent' equilibrium.*[12]

Proof. See Appendix B ■

From lemma 2 and 3, whenever communication equilibria exist, coordination through authority involves considerably less communication costs relative to coordination by consensus. Indeed, whereas coordination by consensus is characterized by an information overload in which everyone claims to have worthwhile idea, under authoritative coordination, an advisor will often show restraint in advocating his idea whenever the latter is mediocre. As argued above, reason for this restraint is that it is much more difficult to get a mediocre idea 'approved' by a superior, which is biased in favor of his own ideas, than by a group deciding in all objectivity. As a result, under authoritative coordination, advocating a mediocre idea then mainly results in delays and costly investigations, but rarely results in this idea being adopted. Since many mediocre solutions are

[12] If $c = sb\left(1 - \frac{b}{v}\right)$, then there exists a range of equilibria with $\rho^* = \rho_H^* = \rho_L^*$ and p_1 and p_2 such that $V(\rho) = 0$. This range of equilibria includes and is pareto-dominated by the above characterized communication equilibrium.

'screened out' in the cheap talk stage - they are never brought forward in the discussions - this yields considerable savings on time-consuming investigations and discussions for the organization. In addition to these communication savings, authoritative coordination has the obvious advantage that the controlling agent can implement his own high-quality ideas without needing to convince the other group-members. Communication savings are again obtained. As a result, whereas under consensus, average communication costs equal $(2-s)c$ in a communication equilibrium, under authority, *expected communication costs* equal

$$(1-\alpha)\left[\alpha+(1-\alpha)\rho_H^*\right]c \tag{7}$$

if $c<(1-s)b$, and

$$(1-\alpha)p^*\left[\alpha+(1-\alpha)\rho_L^*\right]c$$

if $c>(1-s)b$.

This improved information aggregation, however, typically comes at the expense of ex post suboptimal decision-making. First, provided that the superior consults his advisor, she will often be biased in favor of her own idea. In particular, if an investigation is inconclusive, she will often prefer to implement her own mediocre idea, even though the proposed idea is at least as good. Thus, not only mediocre proposals have a difficult time to get approval under authoritative coordination - resulting in a better information aggregation relative to consensus - also high-quality proposal are often turned down if their merits are not sufficiently clear. In particular, from lemma 3, if $c<(1-s)b$, a superior fails to implement an available high-quality idea if (i) she herself has a mediocre idea, (ii) her advisor has a high-quality idea, (iii) an investigation is uninformative and (iv) she subsequently rejects the proposal. This results in an *allocative efficiency loss* equal to

$$\alpha(1-\alpha)(1-s)(1-a^*)v \tag{8}$$

Note, however, that for larger communication costs, that is if $c>(1-s)b$, authoritative coordination always selects the best available idea. Enough mediocre ideas are then screened out in the cheap talk stage such that the superior strictly prefers to accept a proposed idea if an investigation is uninformative. Compared to consensus, authoritative coordination then achieves a better allocative efficiency at lower communication costs.

A second bias in decision-making concerns the decision whether or not to seriously consider a proposal made by an advisor. In particular, if communication costs are large, the superior may simply refrain from consulting the advising agent and directly implement his own idea, even when this idea is mediocre. This will be the case whenever c is larger than

$$c_p^{au} \equiv s\frac{b}{v}\left(1 - \frac{b}{v}\right)v$$

Whenever $c_p^{au} < c_p^{con} \equiv s\alpha\left(1-\alpha\right)v$, that is whenever $b > (1-\alpha)v$, then for $c \in \left[c_p^{au}, c_p^{con}\right]$, a superior will always implement his own idea, whereas a group deciding by consensus would launch an investigation into a least one proposal. A second default of coordination by authority is thus that *alternative proposals may not get the necessary attention when incentive conflicts are large.*

3.3 Authority versus Consensus

We now compare the outcome under authority with that under consensus. Let us first assume that communication costs are not excessive such that a communication equilibrium exists both under authority and under consensus decision-making, that is $c < \max\left\{c_p^{au}, c_p^{con}\right\}$. As argued above, consensus decision-making then always involves much higher communication costs. Consensus may still be preferred over authority, though, if it selects the best idea with a much higher probability. Authoritative coordination never fails to implement the best idea if $c > (1-s)b$, whereas if $c < (1-s)b$, the superior fails to implement a high-quality idea with a probability $\alpha(1-\alpha)(1-s)(1-a^*)$. Consensus fails to achieve the best idea available with a probability $\alpha(1-\alpha)(1-s)^2$. Substituting a^*, it follows that authoritative coordination selects the best idea with a higher probability whenever

$$c > s(1-s)b$$

Coordination by authority is then always optimal. For $c < s(1-s)b$, consensus results in a better selection of solutions, but at the expense of higher communication costs. Under consensus, the total efficiency loss - that is communication costs plus allocative efficiency loss - equals

$$\alpha(1-\alpha)(1-s)^2v + (2-s)c$$

Substituting ρ_H^* and a^* in (7) and (8), it follows that under authoritative coordination, the total efficiency loss equals

$$\alpha(1-\alpha)(1-s)v$$

Let us denote by σ_v^2 the *variance in the quality of ideas*:

$$\sigma_v^2 \equiv 2\alpha(1-\alpha)v \tag{9}$$

The following result follows:

Lemma 4 *If $c < \min\left\{c_p^{au}, c_p^{con}\right\}$, authority will be preferred over consensus whenever $c > \lambda * \sigma_v^2$, where*

$$\lambda \equiv \frac{s}{2}\frac{1-s}{2-s} \tag{10}$$

It is obvious to see that $c_p^{con} > \lambda * \sigma_v^2$. Moreover, $c_p^{au} > \lambda * \sigma_v^2$ if and only if b is smaller than some threshold b_H given by

$$b_H \equiv \max\left\{b \in (0,v) : \frac{b_H}{v}(1-\frac{b_H}{v}) = \frac{1-s}{2-s}\alpha(1-\alpha)\right\}$$

Assume now that $c > \min\left\{c_p^{au}, c_p^{con}\right\}$. From lemma (3) and (2), whenever $c > \max\left\{c_p^{au}, c_p^{con}\right\}$, both authoritative and consensus decision-making yield the same outcome: either the superior always implements his own idea, or the group picks an idea at random. Whenever $c < c_p^{au}$, coordination through authority will improve upon this outcome, as a superior with a mediocre idea sometimes implements a high-quality proposal of his advisor. Similarly, if $c < c_p^{con}$, then a group deciding by consensus will launch an investigation into one or both of the proposed ideas, which must improve upon randomly picking an idea, as otherwise the group would refrain from doing so. It follows that if $c \in \left(c_p^{con}, c_p^{au}\right)$, authoritative decision-making strictly dominates coordination through consensus. In contrast, if $c \in \left(c_p^{au}, c_p^{con}\right)$, consensus decision-making strictly dominates. It is easy to see that $c_p^{con} < c_p^{au}$ if and only if $\alpha < b/v < 1-\alpha$

We summarize the above insights in the following proposition:

Proposition 1

- *If $b \in (\alpha v, b_H)$, then*
  - *coordination by consensus strictly pareto-dominates if $c < \lambda * \sigma_v^2$, with λ defined by (10).*

- *if* $b < (1-\alpha)v$, *then for* $c > \lambda * \sigma_v^2$, *coordination by authority pareto-dominates, where this dominance is strict as long as* $c < s\frac{b}{v}(1-\frac{b}{v})v$.
- *if* $b > (1-\alpha)v$, *then for* $c \in \left(\lambda * \sigma_v^2, s\frac{b}{v}(1-\frac{b}{v})v\right)$, *coordination by authority strictly pareto-dominates, for* $c \in \left(s\frac{b}{v}(1-\frac{b}{v})v, s\alpha(1-\alpha)v\right)$ *coordination by consensus strictly dominates, whereas for* $c > s\alpha(1-\alpha)v$, *both yield the same outcome.*

- *If* $b > b_H$, *then coordination by consensus always pareto-dominates coordination by authority. This dominance is strict if and only if* $c < s\alpha(1-\alpha)v$.

Proof. The proof follows immediately from the above observations ■

Figure 3 and Figure 4 illustrate the optimal decision procedure - authority or consensus - as a function of the *relative incentive conflict* b/v (vertical axis) and the *relative communication costs* c/v (horizontal axis), and this for $\alpha = 0.2$ (Fig. 1) and $\alpha = 0.4$ (Fig. 4). In both figures, it is assumed that $s = 2/3$. Four zones can be distinguished: (i) A zone in which consensus is optimal because communication costs are small. (ii) A zone in which consensus is optimal because the incentive conflict is very large. (iii) A zone in which authority is optimal. (iv) A zone in which consensus and authority yield the same outcome, as communication costs are excessive and the silent equilibrium is the only outcome in both settings.

