Communication and Binary Decisions: Is it better to communicate?*

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Abstract

We study information transmission between informed experts and an uninformed decision-maker who only takes binary decisions. In the single expert case, we show that information transmission can only be relatively poor. Hence, even sophisticated communication games do not yield equilibria which (ex ante) outperform delegation. Referring to multiple experts allow the decision-maker to obtain more information. However, this information can never be perfect, and sophisticated communication games, for instance with multilateral, multistage communication, do not outperform simple communication methods.

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1 Introduction

It is often the case that choices are limited to yes/no decisions: CEOs have to decide whether or not to realize a project, politicians must choose to approve or reject a reform, competition authorities have to decide whether or not to clear a merger or whether or not to sanction a practice. Although these types of decisions are not always simply binary, the choices are usually rather limited to a small number of options and perfect fine-tuning is not possible. In many of these cases, the decision-maker is initially uninformed about the optimal decision, and often seeks advice from better informed experts.[1] In some instances, these experts may have their own agenda or their preferences may conflict with decision-maker's optimal option. They can thus be tempted to withhold information from or transmit false information to the decision-maker in order to influence him – to their own private interest.

This raises a number of interesting questions concerning the interactions between the decision-maker and the informed experts. The decision-maker can simply delegate the decision process to one expert (i.e., letting her decide), or try to obtain advice from one or more of these experts. How this communication process is organized is likely to influence the quality of the information that the decision-maker receives. The decision-maker thus needs to decides whether to seek advice from one or more experts, or whether to allow experts to provide additional information once they have observed the information that the rival experts transmitted. This paper compares different communication games in order to identify whether it may indeed be helpful to use sophisticated mechanisms or not. To achieve this, we build on Crawford and Sobel (1982) who proposed a simple cheap-talk game between a perfectly informed expert and an uninformed decision-maker.[2] We however restrict our attention to binary decisions and assume that the expert is not systematically biased. However, since we limit our analysis to binary decisions, we do not need to restrict attention to unidimensional information.[3] We show that in such a setting, the only information that the decision-maker can extract is whether the expert would prefer to implement the project or not. Therefore, the most informative equilibrium yields the same outcome as delegating the decision to the expert. We also show that there is no point in complicating the communication process as no additional information will be revealed. For instance, adding bilateral and multistage communication between the expert and the decision-maker (e.g., through face-to-face meetings à la Krishna and Morgan 2004) yields a worse outcome than the single-stage communication game à la Crawford and Sobel (1982). Thus, when using a single expert, the decision-maker does not need to communicate with him: he achieves the

[1] For example, CEOs routinely seek advice from marketing specialists, investment bankers or management consultants; politicians rely on many advisers; competition authorities rely on case handlers to decide on each case.

[2] These cheap-talk models have been frequently used by political scientist, but they always consider the continuous decision case. See for instance Gilligan and Krehbiel (1987 and 1989), Krishna and Morgan (2001a) or Mylovanov (2008) who analyze how legislative rules influence information transmission.

[3] Note that Austen-Smith (1993), Battaglini (2002) and Levy and Razin (2007) also study multidimensional models of cheap talk when the decision variable is continuous.

same outcome by letting her decide. The result that delegation is preferred to communication (at least when the expert is not too biased), derived by Dessein (2002) in a continuous decision model, thus continues to hold in the binary case, although delegation and communication are then equivalent.

We then move on to the multiple experts case and show, in a simple game (adapted from Khrisna and Morgan 2001b) where the experts sequentially send one message each before the decision is taken, that communication with both experts may then improve information transmission.[4] Indeed, although the non-informative equilibrium and delegation-like equilibria exist again, there may also exist additional equilibria that rely on both messages. Moreover, any of these new equilibria, namely a veto-power equilibrium where a project is rejected unless both experts advise to implement it, and an implementation-power equilibrium where a project is implemented unless both experts advise against it, may well be the decision-maker's preferred outcome. Finally, we also study the possibility that experts engage in an extended back-and-forth debate and consider a rebuttal game. In the continuous decision case, Krishna and Morgan (2001b) have shown that such a mechanism leads to full information revelation when the two experts have opposite biases (as long as there are not "extremists"). This result no longer holds when decisions are binary. As we show in this paper, multiple rounds of communication do not induce the experts to reveal more information than a simple one round of communication in which each expert speaks only once.

