



Paper to be presented at the DRUID Academy conference in Rebild, Aalborg, Denmark on January

21-23, 2015

## **Strategic information sharing in decision-making hierarchies**

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### **Abstract**

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### **Research Gap and Method**

The purpose of this paper is to build a framework to study how information is passed on and aggregated in organizations. To that end we have developed a model which traces how information originally distributed among members of the organization with private information and potentially diverging interests, is being revealed to a final decision-maker. The approach details a two-layered hierarchical group, tasked with selecting a candidate, in which information is located at the lower level and decision rights either are given to the supervisor (centralized decision making), the subordinates (decentralized), or a combination of both (intermediate). The decision structures mirror important aggregation rules often found in organizations: consensus/majority rule (decentralized), hierarchical decisions

(centralized), and intermediate rules such as the possibility of a veto by the supervisor. We model the strategic information exchange from the perspective of (boundedly) rational subordinates who have to decide whether to share their private information.

## Results

In particular we examine how the decision climate, i.e. agents' beliefs about their alignment with others, and the decision structure interact to shape the incentives of agents. First, regardless of the decision structure employed, we find a robust effect of decision climate such that a perception of alignment of interests ensures information sharing will occur, whereas a decision climate that suggests mis-alignment of interests will prevent information sharing. Further, increasing beliefs in an aligned decision climate will encourage information sharing within all decision structures. Second, we find that switching the decision structure (a variable that is within the control of managers) from decentralization to centralization increases incentives to share information in misaligned decision climates but decreases incentives to share information in aligned decision climates.

## State-of-the-art and theoretical arguments

This approach, we believe, is distinct from prior work that has focused on the aggregation of information or opinion (i.e. voting) among non-strategic agents, or the aggregation of opinion among strategic agents. Our approach may be a better representation of how strategic decisions in corporations are made; unitary actor or convergent incentive conditions are rare, aggregation processes rarely rely exclusively on voting, and stable organizational properties such as culture, norms and identity shape the decision climate.

More generally, our approach aims to strike a balance between allowing for strategic interaction but not assuming implausible levels of iterative strategic reasoning. Our results assume symmetric knowledge/belief of certain parameters, but nothing in terms of common knowledge. However, whether even this degree of forward looking strategic thinking is a reasonable assumption about behavior remains to be determined.

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# Strategic information sharing in decision-making hierarchies

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This version: July 2014

Preliminary. Please do not cite or circulate

**Abstract:** TO COME

**JEL classifications:** TO COME

**Keywords:** TO COME

## **Introduction**

A fundamental challenge in strategy research is to explain sustained performance differences across organizations. Over the past decades, theories have emerged that attribute this variation to relative market positions of rivals (Porter, 1991), the uniqueness of resources or capabilities available to or within different organizations (Barney, 1991; Grant, 1996; Kogut and Zander, 1992) as well as processes that convert initial random differences into stable differences in performance (Denrell, Fang, and Liu, 2014). Yet, it is possible to argue that an important category of explanations for sustained performance differences between organizations—namely variations in their strategic decision making processes – remains largely underexplored (Csaszar and Eggers, 2013; Gavetti, Levinthal, and Ocasio, 2007).

Anecdotally, many examples are available of performance differences across firms that can plausibly be traceable to how they (re) structured decision making processes. Prominent instances include: Samsung's history of moving from a highly centralized to a decentralized decision-making structure in the late 1990s, facilitating peer-to-peer co-ordination of specialists working on new product development, and paving the way for profit increases from average industry figures to over 9\$US billion in 2004 (Chaudhuri, 2005); BP's re-organization to facilitate bottom-up knowledge flows in the organization between 1990 and 1998, credited with helping the corporation rise to 2nd place in the Fortune 500 rankings (Sisodia, 2004); and Caterpillar's decentralization of decision-making rights to hold business units accountable for product development, earning the organization best management awards by Forbes magazine (Neilson, 2005). Recent empirical studies focusing on the impact of participatory decision-making (Carmeli, Sheaffer, and Halevi, 2009), empowerment of employees in the decision-making process (O'Regan, Sims, and Ghobadian, 2005), and IT-support for decision-making (Andersen and Segars, 2001) on firm performance all suggest

that variance in the nature of the decision-making process may account for variation in firm performance, all else being equal.

Despite the admitted importance of strategic decision making in organizations, and anecdotal and systematic evidence corroborating this, we maintain that important aspects of the process continue to be under-theorized. In particular, our claim is that we are in need of a theory that explains the process of how relevant information, an antecedent to ultimate decisions at the organizational level, is being aggregated through the strategic interactions between individuals at various levels of a hierarchy, who have private information and vested interests. Vested interests among agents (March and Simon, 1958; Simon, 1948)– a central assumption in classic (information) economics (Holmstrom, 1979; Jensen and Meckling, 1976; Spence, 1973; Stiglitz, 1975) or game theory (Kocher and Sutter, 2005; Mueller, 2004) – do not feature in established theories describing the process of group decision-making, be this the literature on information aggregation in teams (Laughlin, 2011), the secretary problem (Kahan, Rapoport, and Jones, 1967), the judge-advisor problem (Snizek and Buckley, 1989), or hidden profile tasks (Stasser and Titus, 1985), and *vice versa*. Economic theories studying preference aggregation (Arrow, 1963; Dyer and Sarin, 1979; Harsanyi, 1955; Hylland and Zeckhauser, 1979) do not examine the process of directly disclosing private information (other than through the acts of voting or vetoing).

In this paper we seek to close this gap by focusing on the process of information aggregation in hierarchically structured groups with conflicting incentives. Arguing from the premise that more decision-relevant information leads to better decisions, all else being equal, we focus on how the strategic interaction process between agents with private information and vested interests leads to the revelation of relevant information.