Proposition 1 has a number of interesting implications as to when authoritative coordination is most likely to be optimal:

The impact of the complexity and urgency of the problem: The communication cost c is most naturally interpreted as a measure of the complexity and the urgency of the problem at hand. Indeed, as a problem becomes more complex, the time and resources needed to evaluate potential solutions tends to increase dramatically. Similarly, if the resolution of a problem is very urgent, time-consuming investigations and discussions become very costly. From proposition 1 and Figure 3 and 4, as long as this complexity or urgency is limited, consensus is a better way to coordinate the activities of agents. Consensus then leads to a better allocative efficiency at the expense of only marginally larger communication costs. For intermediate incentive conflicts, however, authoritative coordination becomes optimal once c exceeds a relative small threshold. Coordination through authority then manages to substantially reduce communication costs relative to consensus. As c further increases, authority may even result in a better allocative efficiency as agents with mediocre ideas increasingly

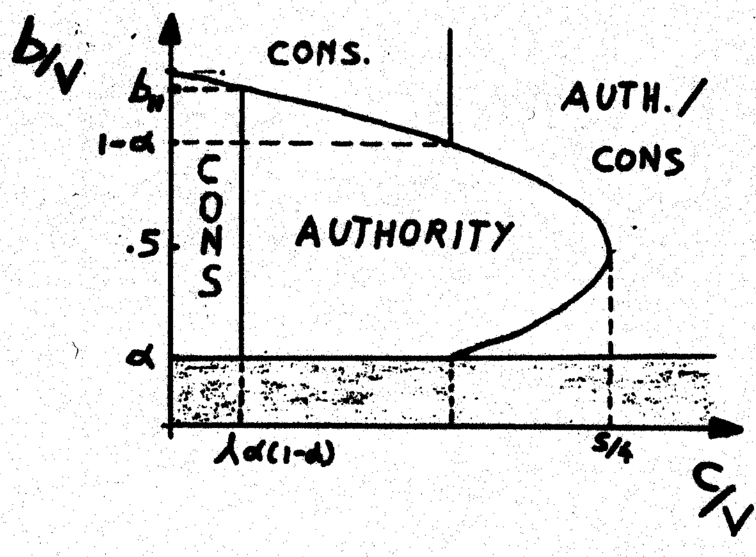


Figure 3: Authority vs Consensus: $\alpha = 0.2$, $s = 2/3$.

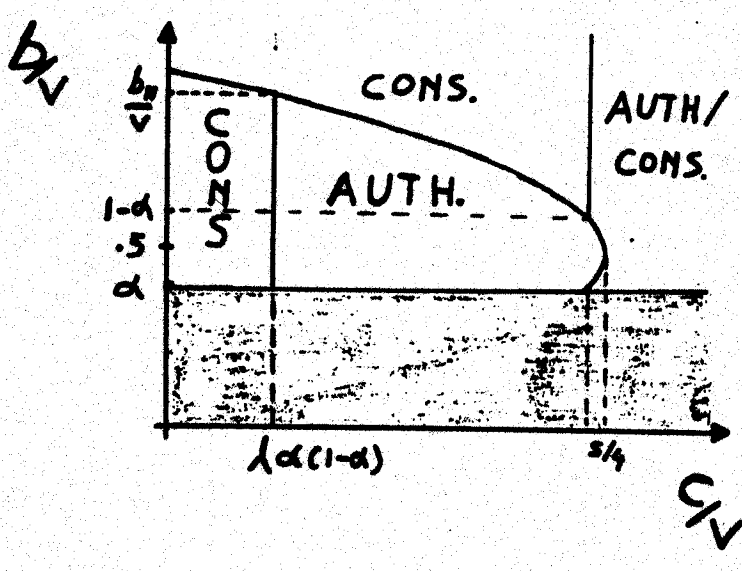


Figure 4: Authority vs Consensus: $\alpha = 0.4$, $s = 2/3$.

refrain from delaying the decision process.
The impact of complexity and urgency, however, is non-monotonic. First, as c becomes unduly large, both authority and consensus yield the same outcome: they randomly pick an idea. Perhaps more important, if incentive conflicts are large, the superior may lack the motivation to investigate his advisor's proposal once communication costs exceed a certain level. As long as c is not excessive, that is as long as $c < s\alpha(1-\alpha)v$, consensus decision-making then ensures that all proposals are considered and is strictly preferred over authority. As can be seen on Figure 3 and 4, this strict non-monotonicity is only relevant for large biases. For intermediate biases, it is non-existent or negligible.

The impact of the variance in the quality of solutions: If the variance in the quality of ideas becomes larger - because agents are more likely to have ideas which differ in quality or because the difference in quality of ideas becomes larger - consensus remains optimal for larger values of c. Indeed, the communication cost threshold above which authority becomes optimal for intermediate incentive conflicts, is increasing in σ_v^2. Intuitively, as long as $c < s(1-s)b$, consensus results in a better allocative efficiency. Since selecting the best idea is more important as the variance in the quality of ideas increases, consensus is then optimal for larger values of c.
In addition to this, as the variance in the quality of ideas increases, a communication equilibrium exists for a much larger range of communication costs under consensus. If this is due to $\alpha(1-\alpha)$ being larger, this increases the range of incentive conflicts b for which the impact of c is strictly non-monotonic.
Figure 3 and 4 illustrate the impact of an increase in the variance. As one can see, conditional on $b > \alpha v$, the zones in which consensus is optimal are much larger in Fig. 4, where the variance is much larger than in Fig. 3.[13]

The impact of the magnitude of the incentive conflict: As the incentive conflict becomes larger, the superior is less and less motivated to delay the implementation of his own solution in order to find out if his advisor has a better idea. For large enough a bias, the superior then simply neglects any advice, and always implements his own idea. As a result, even when $c > \lambda * \sigma_v^2$, if b is larger than some threshold which is decreasing in c, authoritative coordination is pareto-dominated by consensus. This dominance is strict as long as a communication equilibrium exists under consensus.

[13] The variance in the quality of ideas equals $2\alpha(1-\alpha)v$ and is maximized for $\alpha = 0.5$.

3.4 Non-strategic communication

Whenever $b < \alpha v$, an agent with a mediocre idea prefers to implement a rival solution of unknown quality. Under consensus decision-making, there exists then an equilibrium in which each agent truthfully announces the quality of his solution. To see this, consider the decision of agent L to announce whether or not his idea is high-quality. In a truthful equilibrium, the group never launches and investigation, but picks the solution which is claimed to be high-quality if the announcements of two agents differ, and randomizes otherwise. Obviously, if L has a high-quality idea, he will always announce this. In contrast, if L has a mediocre idea, then by falsely declaring his idea to be high-quality, he always increases the chances that his solution is adopted by fifty percent. On the one hand, with a probability $(1-\alpha)$, L then sees his own mediocre idea implemented instead of $R's$ mediocre idea, increasing his pay-off with b. On the other hand, with a probability α, he prevents $R's$ high-quality solution from being implemented, decreasing his pay-off by $v - b$. It follows that L will reveal his idea to be mediocre if and only if

$$(1-\alpha)\frac{1}{2}b - \alpha\frac{1}{2}\left[v-b\right] < 0$$

which will be satisfied if and only if $b < \alpha v$.

In addition to the above *truth-full equilibrium*, it is easy to show that as long as $c < c_\rho$, defined by (5), there also exists an equilibrium with *strategic communication* in which each agent always claims to have a high-quality idea, and the group always launches an investigation.[14] While such a pareto-dominated equilibrium may be reminiscent of 'communication failures' which are often encountered in real life, it seems reasonable to assume that the agents will be able to coordinate on the most efficient equilibrium. We will therefore focus on the latter outcome.