The paper proceeds as follows. We start by the single expert case, looking at unilateral as well as multilateral communication (Section 2). We then move on to the multiple experts case, and consider games with a single round of communication as well as with multiple rounds (Section 3). Section 4 concludes. Formal proofs are relegated in the Appendix.

2 Seeking advice from one expert

We first focus on the interactions between an uninformed decision-maker (DM, he) and a perfectly informed expert (E, she). In contrast to the standard cheap-talk literature (à la Crawford and Sobel 1982) that considers continuous decisions, we envisage binary decisions, that is, situations in which DM can only decide whether to implement a project ($d = 1$) or not ($d = 0$). As discussed in the introduction, we believe that there are many situations for which this is a more appropriate setting: deciding whether to implement a project or not for a board of directors, deciding to clear a given practice or a merger for competition authorities or not, approving a proposed (already fine-tuned) reform for a governmental cabinet or not.

A project is characterized by its "type" $\theta \in \Theta$, which may be multi-dimensional. E perfectly observes θ, while DM only knows from which distribution it is drawn. If the project is implemented private net benefits are generated. These net gains are denoted $u_{DM}(\theta)$ and $u_E(\theta)$ for

[4] Li and Madaràsz (2007) also consider multiple experts (in a continuous decision setting) but assume that the decision-maker does not observe the experts' biaises. They show that nondisclosure may then dominate mandatory disclosure.

the decision-maker and the expert respectively. We assume that these gains can be positive or negative, and we can thus define the following subsets of Θ:

- $DM^+ = \{\theta \in \Theta \mid u_{DM}(\theta) > 0\}$ and $DM^- = \{\theta \in \Theta \mid u_{DM}(\theta) < 0\}$.
- $E^+ = \{\theta \in \Theta \mid u_E(\theta) > 0\}$ and $E^- = \{\theta \in \Theta \mid u_E(\theta) < 0\}$.

For simplicity sake, we assume that the sets of values of θ for which $u_{DM}(\theta) = 0$ or $u_E(\theta) = 0$ are of measure 0, and that:[5]

$$E_\theta\left(u_{DM}(\theta) \mid \theta \in E^+\right) \neq 0,\ E_\theta\left(u_{DM}(\theta) \mid \theta \in E^-\right) \neq 0 \text{ and } E_\theta\left(u_{DM}(\theta)\right) \neq 0.$$

2.1 Unilateral Communication, Delegation and Centralization

We start by considering a standard unilateral communication game $G(\Theta)$ in which E sends a message $m(\theta)$ to DM, who then decides whether to implement the project or not. Whatever the perfect Bayesian equilibrium (PBE) of this simple game, either DM does not listen to E and takes his decision on the basis of his prior beliefs or there are at least two different messages for which DM's decision differs. The first situation is always a (non-revealing) equilibrium. If E anticipates that her message will not affect the decision, she can as well transmit an uninformative signal. But, if the equilibrium message is uninformative, DM's optimal decision can only be based on his prior beliefs. In this case, DM decides to implement (resp., reject) whatever project when his priors are optimistic (resp., pessimistic), i.e., $E_\theta(u_{DM}(\theta)) > 0$ (resp., $E_\theta(u_{DM}(\theta)) < 0$). But information transmission is not needed in this case, *centralization* (i.e., committing not to use any expert) yields exactly the same outcome.

Suppose now that there exist at least two different messages for which DM's decision differs and define $M^+ = \arg\max_m d(m)$ and $M^- = \arg\min_m d(m)$.

If E wants a project to be implemented (resp., rejected), that is, if $\theta \in E^+$ (resp., if $\theta \in E^-$), she tries to maximize (resp., minimize) the chances that the project goes through and thus selects a message within M^+ (resp., M^-). Since $E_\theta\left(u_{DM}(\theta) \mid \theta \in E^+\right) \neq 0$, there exists a message $m^+ \in M^+$, such that $E_\theta\left(u_{DM}(\theta) \mid m(\theta) = m^+\right) \neq 0$. Therefore, for any $m \in M^+$, $d(m) = d^+ \in \{0, 1\}$. A similar argument ensures that, for any $m \in M^-$, $d(m) = d^- \in \{0, 1\}$. However, we are only looking for PBE such that $d^+ > d^-$, which implies that only projects in E^+ are implemented.[6] Any such PBE exists if and only if following E's advice is indeed his optimal strategy, that is, if and only if:

$$E_\theta\left(1_{\{\theta \in E^+\}} u_{DM}(\theta)\right) > 0 \text{ and } E_\theta\left(1_{\{\theta \in E^-\}} u_{DM}(\theta)\right) < 0. \qquad (C)$$

However, this outcome could also be obtained without information transmission through *delegation*, that is, when the decision-maker *credibly* leaves the decision to the expert. Delegation

[5] These assumptions are equivalent to limit our attention to generic versions of the game. They do not qualitatively affect our results.