In an attempt to formalize such a depiction of realistic information aggregation within organizations, we model a simple two-layered hierarchical structure, consisting of two subordinates and one supervisor, whose task it is to choose a solution to an organizational

problem from a set of alternatives. The agents in our model hold private information on different solutions, have vested interests, and they do not know ex-ante what the interests of the other agents are. However, they hold a belief about whether their interests are aligned with those of other agents or not.

One specific instance of this general challenge which we consider in more detail is a candidate selection task. A committee operating within the above two-layered structure is tasked with recruiting one out of two senior candidates for a management position. Members of the committee have only partial information on candidates and do not know what the interests of the other committee members are, though they have some beliefs about these, which we refer to as the *decision climate*- their beliefs about the probability of their interest being aligned. Additionally, the *decision structure* of this simple hierarchy can vary: the supervisor presiding over the committee may have final decision-making power (i.e. “centralization”), just endorse the consensus among subordinates (“decentralization”), or decide to intervene in those instances in which the committee is not able to reach an agreement (a.k.a “conditional decentralization”).

Within this framework of assumptions, we develop a baseline rational choice model that can be used to describe agents’ subjective expected utility of sharing privately held information about the candidates, depending on (1) decision climate and (2) decision structure. Critically, we derive our results without assuming implausible levels of iterative reasoning about their strategic interactions for our agents.

By predicting the impact that organizational structure has on the decision of agents to strategically reveal information that is relevant to the organization eventually, our model serves three purposes. First, it allows us to guide experimental investigations into the strategic information transfer between agents within an organization to corroborate out theory. Second, it may help scholars and practitioners alike to understand why some organizations make better-informed decisions than others. As such, in a third step, it helps managers to think

about how to structure group decision-making processes in ways that maximize corporate performance.

### **Related prior literature**

It is a truism that decisions of strategic importance in organizations are taken in multi-agent structures more often than not (Tindale, Kameda, and Hinsz, 2003). Further, decisions in organizations often require information that is a) distributed across individuals with b) possibly diverging interests, c) who have authority relationships between them (March and Simon, 1958). Our theorizing builds on prior approaches that have focused on one or more of these features. It is useful to categorize this prior work into two broad categories – excluding or including strategic behavior and incentive conflicts between agents.

In the first category lie multiple streams of experimental work that have focused on *information aggregation* within groups of agents with aligned incentives. The hidden profile experimental paradigm (Stasser and Titus, 1985, 1987, 2003) exemplifies a situation in which agents have partial and biased information but could potentially reach an unbiased decision by sharing information, and have the incentives to do so. A multitude of experiments, however, often show that groups fail to reach an unbiased decision. A similar model is the judge-advisor system. One person in the role of a judge has to answer questions and takes cues from his advisors (Sniezek and Buckley, 1989, 1995) prior to filing a decision. Whereas this setup includes potential for conflicting information, the incentives of advisors and judge are aligned to make the “right” judgement. In the hierarchical decision making model proposed by Humphrey *et al.* (2002), the decision maker receives noisy information from subordinates. The noise in the information depends on the skill of the subordinates, and the focus is on how the decision maker learns to assign correct weights on subordinates through trial and error.

Recent organizational models of *opinion aggregation*, building on Sah and Stiglitz (1985) have examined the problem of screening alternatives by agents arranged in various configurations (Christensen and Knudsen, 2008; Csaszar, 2012; Csaszar and Eggers, 2013). These models offer interesting insights into the creation of effective decision structures that match the environmental constraints on the organization, through the appropriate configuration of agents who are sequentially and parallel screening alternatives, but who do not engage in any strategic interaction. Csazar and Eggers (2013) model the aggregation of diverging opinions from screeners all of whom see the same alternatives, and the effectiveness of various aggregation rules as a function of the properties of alternatives (also see Hastie and Kameda, 2005). Neither the information aggregation nor the opinion aggregation models described above entail strategic interaction between agents.

The second category of work on decision making addresses the weighting and *aggregating of preferences*. An important branch, social choice theory, seeks to derive normative models for preference aggregation - rules that are as close to consistent as possible with individual preferences and beliefs (Arrow, 1963; Dyer and Sarin, 1979; Harsanyi, 1955; Hylland and Zeckhauser, 1979; Keeney and Kirkwood, 1975). The key mechanism studied in this literature for aggregating conflicting interests (or the diverging opinions of individuals with possibly conflicting interests) is voting. Put differently, all agents in the decision structures see the same alternatives but may have different preferences over them. The conditions under which different voting based decision rules lead to welfare maximizing choices is the focus of analysis. Agents are assumed to be capable of voting strategically.

Our interests are complementary but distinct from those of these literatures. Our focus is on understanding how privately held information, possessed by agents with possibly diverging interests, can be surfaced in a manner that is useful to an organization in order to make

informed decisions. It is the information we wish to aggregate, not opinions or preferences, and we wish to study this in the context of strategic agents within an organizational hierarchy.

## **Model**

Our model formalizes the strategic sharing of information in a hierarchical organization, in the context of a decision about selection between alternatives. To keep the model tractable, we propose a simple two-layered hierarchical structure, consisting of two subordinates and one supervisor. We are interested in studying the conditions under which the private information about alternatives is revealed by those who hold it (i.e. the subordinates), as a function of two variables: a) the decision structure – how centralized or decentralized it is and b) the decision climate- to what extent the interests of the organizations members are believed (by the members) to be aligned with each other.

## **Task Environment**

The setting we consider is a candidate selection task. A miniature organization operating with a two-layered hierarchical structure is in charge of recruiting one out of two candidates. It is intuitive to think of these as managerial candidates for a senior position, but it is just as useful to see these as two candidates for resource allocation (e.g. two strategic options).

The model embodies several key features of the phenomenon we believe to be critical. There is a hierarchical structure to the organization, with a single layer 1 agent capable of (but not necessarily) over-ruling the decisions of the two layer 2 agents. Thus we have a simple authority hierarchy of span = 2. For ease of exposition, we refer to the layer 1 agent as “Supervisor” and the 2 layer 2 agents as “subordinates”.