Let us compare this truthful communication equilibrium with the outcome under authority. Obviously, a superior with a high-quality idea, will always implement this idea. Similarly, if $b < \alpha v$, a superior with a mediocre idea will implement the proposal of an advisor in the absence of any additional information. Before accepting the advisor's solution, however, the superior will often

[14] This equilibrium, and the proof of its existence, is identical to that of the unique equilibrium in 2 for $b > \alpha v$ and $c < c_p$. The only difference is that for $b < \alpha v$, $c_\rho < c_p$, and hence the equilibrium only exists as long as $c < c_\rho$. For $c \in [c_\rho, c_p]$, one can show that a bad equilibrium exists in which an agent with a mediocre idea, proposes this idea with a probability $\rho \in (0,1)$.

submit it to excessive investigation. This will happen with positive probability whenever $c < s(1-\alpha)b$.[15] From an efficiency point of view, such a costly investigation is a pure waste, as the advisor's proposal is at least as good as the superior's idea. It follows that coordination through authority is then pareto-dominated by coordination through consensus. We summarize in the following proposition

Proposition 2 *For $b < \alpha v$:*

- *Coordination by consensus achieves the first best*
- *Coordination by authority selects the best available solution, but whenever $c < s(1-\alpha)b$, the superior engages in excessive investigations before accepting a proposal from her advisor.*

This proposition establishes a non-monotonicity result with respect to the nature of the incentive conflict: while for intermediate biases (conflicts of interest), authoritative coordination outperforms consensus whenever c is not too small, both for small and large biases, consensus does always at least as good as authority, where this dominance is strict for small values of c. Note that regardless of the incentive conflict, an increase in c tends to make consensus less attractive.

While the above result is in line with the often made claims that decision-making under consensus tends to work best when interests are sufficiently aligned, one should be careful in generalizing the conclusion that consensus then also outperforms authoritative decision making. In particular, in our model, *non-strategic communication* is only possible since the quality of an idea can only take two values: v or 0. If, in contrast, v were to be a continuous variable, then it is straightforward to show that whenever $b > 0$, only *strategic communication* is possible, where the agents messages are always noisy.

[15] In particular, as long as $c < (1-s)b$, the advisor always proposes his idea and the superior always investigates this idea. If $c > (1-s)b$, an advisor proposes his idea with positive probability $\rho^* \in (0,1)$, given by $c = s(1-\alpha)\rho^* b$, and the superior investigates a proposed idea with positive probability $p^* \in (0,1)$, given by $(1-p^*)b + p^*(1-s)b = c$.

4 Endogenous Information and Decision-Making by Unanimity

So far, we have assumed that each agent was endowed with one idea of exogenous quality. In this section, we endogenize the information structure by assuming that each agent may have several 'rough' ideas - intuitions - as how to solve the problem at hand, and needs to choose one of these intuitions for further development and potential implementation. To the extent that some of these potential ideas are more complex or more difficult to be evaluated by a group than others, decision-making under consensus may push agents to develop 'superficial', 'good-looking' solutions which can easily 'convince' other agents, at the expense of better, but more complex solutions. In contrast, under coordination by authority, a superior has no distorted incentives and will seek to develop and implement his best idea. As in our basic model, however, the superior also tends to be too 'narrow', that is he is biased against ideas from other agents. A trade-off then obtains between quantity and quality, that is the variety of ideas which are brought to bear on a problem and 'deep' these ideas are.

4.1 A model with endogenous generation of solutions

To pursue the above trade-off, we make the following changes to our basic model:

- Each agent has not 1 but n 'rough' ideas - intuitions - whose potential quality, privately known by its inventor, is given by

$$v_i = u_i + w_i$$

  where $u_i, ..., u_n$ and $w_1, ..., w_n$ are independently distributed with $F_i(u_i) \sim N(0, 1)$ and $G_i(w_i) \sim N(0, \sigma)$ for $i = 1, .., n$.

- An agent must choose one intuition for further development. Further development of this intuition is required to enable potential implementation and evaluation by other agents. Since this is a time-consuming process, at most one intuition can be further developed.

- Once an idea is developed, u_i is much easier to evaluate by the group than w_i. To put things extreme, we assume that $c_u = 0$ and $c_w = +\infty$, with c_u and c_w the cost of evaluating u_i and w_i respectively.

- To simplify the analysis, we further assume that b is sufficiently large such that we can neglect any informative cheap talk, where an agent would voluntarily admit that his idea is of a less-than-average quality.[16]

Given the above assumptions, if $n = 1$ as in our basic model, consensus is always superior to authority. Indeed, whereas under authority, the principal always implements his own solution with expected value 0, under consensus, the solution with the highest u_i is selected, resulting in a positive expected value v_i. This illustrates the benefit of consensus in bringing a *greater variety of visions* on a particular problem, whereas authority is characterized by a '*narrowness*' of mind. In addition, by imposing a very large bias, we have eliminated the virtue of coordination by authority as an efficient information aggregation devices, high-lighted in the previous section.

For $n > 1$, it remains optimal for a group deciding by consensus to implement the best-looking proposal, since this idea has also the highest expected value among all proposed solutions. Anticipating this, however, agents then develop their 'best-looking' ideas under consensus, that is the idea with the highest value u_i. The larger is σ, however, the less likely that this is also their best idea. It follows that the solution adopted under consensus will have an expected value equal to

$$E(\max\{u_1, .., u_n, \hat{u}_1, ..., \hat{u}_n\}) = 2n \int_{-\infty}^{+\infty} uF(u)^{2n-1} dF(u) \tag{11}$$

In contrast, a player with authority will develop her most promising idea, that is the idea which maximizes $u_i + w_i$. The controlling agent, however, will fail to listen to ideas proposed by his rivals. The expected value of a solution adopted under authority therefore equals

$$E(\max\{u_1 + w_1, ..., u_n + w_n\}) = n \int_{-\infty}^{+\infty} vH(v)^{n-1} dH(v)$$

[16] Given that u_i and w_i have an infinite support, for any b, when $u_i + w_i$ are sufficiently small, an agent will not seek his idea to be implemented, but voluntary admit that he has a very low quality idea (under consensus) or directly implement a rival idea (under authority). For b large, however, these events will occur with a sufficiently small probability that they do not affect tje trade-off between authority and consensus. They can therefore be neglected in the analysis.

where $H(v) \sim N(0, 1+\sigma)$. Since $H(v) = F(\frac{v}{1+\sigma})$, the above can be rewritten as

$$E(\max\{u_1 + w_1, ..., u_n + w_n\}) = (1+\sigma)n \int_{-\infty}^{+\infty} zF(z)^{n-1} dF(z) \qquad (12)$$

Comparing (11) with (12), yields the following conclusion:

Proposition 3 • *If $n \geq 2$, then there exists a cut-off value $\sigma'(n) < 1$ such that coordination through authority is superior to coordination through consensus if and only if $\sigma > \sigma'(n)$.*

- *$\sigma'(n)$ is decreasing in n.*

Proof. See Appendix ■

Intuitively, σ characterizes the complexity of the problem and its possible solutions. Indeed, as σ increases, the fraction of the value of solutions which can be easily evaluated, decreases. As under consensus, agents only focus on ideas which 'look' good, it is then less likely that they select their best project. It is easy to see that the difference in the expected value between the best-looking and best idea is increasing in n. Moreover, the benefit of consensus in bringing more ideas - visions, approaches - to a problem, also decreases with n. Indeed, as n is larger, then the superior herself has already many views on the problem, and any additional views which may be brought to bear on the problem under consensus are then less likely to consist of big improvements. As a result, the critical threshold value for σ above which coordination by authority becomes optimal, is decreasing in n. Note, finally, that even for $n = 2$, coordination by authority may be optimal even when $\sigma < 1$, and hence u_i, the hard information which can be evaluated by the group, is more important than w_i, the soft information which is only known to the promoter of the idea.

4.2 A rationale for decision-making with unanimity (preliminary)

Unlike in our model with exogenous information, so far, communication costs play no role in our model with endogenous information. Reason for this is our extreme assumption that part of the value of the solution never can be assessed by the group. In this section, we relax this assumption by positing that w_i can be assessed by other agents at a large but not unreasonable cost $c > 0$. We show that decision-making by *unanimity* may then arise as an optimal institution. Intuitively, if one proposal 'looks' sufficiently better than another proposal, then if c is somewhat large, a group deciding by consensus will refrain from any further investigation and directly implement the best-looking proposal. As argued in the previous section, this results in a distortion in information generation ex ante, as agents are induced to develop their best-looking ideas as opposed to their best ideas. Consider now coordination by unanimity, where each agent has the option to veto any decision until all proposals have been fully investigated. Once all the uncertainty has been resolved, we assume that the group coordinates on the most efficient Nash equilibrium, that is the one in which the best available solution is selected.[17] While this may result in excessive communication costs ex post, ex ante this provides agents with the correct incentives to develop and propose their best idea. Thus, unanimity achieves a better allocative efficiency than both authority and consensus, but at the expense of large communication costs. We argue that for intermediate communication-costs, unanimity may then pareto-dominate both authority and consensus.