[6] For the projects such that $u_E(\theta) = 0$, E is indifferent while DM's might not be indifferent. However, since the measure of such projects is equal to 0, DM's decision does not really modify the equilibrium outcome. In what follows, we abstract from considering such projects.

is always preferred to centralization by the expert, since she then chooses the outcome. Moreover, when conditions (C) hold delegation is also ex-ante preferred to centralization by the decision-maker. Indeed, when centralization is such that no project is implemented delegation is preferred since it leads to implementing a project belonging to E^+ and $E_\theta\left(1_{\{\theta\in E^+\}}u_{DM}(\theta)\right)>0$. When centralization is such that any project is implemented, delegation is preferred since it avoids projects belonging to E^- being implemented and $E_\theta\left(1_{\{\theta\in E^-\}}u_{DM}(\theta)\right)<0$.

The next proposition summarizes this discussion.

Proposition 1 *Under (C), any PBE of the unilateral communication game $G(\Theta)$ is outcome-equivalent either to centralization (DM never listens to E) or to delegation (DM always follows E's advice), and delegation is ex-ante Pareto-dominant. Otherwise, all equilibria are outcome-equivalent to centralization.*

The intuition is as follows. Since the expert will always try to influence the outcome and the decision is binary (yes/no) sophisticated messages are useless, and it is sufficient to ask the expert whether she wants the project to be implemented or not. Therefore, communication is not needed: either the decision-maker does not listen to the expert's advice (in which case there is no need to ask for it) or he follows the expert's advice in which case he could as well let the expert decide. As in Crawford and Sobel (1982), the most informative equilibrium (delegation when conditions (C) hold) is also ex-ante Pareto dominant. With continuous decisions, Dessein (2002) has shown that delegation always outperforms informative communication.[7] This result still holds in our binary setting – although in a less extreme form since the most informative equilibrium is equivalent to delegation. Therefore, whether decisions are binary or continuous, communication is not needed: the decision-maker can just ex-ante decide whether to take a decision without any advice or delegate the decision to the expert.

2.2 Face-to-Face Communication

Krishna and Morgan (2004), in a Crawford and Sobel's setting, have shown that adding stages of communication could improve information transmission (i.e., yield more informative equilibria). They introduced an additional stage of simultaneous exchange of cheap-talk messages (i.e., a face-to-face meeting between DM and E) before the unilateral communication game. Even though DM is initially uninformed, they showed that this meeting could improve information transmission. Nevertheless, the outcome of this additional stage has to be random, otherwise the expert would be able to anticipate DM's action and would have no incentives to reveal more information *in fine*. An uncertain relationship between E's message and DM's decision reduces the incentives of a risk-averse expert to withhold information from DM strategically because revealing more information reduces uncertainty.

We now show that adding stages of communication does not improve communication when the decision is binary, independently of E's attitude towards risk. Following Khrisna and Morgan

[7] Whenever the expert's bias is sufficiently small to ensure that an informative equilibrium exists.

(2004), we consider a simple multistage bilateral communication game, in which a face-to-face meeting occurs before the unilateral communication game. Formally, E and DM simultaneously send messages, which we note as (i, A_E) for E and A_{DM} for DM.[8] The first part of E's message (i) transmits information revealing which subset Θ_i type θ belongs to, where the subsets Θ_i (with $i = 1, ..., N$) form a partition of Θ. The second part of E's and DM's message are then used to determine the outcome of a *jointly-controlled lottery* à la Aumann and Maschler (1995). More specifically, whenever the game $G(\Theta_i)$ admits a delegation-like equilibrium,[9] the jointly-controlled lottery determines which of the two equilibria (centralization vs delegation) is played. The crucial element of this additional stage is that none of the two players can unilaterally influence the outcome of this lottery. An equilibrium of this multistage communication game is thus characterized by a partition of $\Theta = \cup_{i=1}^{N} \Theta_i$ and the corresponding probabilities β_i (one for each i), where β_i denotes the probability that *centralization* occurs in the continuation game $G(\Theta_i)$.[10]

The following proposition, for which the proof is relegated to Appendix 5.1, indicates that adding this bilateral communication stage cannot improve information transmission.