Ex-ante, no agent has information about both candidates. The two sub-ordinates have private information about one candidate each. They do not however know if the candidate they have information about is their preferred one. The supervisor does not have any information about either candidate to begin with.

### *Decision climate*

The preferences of agents over candidate may or may not be aligned, and they do not know if the interests of others are aligned with their own or not, though they may have beliefs about this. These beliefs correspond to the “*decision climate*”- the belief that the interests of other members of the organization correspond (or not) to one’s own interests. We model agents’ belief about the decision climate via the probability  $a$ , which captures the subjective beliefs of agents about the likelihood that their preferences are aligned with those of other agents<sup>1</sup>.

When  $a > \frac{1}{2}$ , then we say the decision climate is characterized by *alignment*, with stronger beliefs about alignment as  $a$  approaches 1. When  $a < \frac{1}{2}$ , we say the decision climate is characterized by *misalignment*, with the strength of belief in misalignment increasing as  $a$  approaches 0. The beliefs about the decision climate are assumed to be symmetric in the organization (but need not be common knowledge).

### *Decision structure*

We analyze three canonical types of “*decision structure*” of the organization:

1. Centralization: the supervisor makes the final decision, based on the information communicated by the subordinates to her.
2. Decentralization: In a completely decentralized decision-making process, the supervisor has transferred her decision-making power, and she can only observe the behavior and decisions of the subordinates. In this setting, some form of consensus must arise between the subordinates and they must reach an agreement among themselves through communicating what they know about the candidates. Failing to do so will result in no candidate being selected.

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<sup>1</sup> All parameters are symmetric, i.e. they refer to all agents unless otherwise stated.

3. Conditional Decentralization: This describes a situation in which the supervisor has delegated decision making to the subordinates, and subordinates are tasked with finding an agreement on their own, but failing to do so results in the supervisor taking the final decision. The supervisor is able to observe the interaction and communication among the subordinates. In this juxtaposition of the decentralized and centralized scenarios, supervisors effectively act as they would in the centralized situation if subordinates do not agree, else the case is the same as decentralization. The probability of switching between these regimes is of course endogenous to the model.<sup>2</sup>

The decision structure in use is also assumed to be widely known in the organization (but need not be common knowledge). To reiterate, ex ante the subordinates have information on only one of the candidates and do not know what the interests of the other agents are (though they may have some subjective beliefs about these). Our interest is to understand how the likelihood of sharing of information by subordinates depends on the structure of decision making and the organizational climate in which decision making is taking place.

### **Agent goals, beliefs, and behaviors**

Each agent's goal is to have their preferred candidate selected. To achieve this goal, they can disclose information about the candidates they know, or withhold it. Eventually they must choose independently one of the candidates based on the information that has been revealed (or not). If the choices of the subordinates coincide, there is consensus. Under decentralization or conditional decentralization, this suffices to complete the decision. If the subordinates do

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<sup>2</sup> Other decision structures are imaginable; one that we have also analyzed involves a veto right retained by the supervisor

not reach consensus, then under decentralization, there is a deadlock. Under the other decision structures, the decision passes into the hands of the supervisor.

Whether to reveal information they know about a candidate may be unclear to agents, however, because they do not know ex-ante which candidate best matches their preferences. They also are uncertain as to the preferences of the other agents, and whether they are aligned with their own. Importantly, revealing information enables other agents to make a fully informed decision. Without such information, they will randomly choose between alternatives.

To appreciate the decision-making tradeoff, consider two extreme cases: when the decision climate indicates conflict of interests, informing other agents fully is undesirable for any focal agent; in case of known alignment of interests, on the contrary, withholding relevant information will lower the probability of two members agreeing on the same candidate to chance levels. Agents thus face trade-offs when exchanging information, and the optimal choice about revealing or not revealing information will depend on their beliefs about other agents' preferences and likely actions within a given decision structure. To study this dependence in a rigorous manner, our model sets up a rational forward looking subordinates choice of whether to share his private information with the other sub-ordinate. Finally, we also assume all agents face strategic uncertainty and are limitedly rational, resulting in their making erroneous choices (i.e. selecting their less preferred choice) with a probability  $1 - q$ , where  $q > \frac{1}{2}$ . As  $q$  increases, their choices align closely to their preferences, and at its lower bound,  $q = \frac{1}{2}$ , choices are random.<sup>3</sup>

*Insert Table 1 about here*

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<sup>3</sup> The parameter captures the concept of a quantal response function, which allows for errors in choice (McKelvey and Palfrey, 1995).

The decision making process consists of three stages.

*First*, the two subordinates decide simultaneously whether to reveal information.<sup>4</sup> There are thus four possible scenarios in terms of information revelation in stage one: 1) both, 2) only focal 3) only other or 4) neither subordinate reveals private information.

*Second*, unless decision-making resides only with the supervisor, as is the case in the centralized decision-making scenario, subordinates can vote simultaneously for a candidate. Depending on the information revealed, agents make an informed choice with probability  $q$ . In the centralized case, the supervisor chooses, and makes an informed choice with probability  $q$ .

*Third*, a candidate is selected (or a deadlock arises) contingent on the information revealed, decision climate and decision structure. Conditional on the information revelation, decision climate and decision structure, with some probability a focal sub-ordinates preferred or non-preferred candidate is selected. Let the payoff for a candidate being selected be denoted by  $G_i$ , where  $i = H$  or  $L$  (the Preferred or Non-Preferred candidate). For simplicity we normalize the payoff from deadlock to zero, so that it drops out of consideration and set payoff from least preferred candidate to 1, with that from the most preferred candidate then being equal to  $m$  ( $m > 1$ ). Looking forward to this third stage process, agents in stage one may choose accordingly whether to reveal information or not. Thus, we formulate a rational choice model that describes the expected utility of sharing privately held information in stage one, based on foresight about the possible outcomes in stage three.