Assume that each agent i, $j = L, R$, has two ideas, $i = 1, 2$, whose value is given by

$$v_{ij} = u_{ij} + w_{ij} \qquad i = 1, 2; j = L, R$$

Let $v_j^* = u_j^* + w_j^*$ be the idea developed and proposed by agent j, $j = L, R$, where w_j^* has a distribution $F^*(w)$ with mean $\bar{w}$.[18] Under consensus, given $c > 0$, the group will then launch and investigation if and only if $|u_R^* - u_L^*| < \Delta$, where $\Delta \equiv \Delta(c)$ is given by

$$c = \int_{\bar{w}+\Delta}^{+\infty} [w - \bar{w} - \Delta] \, dF^*(w)$$

It is easy to see that as c increases and, hence, Δ decreases, the probability with which agent L and R will develop ex ante their best-looking idea as opposed to their best idea also increases. As Δ goes to zero, each agent always selects his best looking project, as in the previous section. As a result, while it is ex post optimal not to investigate two proposals which seem to differ a lot in quality, a group may want to commit to do this anyway in order to improve ex ante

[17] Alternatively, one could assume that the group first decides by unanimity, and when after a given time-span (sufficiently long to investigate both ideas further in detail) no agreement is reached, the group then decides by majority.

[18] If w_{ij} has a distribution $F(w)$ with mean 0, then so will w_j^* if each agent proposes and develops his best-looking idea. If, however, each agent, with positive probability, selects his best idea even when this not his best-looking idea, then $\bar{w} > 0$, and $F^*(w) \neq F(w)$.

incentives. The following lemma shows that this is exactly what happens under coordination by unanimity for b large:

Lemma 5 *If each agent has a veto-right to delay a group decision until all proposals are fully investigated, then as b tends to infinity, there exists a unique equilibrium in which*

- *each agent always develops and proposes his best idea*
- *the best looking proposal is always fully investigated*
- *If $u_R^* > u_L^*$, then both proposals are fully investigated if and only if $v_L^* < v_R^*$*

Proof. See Appendix C ■

Given that the true value of a proposed solution is fully revealed, a veto-right gives an agent the proper incentives to propose complex solutions whose benefit may not be immediately clear. This contrasts with consensus (with majority-rule), where a very good idea will often be rejected without being thoroughly analyzed, as it is too complex and its benefits are not immediately clear. As a result, unanimity achieves the best of both authority and consensus in terms of allocative efficiency: it brings the diversity of ideas to bear on a problem, one of the virtues of consensus, but it also fosters deep thinking and the development of complex but highly valuable ideas, one of the virtues of authority. All this, however, comes at the expense of huge communication costs. Intuitively, one may therefore suspect coordination through veto-power to be optimal for intermediate values of c, where c is large enough such that consensus too often fails to investigate ex post in order to motivate agents to develop their best ideas, but where c is not too large such that the larger communication costs associated with unanimity off-set its benefits.

As solving the equilibrium under (simple) consensus is very complex with a continuous support, we illustrate the above conjecture with two examples in which w_{ij} and u_{ij} have a discrete distributions.

Assume first that $u_{ij} \in \{-1, 0, 1\}$ with equal probability and $w_{ij} \in \{-2, 0, 2\}$ with equal probability for $i = 1, 2$, $j = L, R$, where u_{ij} can be assessed at no cost and w_{ij} at a cost $c > 0$. As before, we denote by $v_j^* = u_j^* + w_j^*$, the idea developed and proposed by agent j. If coordination occurs through *authority*, the superior will always develop and implement his best idea, yielding an expected pay-off equal to

$$E(\max\{u_{L1} + w_{L1}, u_{L2} + w_{L2}\})$$

If coordination occurs through *unanimity*, then, as in lemma 5 , one can show that each agent will always propose and develop his best idea, and, at the decision stage, each agent will veto the implementation of another idea as long as his proposal may turn out to be as valuable. As a result, the expected value of the solution which is implemented under unanimity equals

$$E(\max\{u_{L1}+w_{L1}, u_{L2}+w_{L2}, u_{R1}+w_{R1}, u_{R2}+w_{R2}\},$$

but this will come at the expense of communication costs whose expected value is bounded above by

$$[1+\Pr(v_L^* \geq v_R^*)]\, c$$

Finally consider decision-making by *consensus.* Taking for granted that each agent always proposes his best-looking idea, then whenever $u_L^* = u_R^*$, one can show that the group will launch an investigation into at least one idea if and only if $c < 2/3$. Moreover, if the outcome of this investigation is that $w_i^* = 0$, also the second proposal will be investigated. In contrast, if $u_i^* \geq u_j^* - 1$, i, j, it is easy to show that the group will pick the best looking project without any further investigation if and only if $c > 1/3$. We now verify now that given the above group behavior, each agent indeed always propose his best looking project. An agent L must make a choice between his best-looking and his truly best idea whenever

$$u_{L1} = u_{L2} - 1 \text{ but } w_{L1} \geq w_{L2} + 2 \tag{13}$$

or

$$u_{L1} = u_{L2} - 2 \text{ but } w_{L1} = w_{L2} + 4 \tag{14}$$

We only show that agent L prefers to develop idea $L2$ instead of $L1$ in situation (13), as this is obvious for situation (14). If (13) holds, then the only situation in which player $L's$ choice will matter is when $u_{L1} = u_R^*$ or $u_{L2} = u_R^*$. Whenever $u_{L2} = u_R^*$, by not proposing his best looking solution, player $L's$ idea is never implemented. In contrast, if he would have proposed his best looking project, this would have occurred with positive probability. Similarly, whenever $u_{L1} = u_R^*$, by choosing his best-looking idea, L is guaranteed of having it implemented. In contrast, if he proposes chooses his truly best project, there is positive probability that $R's$ proposal will be implemented. It follows that it is a dominant strategy for L to always propose his best-looking idea. The following lemma characterizes the equilibrium under consensus decision-making for $c > 1/3$:

Lemma 6 *For $c > 1/3$, under consensus with majority voting, there is a unique equilibrium in which each agent always proposes his best-looking idea and for $c \in (1/3, 2/3)$, the group investigates at least one proposal if and only if $u_L^* = u_R^*$, whereas for $c > 2/3$, the group never investigates a proposal.*

For simplicity, we will restrict our analysis to $c > 1/3$, as for $c < 1/3$, equilibria under consensus are much more sophisticated. From lemma **??**, for $c > 2/3$, the expected pay-off under consensus then equals

$$E(\max \{u_{L1}, u_{L2}, u_{R1}, u_{R2}\})$$

For $c \in [1/3, 2/3]$, in contrast, the group will investigate whenever $u_L^* = u_R^*$, in which case an investigation increase the expected pay-off of the group by[19]

$$1/3 * 2 - c + 1/3 [1/3 * 2 - c]$$

Hence, the expected pay-off under consensus then equals

$$E(\max \{u_{L1}, u_{L2}, u_{R1}, u_{R2}\}) + \Pr(u_L^* = u_R^*) \left[\frac{4}{3}\left(\frac{2}{3} - c\right)\right]$$

In Appendix, we compare the expected payoffs authority, consensus and unanimity. We summarize our findings:

Example 1 *If $u_{ij} \in \{-1, 0, 1\}$ and $w_{ij} \in \{-2, 0, 2\}$, with all values equally likely, then $\exists c' > 0.52$ such that for $c \in [1/3, c']$, coordination through unanimity is strictly preferred over coordination through consensus or authority, whereas for $c > c'$, coordination through authority is optimal.*

In the above example, the complexity of the problem is such that for large values of c, consensus is always dominated by authority. If, however, one were to assume that $w_{ij} \in \{-1, 0, 1\}$ instead of $w_{ij} \in \{-2, 0, 2\}$ (the hard-to-evaluate part of an idea is less important), then in Appendix, we show that consensus

[19] If the group implements $X's$ idea directly, then $E(w_X^*) = 0$. In contrast, if she first investigates $X's$ idea, then with a probability 1/3, the group finds out that $w_X^* = -2$, in which case she implements $Y's$ idea, with $E(w_Y^*) = 0$. With a probability 1/3, she finds out that $w_X^* = 0$, in which case she also investigates also $Y's$ idea and implements Y if she learns that $w_Y^* = 2$. With a probability 1/3, she learns that $w_X^* = 2$, and she directly implements X as she would have done in the absence of an investigation.