Proposition 2 *If conditions* (C) *do not hold, any PBE of the two-stage multilateral communication game is outcome-equivalent to centralization. Otherwise, any PBE is ex-ante Pareto dominated by delegation which can arise as an equilibrium of this two-stage multilateral communication game.*

The intuition is as follows. Look for instance for an equilibrium where during the first stage E reveals whether θ belongs to one of the two subsets Θ_1 or Θ_2.[11] The principle of the jointly-controlled lottery is simply that, for each of the two subsets, E and DM randomize to decide over which equilibrium of the continuation game $G(\Theta_i)$ they coordinate. In order for the partition to affect the outcome, it must be the case that, either the equilibria in the two continuation games are different and/or the probabilities β_1 and β_2 differ. Moreover, the equilibria in the two continuation games are going to be different only when the two non-informative equilibria (for the two subsets Θ_1 and Θ_2) are different, since a delegation-like information is always the same when it exists.

Suppose first that the two non-informative equilibria are the same.[12] We must then have $\beta_1 \neq \beta_2$. However, this implies that there exists a delegation-like equilibrium for at least one of the two subsets. Without loss of generality, suppose that $\beta_1 < \beta_2$. In this case, the expert is willing to report that θ belongs to Θ_2 only when she is indifferent both to her preferred

[8] See Koessler and Forges (2008), who propose an extensive review of the literature on multistage communication games.

[9] The unilateral communication game $G(\Theta_i)$ always has multiple equilibria. However, there are all outcome-equilibrium equivalent to either centralization or delegation (when this equilibrium exists). We thus restrict our attention to these two equilibria.

[10] By convention, $\beta_i = 1$ when the game $G(\Theta_i)$ does not admit a delegation-like equilibrium.

[11] The intuition easily extends to any partition of Θ.

[12] The equilibria may be different, but it is important that they are outcome equivalent.

action and the action that DM would take in the absence of information. Therefore, this equilibrium is simply equivalent to randomizing between centralization and delegation (with respective probabilities β_1 and $1-\beta_1$) and is therefore ex-ante Pareto-dominated by delegation.

The alternative solution is that the two non-informative equilibria are different. Without loss of generality, assume that all projects are implemented if E reports that $\theta \in \Theta_1$ and rejected otherwise. In this case, E can always ensure that her preferred action is implemented: when she wants the project to be implemented (resp., not implemented), she "reveals" that θ belongs to Θ_1 (resp., Θ_2). Such an equilibrium is thus equivalent to delegation.

As in the continuous decision case analyzed by Krishna and Morgan (2004), the multilateral communication stage may help generating more informative equilibria. However, contrarily to the continuous case, this additional information is not helpful in the binary decision case. Because of the nature of the decision, it is not possible to separate among projects that E would like to implement and those she would like to reject. Therefore, any information that is revealed can only separate the two sets of types E^+ and E^-, which is already possible in the unilateral communication game.

3 Communication with Multiple Experts

We now extend the model and allow the decision-maker to use several experts, and analyze whether using multiple sources of information can improve information transmission. We adapt the setting of Krishna and Morgan (2001b) to the binary decision case. DM can now seek advice from two perfectly informed experts, E_1 and E_2. Expert E_k's net gain of implementing a project of type θ is denoted $u_k(\theta)$. As in the single expert case, we partition the state-space Θ, in subsets on the basis of the expert's preferred actions, that is, for $k = 1, 2$:

$$E_k^+ = \{\theta \in \Theta \mid u_k(\theta) > 0\} \text{ and } E_k^- = \{\theta \in \Theta \mid u_k(\theta) < 0\}.$$

We also define the following four categories of projects:

$$\Theta^{++} = E_1^+ \cap E_2^+,\ \Theta^{+-} = E_1^+ \cap E_2^-,\ \Theta^{-+} = E_1^- \cap E_2^+ \text{ and } \Theta^{--} = E_1^- \cap E_2^-,$$

and assume that none of these subsets is empty. Therefore, although the experts have different preferences, they do not always disagree on the action to be taken. We also assume that when the experts agree, DM also agrees with them (that is, $u_{DM}(\theta) > 0$ for any $\theta \in \Theta^{++}$, and $u_{DM}(\theta) < 0$ for any $\theta \in \Theta^{--}$). Although this is not the most general case we could consider, it is a reasonable assumption that would apply when DM aggregates the views of various lobbying groups (for instance when u_{DM} is a convex combination of u_1 and u_2).