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<sup>4</sup> Simultaneous information exchange on alternative candidates corresponds to a real world setting in which managers submit dossiers containing relevant information to organizers prior to the committee meeting. Simultaneity also prevails de-facto in those settings in which the actual information exchange may be sequential, but the information is so complex that agents are unable to fully process it during the exchange.

As an example, consider the case of decentralized decision-making. For decision climate  $a$ , the probabilities of having the preferred,  $P_{UU}^H$ , (and less preferred,  $P_{UU}^L$ ) candidate for the focal agent selected conditional on both subordinates revealing information (subscripted UU) can be described as:

$$P_{UU}^H = aq^2 + (1 - a)(q(1 - q)), \quad P_{UU}^L = a(1 - q)^2 + (1 - a)(q(1 - q)) \quad (1)$$

If only the second agent reveals information, then only the first agent can make an informed decision, while the second agent chooses randomly, so that the probabilities of having the most and least preferred candidates for the focal agent selected are:

$$P_{NU}^H = a\left(\frac{1}{2}q\right) + (1 - a)\left(\frac{1}{2}q\right) = \frac{1}{2}q, \quad P_{NU}^L = \frac{1}{2}(1 - q) \quad (2)$$

If only the first agent reveals information, then only the second agent can make an informed decision, while the first agent chooses randomly, so that the probabilities of having the most and least preferred candidates for the focal agent selected are:

$$P_{UN}^H = a\left(\frac{1}{2}q\right) + (1 - a)\left(\frac{1}{2}(1 - q)\right), \quad P_{UN}^L = a\left(\frac{1}{2}(1 - q)\right) + (1 - a)\left(\frac{1}{2} * q\right) \quad (3)$$

Finally if neither reveal information, then the probabilities of having the most and least preferred candidates selected are down to chance:

$$P_{NN}^H = \frac{1}{4}, \quad P_{NN}^L = \frac{1}{4} \quad (4)$$

Table 2 provides a summary of the probabilities of selection for the most and least preferred candidates for the focal subordinate across all four information revelation scenarios, for all decision structures.

*Insert Table 2 about here*

Each subordinate must compare the expected utility from across the scenarios in which he shares his private information about a candidate (and the other does or does not) with the expected utility from the scenarios in which he does not share his private information (and the other may or may not). This utility, of course will depend also on the probability of information sharing by the other subordinate, in order to weight the possibility of the different scenarios above arising given one's own decision to reveal or not reveal information.

In order to be able to solve the model without imposing unrealistic common knowledge requirements across the sub-ordinates, we take two less restrictive approaches.

***Approach I: Probability of information revelation by other subordinate as an exogenous belief***

Let the parameter  $c \in (0,1)$  describe the probability that each sub-ordinate ascribes to the other sub-ordinate choosing to reveal information. Then the expected utility of revealing information,  $E(U)$ , and the expected utility of withholding relevant information,  $E(N)$  are respectively:

$$E(U) = c[P_{UU}^H G_H + P_{UU}^L G_L] + (1 - c)[P_{UN}^H G_H + P_{UN}^L G_L] \quad (5)$$

$$E(N) = c[P_{NU}^H G_H + P_{NU}^L G_L] + (1 - c)[P_{NN}^H G_H + P_{NN}^L G_L] \quad (6)$$

A rational agent should reveal relevant information to other agents if the difference of the expected utility of revealing and not revealing relevant information is positive. Note that the structure of the equations (1) and (2) is identical in all decision-making structures. Only the probabilities for selecting a candidate vary, as shown in Table 2.

*Insert Table 3 and 4 about here*

## Results

### The impact of decision climate on information sharing

The effect of the subjective probability that the other subordinate reveals relevant information ( $c$ ) is twofold. While agents undoubtedly benefit from being informed, the effect on the decision to reveal or withhold relevant information is more complex. If the subordinates believe that interests are aligned ( $a > 0.5$ ), a higher  $c$  results in a higher utility of sharing relevant information. This is because expected revelation by other subordinate increases the probability that incentive-aligned agents will be able to make informed decisions; even in the case of no willingness to reveal information by the other agent ( $c=0$ ), the value of revealing information is still positive for conditional centralized and decentralized settings as long as  $a > 0.5$ . On the contrary, the perception of conflicting incentives ( $a < 0.5$ ) leads to a negative marginal effect of  $c$  on the value of revealing information. If subordinates are likely to have diverging interests, revealing information gives the other subordinate (or the supervisor) a clear advantage by enabling a fully informed but differing selection.

Our first set of results on the impact of decision climate on information sharing is captured in these propositions (proofs in Appendix):

**P1a:** A decision climate that suggests alignment of interests (i.e.  $a > 0.5$ ) ensures information sharing within all decision structures; a decision climate that suggests mis-alignment of interests (i.e.  $a < 0.5$ ) prevents information sharing within all decision structures

**P1b:** Increasing beliefs in an aligned decision climate (i.e. increasing  $a$ ) always encourages information sharing within all decision structures

The critical point to note here that  $a = 0.5$  constitutes a sharp separating point in the decision climate; even a small change in belief that interests may be not aligned is sufficient to curtail information sharing. Conversely even a hint of doubt that interests are aligned, is sufficient to

stimulate information sharing. Thus decision climate need not be strong to encourage information sharing, it should merely point towards alignment. Further, even in a misaligned decision climate, the incentives to shares information increase as the perception of alignment increases.

The intuition for these results is as follows: the more likely it is that the other agents will prefer the same candidate as myself, the more beneficial it will be to exchange relevant information. Being informed, aligned committee members can make decisions with high levels of certainty. Even if other agents do not reciprocate by sharing information, but have aligned interests, sharing will benefit a focal committee member by increasing the chance of her preferred candidate being selected. Thus whether the final choice depends on the actions of the other subordinate (i.e. in decentralization), the supervisor (centralization), or both (conditional decentralization), sharing information will always increase the chances of my preferred candidate being selected, as long as alignment can be presumed.