always dominates authority. As in the above example, however, for moderate values of c, unanimity outperforms both consensus and authority:

Example 2 *If both* u_{ij} *and* $w_{ij} \in \{-1,0,1\}$, *with all values equally likely, then* $\exists c' > 0.189$ *such that for* $c \in [1/18, c']$, *coordination through unanimity is strictly preferred over coordination through consensus or authority, whereas for* $c > c'$, *coordination through consensus is optimal.* $1.32141002 \times 10^{-15}$

5 Related Literature

Our rationale for authoritative coordination is related to a number of literatures:

First, the idea that authority is an efficient way to coordinate the activities of many persons when communication is costly, has been put forward informally by Arrow (1974), Williamson (1975), Chandler (1977) and more recently, Milgrom and Roberts (1992). Williamson's argument is exemplary and goes as follows:

> "Consider the problem of devising access rules for an indivisible physical asset which can be utilized by only one or a few members of the group at a time. (...) While a full group discussion may permit one of the efficient rules eventually to be selected, how much simpler if instrumental rules were to be "imposed" authoritatively. (...) Assigning the responsibility to specify access rules to whichever member occupies the position at the center avoids the need for full group discussion with little or no sacrifice in the quality of the decision. Economies of communication are thereby realized." (Williamson (1975), pp 46-47)

The above reasoning, however, suffers on at least two accounts. First, Williamson does not explain why a group deciding by consensus cannot mimic the 'authority-without-communication' outcome by simply selecting a solution *without long discussions.* Secondly, Williamson neglects the impact of incentive conflicts on communication costs. As noted in our introduction, if incentives are perfectly aligned, communication costs are likely to be negligible. In sum, Williamson's reasoning relies on the existence of some *exogenous* communication costs, associated with consensus decision-making, and an *exogenous* loss in decision-quality associated with authoritative decision-making. In contrast, in formalizing the ideas of Williamson and others, this paper has emphasized that communication costs are *endogenous*, and depend both on the variance in the quality of ideas and the incentive conflict among the agents. Moreover, just as a group has the option to select a solution without long discussions, an agent in control can ask other agents for advice and discuss their proposals. Thus, also the loss in decision-quality under authority is endogenous.[20]

Our rationale for authoritative coordination is also very reminiscent of the literature on *influence costs* (Milgrom (1988), Milgrom and Roberts (1988,1990), Meyer, Milgrom and Roberts (1992)). This literature argues that members in organizations often spend considerable time and effort in attempting to influence decision-makers. While such influence activities may provide valuable information to the decision-maker, they typically involve real costs in diverting attention and effort from more productive activities. Optimal decision processes should therefore limit these influence activities, while still allowing decisions to be effective. In our model, influence activities take the form of agents arguing their case strenuously. While this improves the effectiveness of decisions if a proposal is high-quality, it is a waste of time to the organization if ideas are mediocre. Casted in the language of the influence cost literature, our paper argues that *authoritative coordination is often preferred over consensus as it is less vulnerable to rent-seeking activities* by agents with mediocre ideas.

Our paper can further be interpreted as showing the benefits of delegating control to a *visionary manager* - which has ideas, but is biased in favor of them - as opposed to an unbiased, uninformed median voter. In this sense, we contribute to a nascent literature who argues that firms may benefit from employing a CEO whose *vision* biases him in favor of certain projects, as opposed to a purely profit-maximizing CEO. In particular, this vision may positively affect the incentives of employees to innovate and acquire information (Rotemberg and Saloner (2000)), the sorting of employees (Van den Steen (2001)), or the satisfaction and, hence, reservation utilities of employees (Hart and Holmstrom (2002)).

Finally, our argument that authoritative coordination gives the controlling agent the correct incentives to develop his most promising idea has a flavor of Stein (2002)'s argument in favor of decentralization. Stein's main message is that the presence of a CEO with ultimate control over capital allocation

[20] Segal (2001) also formalizes the idea that authority is an efficient way of coordinating acitivities of many persons when communication is costly. In contrast to our model, however, there are no incentive conflicts in Segal (2001). Communication problems, instead, arise because agents do not share a common labelling and need to describe potential actions, which is costly. It is shown that the simplest way to coordinate is by giving one of the players the authority to specify what actions to take.

blunts managerial incentives for information acquisition if information is soft, but improves incentives if information can be costlessly "hardened". Stein notes, though, that if both hard and soft information is available, a hierarchy provides managers excessive incentives to produce hard, verifiable, information, at the expense of soft information. If soft information is very valuable, a decentralized organization – where managers are independent – may then be more attractive. In Stein's model, however, the organizational choice is between having two independent managers making an uncoordinated decision, or putting these managers under the supervision of a CEO who coordinates their decisions. In contrast, in our model, decentralization is not an option as decisions always need to be coordinated. We, instead, are interested in the mechanism through which they are coordinated: authority versus consensus.

6 Appendix

6.1 Appendix A: consensus equilibrium

Proof of Observation 1: if and only if $b > \alpha v : c_p^{con} \leq c_\rho$

c_ρ can be rewritten as

$$c_\rho \equiv s\alpha\left[v - b\right] + \frac{b - \alpha v}{2 - s}$$

from which, for $b > \alpha v$, $c_p^{con} < c_\rho \Leftrightarrow$

$$0 \leq \frac{1}{2 - s} - s\alpha$$

The RHS of the above inequality is minimized for $\alpha = 1$ Since $1 \geq s(2 - s)$ for $s \in [0, 1]$, it thus follows that the above inequality is always satisfied

Proof of Lemma 2:

(i) $c < c_p^{con} \equiv s\alpha(1 - \alpha)v$: Existence follows directly from observation 1 and the definitions of c_p^{con} and c_ρ. Uniqueness follows from the fact that $p(\rho)$ is non-decreasing in ρ whenever $c < c_p^{con}$ and $V(\rho)$ is decreasing in both $p(\rho)$ and ρ.

(ii) $c > c_p^{con} \equiv s\alpha(1 - \alpha)v$: Denoting by $p(\rho)$ the probability with which the group launches an investigation, we have that $p(\rho) > 0$ only if

$$c \leq s\beta(\rho)(1 - \beta(\rho))v$$

Whenever $c \in \left[c_p^{con}, \frac{sv}{4}\right]$, we define

$$\rho_H = \max\{\rho : c = s\beta(\rho)(1-\beta(\rho))v\}$$

Observation (a): $p(\rho) > 0$ only if $\rho \leq \rho_H$

Remember further that $\rho > 1$ only if

$$\begin{aligned} V(\rho) \quad \equiv \quad & \frac{1}{2}(1-\alpha)b - \frac{1}{2}\alpha\left[1 - p(\rho) + p(\rho)(1-s)^2\right](v-b) \\ & -p(\rho)\left[\alpha + (1-\alpha)\rho\right]\left[2-s\right]c \geq 0 \end{aligned} \tag{15}$$

where $\rho = 1$ whenever the inequality holds strict. Finally, for $c > c_\rho$, we define by $\hat{\rho}$ the value of ρ for which $V(\rho) = 0$ given that $p = 1$. Thus

$$\frac{1}{2}(1-\alpha)b - \frac{1}{2}\alpha(1-s)^2(v-b) = \left[\alpha + (1-\alpha)\hat{\rho}\right]\left[2-s\right]c$$

or still

$$\left[\alpha + (1-\alpha)\hat{\rho}\right]c = c_\rho$$

Note that $\hat{\rho} \leq 1$ if $c \geq c_\rho$. Furthermore, since $V(\rho)$ is decreasing in ρ and p, we have that $\rho < \hat{\rho}$ implies $V(\rho) > 0$, leading to the following observation:

Observation (b): If $c \geq c_\rho$, $\rho < \hat{\rho}$ cannot be an equilibrium outcome

We now show that if $c > c_p^{con}$, then $\rho^* = 1$ and $p^* = 0$ is the unique equilibrium outcome:

- Assume first that $\alpha \geq 1/2$, then for any $\rho < 1$, $s\beta(\rho)(1-\beta(\rho))v < s\alpha(1-\alpha)v$. As a result, for $c > c_p^{con} = s\alpha(1-\alpha)v$, $p(\rho) = 0$ for any ρ and, hence, $\rho = 1$.
- Consider now $\alpha < 1/2$. If $c \in \left[c_p^{con}, c_\rho\right)$, then by definition of c_ρ, $V(\rho) > 0$ for any p^*, from which $\rho^* = 1$ and, by definition of c_p^{con}, $p(\rho^*) = 0$. Assume now $c \geq c_\rho$. We show that $\rho_H < \hat{\rho}$, such that from observation (a) and (b), we must have $p(\rho) = 0$ in equilibrium. Indeed

$$\begin{aligned} \rho_H \quad < \quad & \hat{\rho} \Leftrightarrow \left[\alpha + (1-\alpha)\rho_H\right]c < c_\rho \\ \Leftrightarrow \quad & \frac{\alpha(1-\alpha)\rho_H}{\alpha + (1-\alpha)\rho_H} sv < \frac{1}{2}s\alpha\left[v-b\right] + \frac{1}{2}\frac{b-\alpha v}{2-s} \end{aligned}$$

where we used the definition of ρ_H to substitute c in the last inequality. Since the LHS of this inequality is increasing in ρ_H, as sufficient condition for $\rho_H < \hat{\rho}$ is that

$$\alpha(1-\alpha)sv < \frac{1}{2}s\alpha\left[v-b\right] + \frac{1}{2}\frac{b-\alpha v}{2-s}$$

which is equivalent to $c_p^{con} < c_\rho$, which is indeed always verified.