Finally, for any $T \in \{++, +-, -+, --\}$, we denote $U^T = E_\theta\left(1_{\{\theta\in\Theta^T\}} u_{DM}(\theta)\right)$. Under our assumptions, $U^{++} > 0$, $U^{--} < 0$ while U^{+-} and U^{-+} can be either positive or negative. In order to simplify the presentation, we suppose that $U^{+-} \neq 0$ and $U^{-+} \neq 0$.

3.1 Single Round of Communication

First we consider a simple sequential message game adapted from Krishna and Morgan (2001b) where the two experts sequentially send publicly observable messages to the decision-maker who then takes a decision.[13] Without loss of generality, we assume that E_1 is the first expert to transmit a message.

As before, a non-informative equilibrium exists. If both experts anticipate that DM always takes the same decision (i.e., $d(m_1, m_2) = d^*$ for all pairs of messages), each expert can as well always send the same message. Given these "communication" strategies, messages are totally uninformative and it is indeed optimal for DM to take a decision (in equilibrium but also out-of-the-equilibrium) based on his prior beliefs about θ. The equilibrium is such that: DM implements (resp., rejects) any project when his priors are optimistic (resp., pessimistic), $E_\theta(u_{DM}(\theta)) > 0$ (resp., < 0). Once again, this equilibrium is outcome-equivalent to centralization.

We now determine conditions under which a delegation-like equilibrium exists. Consider for instance "delegation to E_1", i.e., DM always follows E_1's advice. Anticipating that DM never listens to her, E_2 can always send an uninformative message, that is, $m_2(m_1, \theta) = m_2^*$ for any m_1 and any $\theta \in \Theta$. Given this strategy, it is optimal for DM not to take E_2's message into account and the situation is formally the same as in the single-expert case. Therefore, a PBE equivalent to delegating the decision to E_1 exists whenever:

$$E_\theta\left(1_{\{\theta\in E_1^+\}} u_{DM}(\theta)\right) = U^{++} + U^{+-} > 0 \text{ and } E_\theta\left(1_{\{\theta\in E_1^-\}} u_{DM}(\theta)\right) = U^{-+} + U^{--} < 0.$$

Similarly, a PBE equivalent to delegating the decision to E_2 exists whenever $U^{++} + U^{-+} > 0$ and $U^{+-} + U^{--} < 0$.

We now look for other (partially) informative equilibria. Since the decision is binary, there is no need for a complicated message-space, and limiting our attention to binary messages is sufficient. Indeed, each expert only cares about the messages that induce the highest and the lowest probabilities of DM deciding to implement the project. Therefore, binary messages are enough, unless two or more messages generate the same outcome.[14] For the purpose of the discussion, we assume that experts can only send one of two messages which we denote by m^+ and m^-. We also restrict attention to pure strategy equilibria.[15] Looking for equilibria which are not outcome-equivalent to the non-revealing equilibrium implies to look at equilibria for which there exist two pairs of messages that induce different decisions. Thus, the four possible pairs of messages need to be separated into two non-empty subsets.

One possibility to "pool messages" is to have one singleton. Given that we can rename the messages if necessary, there are only two such possibilities. The first one is to give a *"veto-power"*

[13] Assuming that messages are sent sequentially rather than simultaneously is a simple way to limit chances that multiple equilibria co-exist. It simply serves as a first selection mechanism but does not affect the final results.

[14] As we prove in Appendix 5.2, this possibility may well generate many other equilibria, but does not generate additional equilibrium outcomes.

[15] The complete analysis is provided in Appendix 5.2.

to the experts, that is, to set $d(m^+, m^+) = 1$ and $d(m_1, m_2) = 0$ for all other pairs of messages. In that case, each expert can always ensure that the project will not be implemented. Given this decision rule, each expert has a (weakly) dominant strategy which is to reveal her preferred action, i.e., sending the message m^+ (resp., m^-) if $\theta \in E_i^+$ (resp., E_i^-). This constitutes an equilibrium if the decisions are optimal for DM given the experts' strategies, that is, if and only if $U^{-+} + U^{+-} + U^{--} < 0$.