#### Comparing Decentralized and Centralized decision structures

Our analysis shows that the impact of increasing centralization is contingent on the decision climate, as follows:

**P2a:** Moving the decision structure from decentralization to centralization increases incentives to share information in misaligned decision climates ( $a < 0.5$ ) but decreases incentives to share information in aligned decision climates ( $a > 0.5$ ).

Thus in an organization with a misaligned decision climate, a switch to a centralized decision structure from a decentralized decision structure can improve information sharing. Conversely, in an organization with an aligned decision climate, a switch to a centralized decision structure from a decentralized structure can reduce information sharing. This leads

naturally to an analysis of the interaction effects between decision structure and decision climate.

**P2b:** As the strength of the belief in alignment increases, the incentive to share information increases more strongly for *decentralized* than *centralized* decision structures.

The two parts of proposition 2 indicate that *decentralization of decision structure and increased beliefs in alignment are complements*. Each increases the marginal effect of the other.

The intuition for these results can be described as follows: in the case of decentralization, the marginal effect of  $a$  on  $E(U)$  is stronger than in case of centralization; revealing information not only increases the likelihood of selecting the preferred candidate it also decreases the likelihood of not selecting any candidate at all. In centralization, on the other hand, the marginal positive effect of revealing relevant information is smaller, because a supervisor can only make an informed decision if both agents reveal relevant information. In centralized decision-making exchanging information has an effect only if both subordinates share. This reduces the marginal impact of any decision to reveal or withhold relevant information. When revealing information in a decentralized setting, it will always improve the accuracy of decision-making of the second subordinate.

### Conditional Decentralization

The case of conditional decentralization is a hybrid of centralization and decentralization. Our analysis shows that it generates stronger incentives to share information than either centralization or decentralization when alignment is high but the likelihood of the other subordinate sharing information is low (see Figure 4a and 4b).

**P3a:** Conditional decentralization produces greater willingness to share information than centralization when  $c < \frac{1}{(1+2a)}$  and  $a > \frac{1}{2}$  and

**P3b:** Conditional decentralization produces greater willingness to share information than decentralization when if  $c < \frac{3-m}{-1+4a+m}$  and  $a > \frac{1}{2}$

The intuition is as follows: when expected alignment is high but the other subordinate is not expected to reveal information, then conditional centralization ensures that the deadlock in decentralization is likely to be broken in one's own favor. This gives it an edge over decentralization. Relative to centralization, in which situation the supervisor may have to choose randomly when the other subordinate does not reveal information, conditional decentralization allows the additional possibility of a consensus to emerge when the other subordinate decides.

*Insert Figures 1 and 2 here*

As can also be seen by the form of P3b, the conditions under which conditional decentralization dominates decentralization depends also on the magnitude of the difference in attractiveness of the candidates; as  $m$  increases the stipulated inequality is easier to satisfy, so that we should also expect that for any value of  $c$ , increasing  $m$  improves the advantage of conditional decentralization over decentralization in terms of encouraging information sharing in high alignment decision climates.

***Approach II: Information sharing as a Nash equilibrium in dominant strategies***

For information revelation by both agents to be a Nash equilibrium in dominant strategies, the conditions to be jointly met are:

$$N^U = [P_{UU}^H G_H + P_{UU}^L G_L] - [P_{NU}^H G_H + P_{NU}^L G_L] > 0 \quad (7)$$

$$N^N = [P_{UN}^H G_H + P_{UN}^L G_L] - [P_{NN}^H G_H + P_{NN}^L G_L] > 0 \quad (8)$$

For information sharing to be a Nash equilibrium in dominant strategies, the possible action of the other subordinate is not relevant. It is thus not necessary to model the probability of information revelation by other subordinate. The strength of the inequalities (7) and (8) suggest a measure equivalent to incentives for information sharing in Approach 1. In additional analysis (not reported here), we find that the qualitative pattern of results appears similar in this approach to that of the previous one.

## **Discussion & Conclusion**

Our approach in this paper has been to build a framework to study how information is aggregated in organizations characterized by situations of divergent interests, distributed information and an authority hierarchy. In particular we have examined how two variables, the decision climate and the decision structure interact to shape the incentives of individuals who choose strategically to share their privately held information about alternatives that the organization must choose between. This approach, we believe, is distinct from though complementary to prior work that has focused on the aggregation of information or opinion (i.e. voting) among non-strategic agents, or the aggregation of opinion among strategic agents. Our approach may be a better representation of how strategic decisions in corporations are made; unitary actor or convergent incentive conditions are rare, aggregation processes rarely rely exclusively on voting, and stable organizational properties such as culture, norms and identity shape the decision climate.

Our results point first of all to the importance of the decision climate; what people think about their alignment (or lack of it) with others in the organization is a crucial variable in explaining information aggregation outcomes. Regardless of the decision structure employed, we find a robust effect of decision climate such that a perception of alignment of interests ensures

information sharing will occur, whereas a decision climate that suggests mis-alignment of interests will prevent information sharing. Further, increasing beliefs in an aligned decision climate will encourage information sharing within all decision structures.

While these results point to the importance of decision climate, it is also the case that this is not a variable that is within managerial control (at least in the short run). Culture, trust, group identity are the results of social processes that unfold over long periods of time and in ways whose outcomes cannot be perfectly forecast. This gives our second set of results their importance.

We find that switching the decision structure (a variable that *is* within the control of managers) from decentralization to centralization increases incentives to share information in misaligned decision climates but decreases incentives to share information in aligned decision climates. This is a normatively actionable implication of our model. Further, exogenous increases in alignment perceptions, we find have different effect in centralized and decentralized decision structures. If, over a series of repeated decisions, the individuals in the organizations are convinced that their interest are in fact aligned, the incentives to share information in future decisions will increase faster in *decentralized* than *centralized* decision structures. If the alignment of interests in fact is high, the decision structure should then stay decentralized. In contrast, if the perceptions of alignment in a centralized structure increase over time in the same way, a switch to a decentralized decision structure is value creating. More generally, our results point to gradual, largely exogenous changes in decision climate as a key trigger for switching decision structures (also see Gulati and Puranam, 2009; Nickerson and Zenger, 2002).