6.2 Appendix B: Authority equilibrium

Let us first consider the decision of the superior to accept a proposal in the face of uncertainty. An ignorant superior will implement a proposal only if ρ is below some threshold ρ_H^* defined by $\beta(\rho_H^*)v = b,$ that is

$$a(\rho) = \begin{cases} = 0 & if \quad \rho > \rho_H^* \\ \in [0,1] & if \quad \rho = \rho_H^* \\ = 1 & if \quad \rho < \rho_H^* \end{cases} \tag{16}$$

Let us now examine $p(\rho)$, the decision of the principal to investigate an idea proposed by R. Given $\rho \leq \rho_H^*$, the principal will strictly prefer to investigate if and only if this yields a higher expected utility than directly accepting $R's$ idea, that is if and only if ρ is larger than a cut-off value ρ_L^* defined by

$$s(1 - \beta(\rho_L^*))b = c$$

Given $\rho > \rho_H^*$, the principal will strictly prefer to investigate if and only if ρ is smaller than a cut-off value ρ' defined by

$$s\beta(\rho')(v - b) = c$$

Note that $\rho_L^* \leq \rho_H^* \leq \rho' \Leftrightarrow \rho_L^* \leq \rho'$. Hence

$$p(\rho) = \begin{cases} = 0 & if \quad \rho < \rho_L^* \text{ or } \rho > \rho' \\ \in [0,1] & if \quad \rho = \rho_L^* \leq \rho' \text{ or } \rho_L^* \leq \rho = \rho' \\ = 1 & if \quad \rho_L^* < \rho < \rho' \end{cases} \tag{17}$$

(i) Assume first that $c < (1 - s)b$. Let us first investigate the existence of an equilibrium in which $p > 0$. As argued in the text, no equilibrium then exists in which $\rho = 1$. From (5), neither does there exist an equilibrium in which $a = 1$, as then $V(\rho) > 0$ for any p, from which $\rho = 1$, a contradiction. Similarly, no equilibrium exists where $\rho = 0$, as then $a = 1$, a contradiction, and no equilibrium exists in which $a = 0$, as then $\rho = 0$, a contradiction. It follows that if $p > 0$, it must be that $\rho \in (0, 1)$ and $a \in (0, 1)$. From (16), $a \in (0, 1)$ only if

$\rho = \rho_H^*$. We consider two cases: (a) If $\rho_H^* < \rho_L^*$, that is if

$$s(1 - \beta(\rho_H^*))b < c$$

or still

$$s(1 - \frac{b}{v})b > c \tag{18}$$

then, from (16), $p = 0$, a contradiction Hence, if (18) holds, no equilibrium exists where $p > 0$. There is then a unique equilibrium in which the superior always implements his own idea, that is $p = 0$.
(b) If $\rho_H^* > \rho_L^*$, that is if

$$s(1 - \frac{b}{v})b < c \tag{19}$$

then $p(\rho_H^*) = 1$. Moreover, since $\rho \in (0,1)$ only if $V(\rho) = 0$, a^* is then given by

$$(1 - s)a^*b - c = 0$$

Thus, if (19) holds, there exists only one equilibrium with $p^* > 0$, characterized by $\rho^* = \rho_H^*, p^* = 1$ and a^* as above.
Let us now investigate the existence of an equilibrium where $p^* = 0$. If $p^* = 0$, then also $a^* = 0$, as otherwise $\rho = 1$, a contradiction. From (16) and (17), this can only be if $\rho > \rho'$, which is only possible if $\rho' < 1$ or still

$$s\alpha(v - b) < c$$

Thus, for $s\alpha(v - b) < c < s\frac{b}{v}(v - b)$, there exists two equilibria, with the 'silent' equilibrium being pareto-dominated by the 'communication' equilibrium. If $c < s\alpha(v - b)$, the communication equilibrium is the unique equilibrium.
(ii) Secondly, consider $c > (1 - s)b$. From (5), then no equilibrium exists where $p^* = 1$, as then $\rho = 0$ implying $p^* = 0$, a contradiction. Consider therefore a candidate equilibrium where $p^* \in (0,1)$. From (16), then $\rho^* = \rho_L^* \leq \rho_H^*$ or $\rho^* = \rho' \geq \rho_H^*$. Whenever $p^* \in (0,1)$, $\rho^* > \rho_H^*$ cannot be an equilibrium as then $a^* = 0$, implying $\rho = 0$, a contradiction. Since $\rho' = \rho_H^*$ implies $\rho' = \rho_L^*$, it follows that $p^* \in (0,1)$, implies $\rho^* = \rho_L^* \leq \rho_H^*$. It follows that if $\rho_H^* < \rho_L^*$, that is (18) holds, then no equilibrium exist where $p^* \neq 0$. The unique equilibrium is then the silent equilibrium discussed above. If, in contrast, (19) holds, that is if $\rho_L^* < \rho_H^*$, then $a^* = 1$, and as $\rho^* \in (0,1) \Leftrightarrow V(\rho) = 0$, p^* is given by

$$(1 - p^*)b + p^*(1 - s)b = c$$

If $\rho_L^* = \rho_H^*$, then there exists a range of equilibria, including and pareto-dominated by the above equilibrium.
Finally, if and only if $s\alpha(v-b) < c < s\frac{b}{v}(v-b)$, the 'silent equilibrium also exists, but this equilibrium is pareto dominated by the above equilibria.

6.3 Appendix C: Endogenous information and Decision-making by Unanimity

6.3.1 Basic Model:

Proof of proposition 3: Authority will be superior over consensus if and only if

$$2n\int_{-\infty}^{+\infty} uF(u)^{2n-1}dF(u) < (1+\sigma)n\int_{-\infty}^{+\infty} zF(z)^{n-1}dF(z)$$

Using the transformation $t \equiv F(u)$, this is equivalent to

$$2n\int_{0}^{1} F^{-1}(t)t^{2n-1}dF(u) < (1+\sigma)N\int_{0}^{1} F^{-1}(t)t^{n-1}dt$$

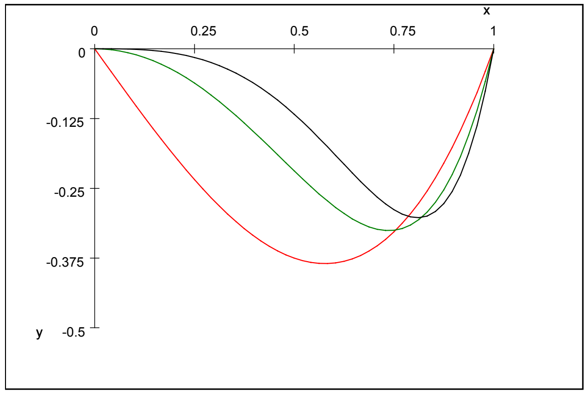
Since the RHS is strictly increasing in σ, is smaller than the LHS for $\sigma = 0$ and goes to infinity as σ goes to infinity, there exists a $\sigma'(n) > 0$ for which the LHS equals the RHS. If and only if $\sigma > \sigma'(n)$, the inequality then holds. We now show that $\sigma'(n) < 1$ and $\sigma'(n)$ is decreasing in n. We have that $\sigma'(n) < 1$ if and only if

$$\int_{0}^{1} F^{-1}(t)t^{n-1}(t^n-1)dt < 0$$

Since $F^{-1}(1/2+z) = -F^{-1}(1/2-z)$ and $F^{-1}(1/2+z) > 0$ for $z \in [0,1/2]$, and since $t^{n-1}(t^n-1) < 1$, a sufficient condition for the latter inequality to hold is that for all $t \in (1/2,1)$ and $n \geq 2$,

$$t^{n-1}(t^n-1) < [1-t]^{n-1}\left[(1-t)^n-1\right]$$

which is indeed the case. The following graph plots $t^{n-1}(t^n-1)$ for $n=2, n=3$ and $n=4$:



We show now that cut-off value σ' above which authority is optimal, is decreasing in n. For $n = n^*$, we have by definition of $\sigma'(n^*)$, that

$$(1+\sigma'(n^*))\int_0^1 F^{-1}(t)t^{n^*-1}\left[\frac{2}{1+\sigma'(n^*)}t^{n^*}-1\right]dt = 0$$

To show that $\sigma'(n)$ is decreasing in n, it is sufficient to show that for $n = n^* + \varepsilon$ with $\varepsilon > 0$ sufficiently small,

$$(1+\sigma'(n^*))\int_0^1 F^{-1}(t)t^{n-1}\left[\frac{2}{1+\sigma'(n^*)}t^{n}-1\right]dt < 0 \tag{20}$$

and thus $\sigma'(n^*+\varepsilon) < \sigma'(n^*)$. We have that

$$\begin{aligned}
&\frac{\partial}{\partial n}\left[(1+\sigma')\int_0^1 F^{-1}(t)t^{n-1}\left[\frac{2}{1+\sigma'}t^{n}-1\right]dt\right] \\
= \;& (1+\sigma')\int_0^1 F^{-1}(t)\left[\frac{2}{(1+\sigma')}(2n-1)t^{2n-2}-(n-1)t^{n-2}\right]dt \\
= \;& (1+\sigma')(n-1)\int_0^1 F^{-1}(t)t^{n-2}\left[\frac{2}{(1+\sigma')}\frac{(2n-1)}{n-1}t^{n}-1\right]dt
\end{aligned}$$

From n^* and the fact that $\frac{(2n-1)}{n-1} > 1$, it follows that for $n = n^*$, the above derivative is negative and hence $\sigma'(n^*+\varepsilon) < \sigma'(n^*)$ for ε sufficiently small

6.3.2 Unanimity

Proof of lemma 5: If $u_L^* < u_R^* - \Delta(c)$, then for b sufficiently large, L will always insist that his idea (or $R's$ idea) is further investigated, as with positive probability $v_x^* > v_R^*$. The same happens if $u_R^* < u_L^* - \Delta(c)$. It follows that at least one idea is fully investigated. Let L's idea be the first to be investigated, then the group knows the value of v_L^* but not the value of v_R^*. Hence, if the group would be willing to adopt $R's$ idea, L will certainly veto this. In contrast, if the group would decide to implement $L's$ idea with value v_L^*, then R will certainly veto this if $v_R^* > v_L^*$. Perhaps surprisingly, R will also put his veto with probability $\rho^* > 0$ when $v_R^* < v_L^*$. Indeed, if R would issue a veto only when $v_R^* > v_L^*$, then $R's$ idea would always be implemented without a further investigation (or a veto of L). Obviously, this cannot be an equilibrium, as R then also would veto $L's$ idea if $v_R^* < v_L^*$. It follows that the unique equilibrium is one in which the group, upon a veto of R, directly adopts $R's$ idea with probability $\lambda > 0$ and R vetoes $L's$ idea with positive probability $\rho > 0$ whenever $v_R^* < v_L^*$, where $\lim_{b\to\infty} \lambda = 0$ and $\lim_{b\to\infty} \rho = 0$.[21] Since in the limit, the best proposal is then always selected, each agent then also proposes his best idea.

Proof of Example 1: $w_{ij} \in \{-2, 0, 2\}$
(a) Authority: If $u_{ij} \in \{-1, 0, 1\}$ and $w_{ij} \in \{-2, 0, 2\}$, with all values equally likely, then the density of $v_{ij} = u_{ij} + w_{ij}$ is given by

$$\begin{aligned} f(3) &= f(2) = f(0) = f(-2) = f(-3) = 1/9 \\ f(1) &= f(-1) = 2/9 \end{aligned}$$

As a result, $f_{au}(.)$, the density of $\max\{u_{L1} + w_{L1}, u_{L2} + w_{L2}\}$ is given by

$$\begin{aligned} f_{au}(3) &= 1 - \left(\frac{8}{9}\right)^2 \\ f_{au}(2) &= 2(\frac{2}{9})(\frac{7}{9}) + (\frac{2}{9})^2 + (\frac{8}{9})^2 - 1 \\ f_{au}(1) &= 2(\frac{4}{9})(\frac{5}{9}) + (\frac{4}{9})^2 - \left[2(\frac{2}{9})(\frac{7}{9}) + (\frac{2}{9})^2\right] \\ f_{au}(0) &= 2(\frac{4}{9})(\frac{5}{9}) + (\frac{5}{9})^2 - \left[2(\frac{4}{9})(\frac{5}{9}) + (\frac{4}{9})^2\right] \\ f_{au}(-1) &= 2(\frac{7}{9})(\frac{2}{9}) + (\frac{7}{9})^2 - \left[2(\frac{4}{9})(\frac{5}{9}) + (\frac{5}{9})^2\right] \\ f_{au}(-2) &= 1 - (\frac{1}{9})^2 - \left[2(\frac{7}{9})(\frac{2}{9}) + (\frac{7}{9})^2\right] \\ f_{au}(-3) &= (\frac{1}{9})^2 \end{aligned}$$

[21] Indeed if $\lim_{b\to\infty} \lambda = 0 > 0$, then necessarily $\lim_{b\to\infty} \rho = 1$, in which case X would never accept that $Y's$ idea is accepted before it is fully investigated, that is $\lambda = 0$, a contradiction. Similarly, if $\lim_{b\to\infty} \rho > 0$, X would never accept that $Y's$ idea is accepted before it is fully investigated, implying $\lim_{b\to\infty} \lambda = 0$. But if $\lambda = 0$, then $\rho = 0$, a contradiction.

from which the expected pay-off under authority equals:

$$E(\max\{u_{L1}+w_{L1},u_{L2}+w_{L2}\}=\frac{28}{27}$$

(b) Consensus: From lemma **??**, for $c>\frac{2}{3}$, the expected pay-off under consensus equals

$$E(\max\{u_{L1},u_{L2},u_{R1},u_{R2}\})=\left[1-(\frac{2}{3})^4\right]-\left[\frac{1}{3}\right]^4=\frac{64}{81}$$

For $c\in\left[\frac{1}{3},\frac{2}{3}\right]$, the expected pay-off equals

$$\frac{64}{81}+\frac{35}{81}*\frac{4}{3}\left[\frac{2}{3}-c\right]$$

It follows that for $c>1/3$, consensus is always dominated by authority.
(c) Unanimity: $f_{un}(.)$, the density of

$$\max\{u_{L1}+w_{L1},u_{L2}+w_{L2},u_{R1}+w_{R1},u_{R2}+w_{R2}\}$$

is given by

$$\begin{aligned}
f_{un}(3) &= 1-\left(\frac{8}{9}\right)^4\\
f_{un}(2) &= 4(\frac{2}{9})(\frac{7}{9})^3+6(\frac{2}{9})^2(\frac{7}{9})^2+4(\frac{2}{9})^3(\frac{7}{9})+(\frac{2}{9})^4+(\frac{8}{9})^4-1\\
f_{un}(1) &= 4(\frac{4}{9})(\frac{5}{9})^3+6(\frac{4}{9})^2(\frac{5}{9})^2+4(\frac{4}{9})^3(\frac{5}{9})+(\frac{4}{9})^4-\left[4(\frac{2}{9})(\frac{7}{9})^3+6(\frac{2}{9})^2(\frac{7}{9})^2+4(\frac{2}{9})^3(\frac{7}{9})+(\frac{2}{9})^4\right]\\
f_{un}(0) &= 4(\frac{4}{9})(\frac{5}{9})^3+6(\frac{4}{9})^2(\frac{5}{9})^2+4(\frac{4}{9})^3(\frac{5}{9})+(\frac{5}{9})^4-\left[4(\frac{4}{9})(\frac{5}{9})^3+6(\frac{4}{9})^2(\frac{5}{9})^2+4(\frac{4}{9})^3(\frac{5}{9})+(\frac{4}{9})^4\right]\\
f_{un}(-1) &= 4(\frac{7}{9})(\frac{2}{9})^3+6(\frac{7}{9})^2(\frac{2}{9})^2+4(\frac{7}{9})^3(\frac{2}{9})+(\frac{7}{9})^4-\left[4(\frac{4}{9})(\frac{5}{9})^3+6(\frac{4}{9})^2(\frac{5}{9})^2+4(\frac{4}{9})^3(\frac{5}{9})+(\frac{5}{9})^4\right]\\
f_{un}(-2) &= 1-(\frac{1}{9})^4-\left[4(\frac{7}{9})(\frac{2}{9})^3+6(\frac{7}{9})^2(\frac{2}{9})^2+4(\frac{7}{9})^3(\frac{2}{9})+(\frac{7}{9})^4\right]\\
f_{un}(-3) &= (\frac{1}{9})^4
\end{aligned}$$

from which

$$E(\max\{u_{L1}+w_{L1},u_{L2}+w_{L2},u_{R1}+w_{R1},u_{R2}+w_{R2}\})=\frac{4096}{2187}$$