Conditional decentralization is a hybrid that combines the right to reach a decentralized consensus with the fallback option of centralized decision making when consensus fails. It captures the essence of authoritative dispute resolution in organizations, and indeed this is one of the central roles of authority. Our analysis showed that conditional decentralization can outperform both centralized and decentralized decisions structures when perceptions of alignment exist but individuals are still pessimistic about the likelihood that others will be willing to share information. In a world where individuals can reason with perfect knowledge about each other, such a condition seems unlikely to arise; but in a world of bounded rationality it very well may, and it is in such conditions that conditional decentralization may be advantageous over either centralized or decentralized decisions structures, in terms of information aggregation.

More generally, our approach aims to strike a balance between allowing for strategic interaction but not assuming implausible levels of iterative strategic reasoning. Our results assume symmetric knowledge/belief of certain parameters, but nothing in terms of common knowledge. (The Nash Equilibrium in dominant strategies approach also requires no common knowledge). However, whether even this degree of forward looking strategic thinking is a reasonable assumption about behavior remains to be determined by comparing the predictions to data. Our next step in this research is to set up experimental tests of the predictions in the behavioral lab.

In sum, strategic decision making in organizations is an extremely important candidate topic to investigate for strategic management scholars, as it may be an important source of variation in inter-firm performance differences. We have attempted to provide an approach to do so that remains true to critical features of the phenomenon (dispersed information, conflicting incentives, hierarchy, a limited degree of strategic thinking) while still being tractable and

yielding clear predictions. Our focus in the current paper has been on information aggregation. However, we believe it could be extended to aggregating opinions and preferences.

## Appendix

Table 1: List of Variables

Variable	Description (all subjective beliefs)
$a$ (0,1)	Probability that agent $i$ 's preferences are aligned with agent $j$ 's and vice versa
$c$ (0,1)	Probability of second agent to reveal utility-related information
$q$ (1/2,1)	Probability that agent $i$ picks solution/alternative that is best for her. (bounded rationality, strategic uncertainty )
$G_i$	Payoff for candidate $i$ , ( $G_H$ for the preferred candidate and $G_L$ for the less preferred candidate)
$m$ ( $>1$ )	Ratio of the payoffs: $\frac{G_H}{G_L}$

Table 2: Probabilities of scenarios

	$P^H$	$P^L$
<b><i>Decentralized</i></b>		
$P_{UU}$	$P_{UU}^H = aq^2 + (1-a)(q(1-q))$	$P_{UU}^L = a(1-q)^2 + (1-a)(q(1-q))$
$P_{UN}$	$P_{UN}^H = a\left(\frac{1}{2}q\right) + (1-a)\left(\frac{1}{2}(1-q)\right)$	$P_{UN}^L = a\left(\frac{1}{2}(1-q)\right) + (1-a)\left(\frac{1}{2}q\right)$
$P_{NU}$	$P_{NU}^H = \frac{1}{2}q$	$P_{NU}^L = \frac{1}{2}(1-q)$
$P_{NN}$	$P_{NN}^H = \frac{1}{4}$	$P_{NN}^L = \frac{1}{4}$
<b><i>Centralized</i></b>		
$P_{UU}$	$P_{UU}^H = aq + (1-a)(1-q)$	$P_{UU}^L = a(1-q) + (1-a)q$
$P_{UN}$	$P_{UN}^H = \frac{1}{2}$	$P_{UN}^L = \frac{1}{2}$
$P_{NU}$	$P_{NU}^H = \frac{1}{2}$	$P_{NU}^L = \frac{1}{2}$
$P_{NN}$	$P_{NN}^H = \frac{1}{2}$	$P_{NN}^L = \frac{1}{2}$
<b><i>Conditional Decentralization</i></b>		
$P_{UU}$	$P_{UU}^H = aq^2 + (1-a)q(1-q) + [a(2q(1-q)) + (1-a)(q^2 + (1-q)^2)][(aq) + (1-a)(1-q)]$	$P_{UU}^L = a(1-q)^2 + (1-a)q(1-q) + [a(2q(1-q)) + (1-a)(q^2 + (1-q)^2)][(a(1-q) + (1-a)q)]$
$P_{UN}$	$P_{UN}^H = a\frac{1}{2}q + (1-a)\frac{1}{2}(1-q) + \frac{1}{4}$	$P_{UN}^L = a\frac{1}{2}(1-q) + (1-a)\frac{1}{2}q + \frac{1}{4}$
$P_{NU}$	$P_{NU}^H = \frac{1}{2}(q) + \frac{1}{4}$	$P_{NU}^L = \frac{1}{2}(1-q) + \frac{1}{4}$
$P_{NN}$	$P_{NN}^H = \frac{1}{2}$	$P_{NN}^L = \frac{1}{2}$

Note: Only in the first scenario is a deadlock possible.

## Appendix

### Proofs for Propositions

We define the difference in utility from sharing information (1) and not sharing information (2) as:

$$E = E(U) - E(N) \quad (9)$$

Using the specific probabilities (Table 2) we can calculate the difference for each decision structure. (Note that we fix the lower payoff  $G_L = 1$ , and set  $G_H = m$ .)

$$E_{Dec} = 2 \left( a - \frac{1}{2} \right) \left( q - \frac{1}{2} \right) \left( \frac{1}{2} (m - 1) + c(m + 1) \left( q - \frac{1}{2} \right) \right) \quad (10)$$

$$E_{Cen} = 2 \left( a - \frac{1}{2} \right) \left( q - \frac{1}{2} \right) c * (m - 1) \quad (11)$$

$$E_{Int} = \left( a - \frac{1}{2} \right) \left( q - \frac{1}{2} \right) (m - 1) \left( 1 - 4cq(1 - q) + c \left( 2 - 8a \left( q - \frac{1}{2} \right)^2 \right) \right) \quad (12)$$

**Proposition 1a:**  $\forall a > \frac{1}{2}$ :  $E_{Dec} > 0, E_{Cen} > 0, E_{Int} > 0$ , for the defined range of parameters  $q > \frac{1}{2}, m > 1, c > 0$

Proof: For  $E_{Cen}$ ,  $E_{Int}$ , and  $E_{Dec}$ , the signs of the expression only depend on the sign of  $\left( a - \frac{1}{2} \right)$ . This is clear from inspection for  $E_{Cen}$ , and  $E_{Dec}$ .