Moreover,

$$\begin{aligned}
& \Pr\left(\max\left\{u_{L1}+w_{L1},u_{L2}+w_{L2}\right\} \geq \max\left\{u_{R1}+w_{R1},u_{R2}+w_{R2}\right\}\right) \\
= & \frac{1}{2}+\frac{1}{2}\Pr\left(\max\left\{u_{L1}+w_{L1},u_{L2}+w_{L2}\right\} = \max\left\{u_{R1}+w_{R1},u_{R2}+w_{R2}\right\}\right) \\
= & \frac{1}{2}+\frac{1}{2}\sum_{x=-3}^{3} f_{au}(x)^2 \\
= & \frac{1}{2}+\frac{1}{2} * \frac{1325}{6561} < 0.601
\end{aligned}$$

An underbound on the expected pay-off under unanimity is thus given by

$$\frac{4096}{2187} - 1.601c$$

It follows that a sufficient condition for unanimity to be strictly preferred over authority is that

$$\frac{28}{27} < \frac{4096}{2187} - 1.601c$$

or still

$$c < 0.52$$

Proof of Example 2: $w_i \in \{-1, 0, 1\}$:

(a) Decision-making under consensus: It is easy to verify that for

$$1/18 < c < 1/3$$

the group will launch an investigation if and only if $u_L^* = u_R^*$. For $c > 1/3$, the group will never investigate, whereas, for $c < 1/18$, the group will investigate with positive probability even if $u_L^* = u_{Lj}^* + 1$. By the same argument as for $w_i \in \{-2, 0, 2\}$, one can show that for $c > 1/18$, each player then still proposes the project which looks best at first sight, not the one which is best overall.

Let us now calculate the pay-off of consensus whenever $1/18 < c < 1/3$. The expected overall value of the best-looking project is then given by

$$\left[1-(\frac{2}{3})^4\right] - \left[\frac{1}{3}\right]^4 = \frac{64}{81}$$

However, whenever there is tie, the group investigates one of the projects and accepts (rejects) it whenever $w_i = 1$ ($w_i = -1$). Whenever $w_i = 0$ in the latter case, the group also investigates w_j and accepts (rejects) the latter whenever $w_j = 1$ ($w_j = -1$). Given a cost of c per investigation, the net benefit of such an investigation (potentially two investigations) is given by

$$1/3 - c + 1/3\,[1/3 - c] = 4/3\,[1/3 - c]$$

Since a tie occurs with a probability of 1/3, the expected pay-off under consensus for $1/18 < c < 1/3$ is given by

$$\frac{64}{81} + 1/3 * 4/3\,[1/3 - c] = \frac{76}{81} - \frac{4}{9}c$$

For $c > 1/3$, the expected pay-off under consensus equals $\frac{64}{81}$

(b) Authority: Under coordination by authority, the superior implements his best idea. The distribution of the overall value of a project $w_i + u_i$ is given by

$$f(2) = \frac{1}{9}, f(1) = \frac{2}{9}, f(0) = \frac{3}{9}, f(-1) = \frac{2}{9}, f(-2) = \frac{1}{9}$$

As a result, the density $f_{au}(.)$ of $\max\{u_{L1} + w_{L1}, u_{L2} + w_{L2}\}$ is given by

$$\begin{aligned}
f_{au}(2) &= 1 - (\frac{8}{9})^2 \\
f_{au}(1) &= 2(\frac{3}{9})(\frac{6}{9}) + (\frac{3}{9})^2 + (\frac{8}{9})^2 - 1 \\
f_{au}(0) &= 2(\frac{3}{9})(\frac{6}{9}) + (\frac{6}{9})^2 - \left[2(\frac{3}{9})(\frac{6}{9}) + (\frac{3}{9})^2\right] \\
f_{au}(-1) &= 1 - (\frac{1}{9})^2 - \left[2(\frac{3}{9})(\frac{6}{9}) + (\frac{6}{9})^2\right] \\
f_{au}(-2) &= (\frac{1}{9})^2
\end{aligned}$$

from which authority yields an expected pay-off equal to

$$E(\max\{u_{L1} + w_{L1}, u_{L2} + w_{L2}\}) = \frac{52}{81}$$

It follows that authority is always dominated by consensus

(c) Unanimity: Assume now, in contrast, that we have a committee which decides by unanimity. Then, each agent will select his best overall project and insist that it is fully investigated unless it is accepted. This will imply that the best idea is selected, but result in investigation costs which are bounded above

by

$$[1 + \Pr\left(\max\left\{u_{L1} + w_{L1}, u_{L2} + w_{L2}\right\} \geq \max\left\{u_{R1} + w_{R1}, u_{R2} + w_{R2}\right\}\right)]\, c,$$

We have that $f_{un}(.),$, the density of

$$\max\left\{u_{L1} + w_{L1}, u_{L2} + w_{L2}, u_{R1} + w_{R1}, u_{R2} + w_{R2}\right\}$$

is given by,

$$\begin{aligned}
f_{un}(2) &= 1 - (\frac{8}{9})^4 \\
f_{un}(1) &= 4(\frac{3}{9})(\frac{6}{9})^3 + 6(\frac{3}{9})^2(\frac{6}{9})^2 + 4(\frac{3}{9})^3(\frac{6}{9}) + (\frac{3}{9})^4 + (\frac{8}{9})^4 - 1 \\
f_{un}(0) &= 4(\frac{3}{9})(\frac{6}{9})^3 + 6(\frac{3}{9})^2(\frac{6}{9})^2 + 4(\frac{3}{9})^3(\frac{6}{9}) + (\frac{6}{9})^4 \\
&\quad - \left[4(\frac{3}{9})(\frac{6}{9})^3 + 6(\frac{3}{9})^2(\frac{6}{9})^2 + 4(\frac{3}{9})^3(\frac{6}{9}) + (\frac{3}{9})^4\right] \\
f_{un}(-1) &= 1 - (\frac{1}{9})^4 - \left[4(\frac{3}{9})(\frac{6}{9})^3 + 6(\frac{3}{9})^2(\frac{6}{9})^2 + 4(\frac{3}{9})^3(\frac{6}{9}) + (\frac{6}{9})^4\right] \\
f_{un}(-2) &= (\frac{1}{9})^4
\end{aligned}$$

It follows that the expected value of the solution selected under unanimity equals

$$E(\max\left\{u_{L1} + w_{L1}, u_{L2} + w_{L2}, u_{R1} + w_{R1}, u_{R2} + w_{R2}\right\} = \frac{7648}{6561}$$

We further have that

$$\begin{aligned}
& \Pr\left(\max\left\{u_{L1} + w_{L1}, u_{L2} + w_{L2}\right\} \geq \max\left\{u_{R1} + w_{R1}, u_{R2} + w_{R2}\right\}\right) \\
= & \frac{1}{2} + \frac{1}{2} \sum_{x=-2}^{2} f_{au}(x)^2 \\
= & \frac{1}{2} + \frac{1}{2} * \frac{1867}{6561} < 0.643
\end{aligned}$$

It follows that an underbound on the expected pay-off under unanimity is given by

$$\frac{7648}{6561} - 1.643c,$$

and a sufficient condition for unanimity to be preferred over both consensus and authority is given by

$$\frac{76}{81} - \frac{4}{9}c < \frac{7648}{6561} - 1.643c$$

or still

$$0.056 \cong \frac{1}{18} < c < 0.189$$

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