For  $E_{Int}$  we need to show that last bracket of (12) is larger than zero. We do this by demonstrating that each part of the bracket is larger than zero:

$$1 - 4cq(1 - q) \geq 0, \text{ because } c \leq 1 \wedge 4q(1 - q) \leq 1 \quad (13)$$

$$2 - 8a \left( q - \frac{1}{2} \right)^2 \geq 0, \text{ as } \left( q - \frac{1}{2} \right)^2 \leq \frac{1}{4} \quad (14)$$

$$1 - 4cq(1 - q) > 0 \wedge c \left( 2 - 8a \left( q - \frac{1}{2} \right)^2 \right) > 0 \Rightarrow E_{Int} > 0 \forall a > \frac{1}{2}$$

**Proposition 1b:**  $\forall a: \frac{\partial E_{Dec}}{\partial a} > 0, \frac{\partial E_{Cen}}{\partial a} > 0, \frac{\partial E_{Int}}{\partial a} > 0$ , conditional on  $m > 1, q > \frac{1}{2}, c > 0$

$$\frac{\partial E_{Dec}}{\partial a} = (m-1)\left(q - \frac{1}{2}\right) + c(m+1)\left(\frac{1}{2} + 2q(q-1)\right) \quad (13)$$

$$\frac{\partial E_{Cen}}{\partial a} = 2c\left(q - \frac{1}{2}\right)(m-1) \quad (14)$$

$$\frac{\partial E_{Int}}{\partial a} = \left(q - \frac{1}{2}\right)(m-1)c\left(\frac{1}{c} + 2 - 8\left(2a - \frac{1}{2}\right)\left(q - \frac{1}{2}\right)^2 - 4(1-q)q\right) \quad (15)$$

**Proof:**

$\frac{\partial E_{Dec}}{\partial a}$  are  $\frac{\partial E_{Cen}}{\partial a}$  clearly positive (independent of the value of a) by inspection. For  $\frac{\partial E_{Int}}{\partial a}$ , we have to show .

$$\frac{1}{c} + 2 - 8\left(2a - \frac{1}{2}\right)\left(q - \frac{1}{2}\right)^2 - 4(1-q)q \geq 0 \quad (16)$$

The smallest possible value of the sum of the two negative terms is -1, within the defined range of parameters. Therefore (16) is always true, and  $\frac{\partial E_{Int}}{\partial a} \geq 0$

**Proposition 2a:**  $E_{Cen} - E_{Dec} < 0 \forall a > \frac{1}{2} \wedge E_{Cen} - E_{Dec} > 0 \forall a < \frac{1}{2}$

$$E_{Cen} - E_{Dec} = E_{Diff} = 2\left(a - \frac{1}{2}\right)\left(q - \frac{1}{2}\right)\left(c * m - c(m+1)\left(q - \frac{1}{2}\right) - \frac{1}{2}(m-1)\right) \quad (17)$$

**Proof:** We must show for all  $a$ :

$$\left(c * m - c(m+1)\left(q - \frac{1}{2}\right) - \frac{1}{2}(m-1)\right) < 0 \quad (18)$$

$$cm < cm\left(q - \frac{1}{2}\right) + \frac{1}{2}(m-1) + \frac{1}{2}c\left(q - \frac{1}{2}\right) \quad (19)$$

$$c(m+1)\left(q - \frac{1}{2}\right) > \frac{cm}{2} \wedge \frac{1}{2}(m-1) + \frac{1}{2}c\left(q - \frac{1}{2}\right) > \frac{cm}{2} \quad (20)$$

$$c(m+1)\left(q - \frac{1}{2}\right) + \frac{1}{2}(m-1) + \frac{1}{2}c\left(q - \frac{1}{2}\right) > 2\frac{cm}{2} = cm \quad (21)$$

$$\left( c * m - c(m+1) \left( q - \frac{1}{2} \right) - \frac{1}{2} (m-1) \right) < 0 \Rightarrow E_{Diff} < 0 \forall a > \frac{1}{2}$$

**Proposition 2b:**  $\forall a: \frac{\partial E_{Dec}}{\partial a} \geq \frac{\partial E_{Cen}}{\partial a}$

Proof :

$$\frac{\partial E_{Dec}}{\partial a} \geq \frac{\partial E_{Cen}}{\partial a} \quad (22)$$

$$(m-1) \left( q - \frac{1}{2} \right) + c(m+1) \left( \frac{1}{2} + 2q(q-1) \right) \geq 2c \left( q - \frac{1}{2} \right) (m-1) \quad (23)$$

$$\left( q - \frac{1}{2} \right) + \frac{c(m+1)}{(m-1)} \left( \frac{1}{2} + 2q(q-1) \right) \geq 2c \left( q - \frac{1}{2} \right) \quad (24)$$

$$1 + \frac{c(m+1)}{(m-1)} \frac{\left( \frac{1}{2} + 2q(q-1) \right)}{\left( q - \frac{1}{2} \right)} \geq 2c \quad (25)$$

$$\frac{1}{c} + \frac{(m+1)}{(m-1)} \frac{\left( \frac{1}{2} + 2q(q-1) \right)}{\left( q - \frac{1}{2} \right)} \geq 2 \quad (26)$$

$$\frac{1}{c} \geq 1, \frac{(m+1)}{(m-1)} \left( 2q + 1 + \frac{1}{q - \frac{1}{2}} \right) \geq 1 \Rightarrow \frac{\partial E_{Dec}}{\partial a} \geq \frac{\partial E_{Cen}}{\partial a} \quad (27)$$

**Proposition 3a:**,  $E_{Cen} - E_{Int} \leq 0$  if  $a > \frac{1}{2}$  and  $c < \frac{1}{(1+2a)}$

$$E_{Cen} - E_{Int} = \left( a - \frac{1}{2} \right) \left( q - \frac{1}{2} \right) (m-1) \left( 2c - \left( 1 - 4cq(1-q) + c \left( 2 - 8a \left( q - \frac{1}{2} \right)^2 \right) \right) \right) \quad (17)$$

Consider  $2c - \left( 1 - 4cq(1-q) + c \left( 2 - 8a \left( q - \frac{1}{2} \right)^2 \right) \right)$

$$0 \leq 1 - c \leq 1 - 4cq(1-q) \leq 1 \quad (18)$$

$$0 \leq 2c(1-a) \leq c(2-8a\left(q-\frac{1}{2}\right)^2) \leq 2c. \quad (19)$$

$$\Rightarrow 2c - (1-c+2c(1-a)) \geq 2c - \left(1-4cq(1-q) + c\left(2-8a\left(q-\frac{1}{2}\right)^2\right)\right) \geq 2c - (1+2c)$$

$$\Rightarrow -1 + c(1+2a) \geq 2c - \left(1-4cq(1-q) + c\left(2-8a\left(q-\frac{1}{2}\right)^2\right)\right) \geq -1$$

$$\Rightarrow \text{when } c < \frac{1}{(1+2a)}, \text{ then } 2c - \left(1-4cq(1-q) + c\left(2-8a\left(q-\frac{1}{2}\right)^2\right)\right) < 0$$

Proposition 3b:  $E_{Int} - E_{Dec} \geq 0$ , if  $c < \frac{3-m}{-1+4a+m} \wedge a > \frac{1}{2}$

$$E_{cInt} - E_{Dec} = 2\left(a-\frac{1}{2}\right)\left(q-\frac{1}{2}\right)\left(\left(1-4cq(1-q) + c\left(2-8a\left(q-\frac{1}{2}\right)^2\right)\right) - c(m+1)\left(q-\frac{1}{2}\right) - \frac{1}{2}(m-1)\right) \quad (20)$$

For  $1-4cq(1-q)$ , and  $c(2-8a\left(q-\frac{1}{2}\right)^2)$  see (18) and (19).

$$0 \leq c(m+1)\left(q-\frac{1}{2}\right) \leq \frac{c(m+1)}{2}$$

So the minimal value of the expression (20) is:

$1-c+2c(1-a) - c\frac{(m+1)}{2} - \frac{(m-1)}{2}$ , which is zero for  $c = \frac{3-m}{-1+4a+m}$  and positive

for smaller values of  $c$ .

Figure 1: Difference in E between conditional centralization and Centralization

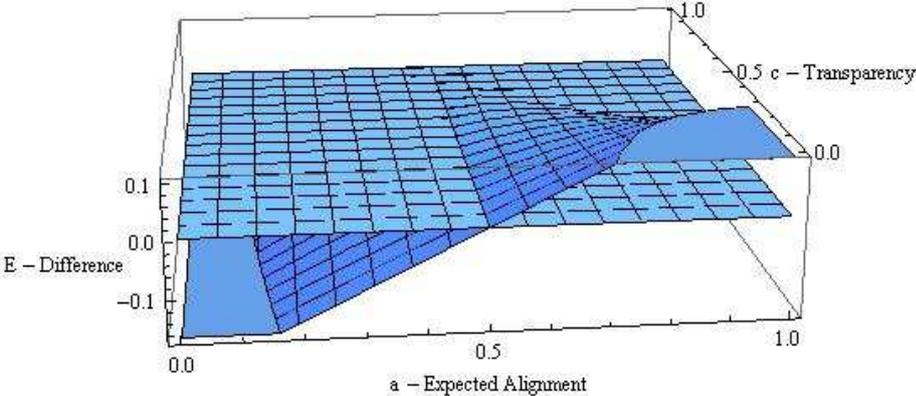
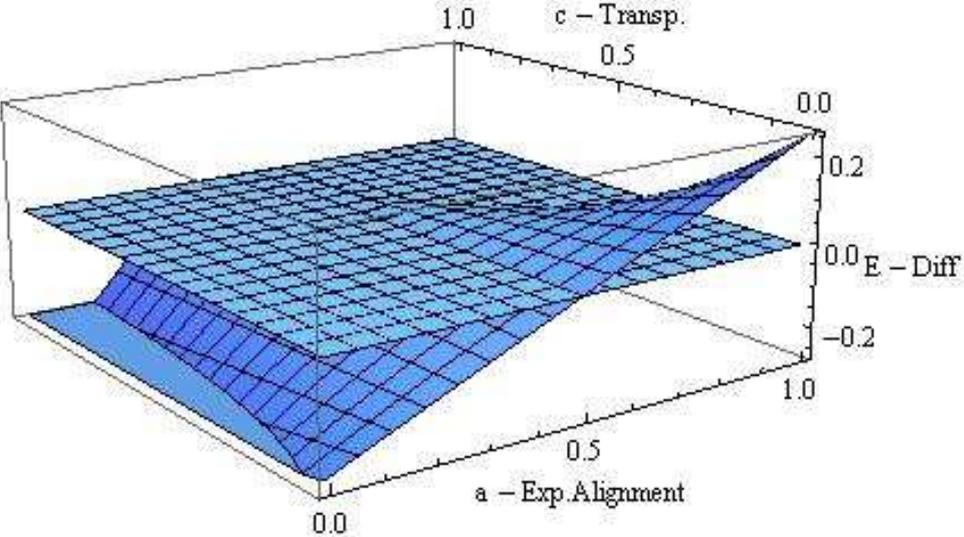


Figure 2: Difference in E between conditional centralization and De-Centralization



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