The second possibility is to allow each expert to have an *"implementation-power"*, that is, to set $d(m^-, m^-) = 0$ and $d(m_1, m_2) = 1$ for all other pairs of messages. Once again, revealing her preferred action is a (weakly) dominant strategy for each expert, implying that an implementation-power equilibrium exists whenever $U^{++} + U^{-+} + U^{+-} > 0$.

The final possibilities to "pool messages" are to have two subsets containing two elements each, which can be done in three different ways. The first one is such that $d(m^+, m^+) = d(m^+, m^-)$ and $d(m^-, m^+) = d(m^-, m^-)$, and is equivalent to delegating the decision to E_1. The second one is such that $d(m^+, m^+) = d(m^-, m^+)$ and $d(m^-, m^-) = d(m^+, m^-)$, and is equivalent to delegating the decision to E_2. The third possibility is such that $d(m^+, m^+) = d(m^-, m^-)$ and $d(m^-, m^+) = d(m^+, m^-)$. However, since message are sent sequentially, this is equivalent to delegating the decision to E_2, because she can always adapt her message to the decision rule once she has observed the message sent by E_1.

The following lemma, whose complete proof is in Appendix 5.2, summarizes these results.

Lemma 1 *Any PBE of the sequential-message game is outcome equivalent to either centralization, delegation to one expert, veto- or implementation- power.*

- *A non-revealing equilibrium (centralization) always exists.*
- *A PBE equivalent to delegation to E_1 (resp., E_2) exists if and only if $U^{++} + U^{+-} > 0$ and $U^{-+} + U^{--} < 0$ (resp., $U^{++} + U^{-+} > 0$ and $U^{+-} + U^{--} < 0$).*
- *The veto-power equilibrium exists whenever $U^{-+} + U^{+-} + U^{--} < 0$.*
- *The implementation-power equilibrium whenever $U^{++} + U^{-+} + U^{+-} > 0$.*

When two or more of these equilibria co-exist, we now search for the decision-maker's preferred equilibrium. The reason to give to DM the opportunity to select his preferred equilibrium is that it could credibly ex-ante commit to the corresponding decision mechanism.

We can first remark that the non-revealing equilibrium is never the preferred equilibrium. Indeed, suppose that DM's priors are pessimistic ($E_\theta(u_{DM}(\theta)) < 0$), so that, in the absence of any information, DM blocks any project. Since $U^{++} > 0$ by assumption, the veto-power equilibrium also exists and is preferred to this non-informative equilibrium. Moreover in this equilibrium, only projects that generate a net benefit for each of the two experts are implemented. The veto-power equilibrium thus ex-ante Pareto-dominates the non-informative equilibrium. Similarly, when $E_\theta(u_{DM}(\theta)) > 0$, the non-revealing equilibrium is ex-ante Pareto-dominated by the implementation-power equilibrium, which exists since $U^{--} < 0$ by definition.

To select among the remaining co-existing equilibria, we must now compute DM's expected gains. Remark that the only potential conflicts between the experts and the decision-maker occur when the experts disagree (i.e., when $\theta \in \Theta^{+-} \cup \Theta^{-+}$). When U^{+-} and U^{-+} are both positive (resp., negative), DM would like to implement a project if and only if it is supported by at least one expert (resp., by both experts). He thus selects the implementation-power (resp., veto-power) equilibrium, which indeed exists when U^{+-} and U^{-+} are both positive (resp., negative). Suppose now that $U^{+-} > 0$ and $U^{-+} < 0$. In that case, the best possibility for DM is to delegate the decision to E_1, and such an equilibrium indeed exists. By symmetry, delegation to E_2 is preferred whenever $U^{-+} > 0$ and $U^{+-} < 0$.

This discussion is summarized in the following proposition.

Proposition 3 *DM prefers a delegation-like equilibrium when U^{+-} and U^{-+} have opposite signs, with delegation to E_1 (resp., E_2) when $U^{+-} > 0$ (resp., < 0), while he favors the implementation-power (resp., veto-power) equilibrium when U^{+-} and U^{-+} are both positive (resp., negative). Finally, the non-revealing equilibrium is always ex-ante Pareto-dominated.*

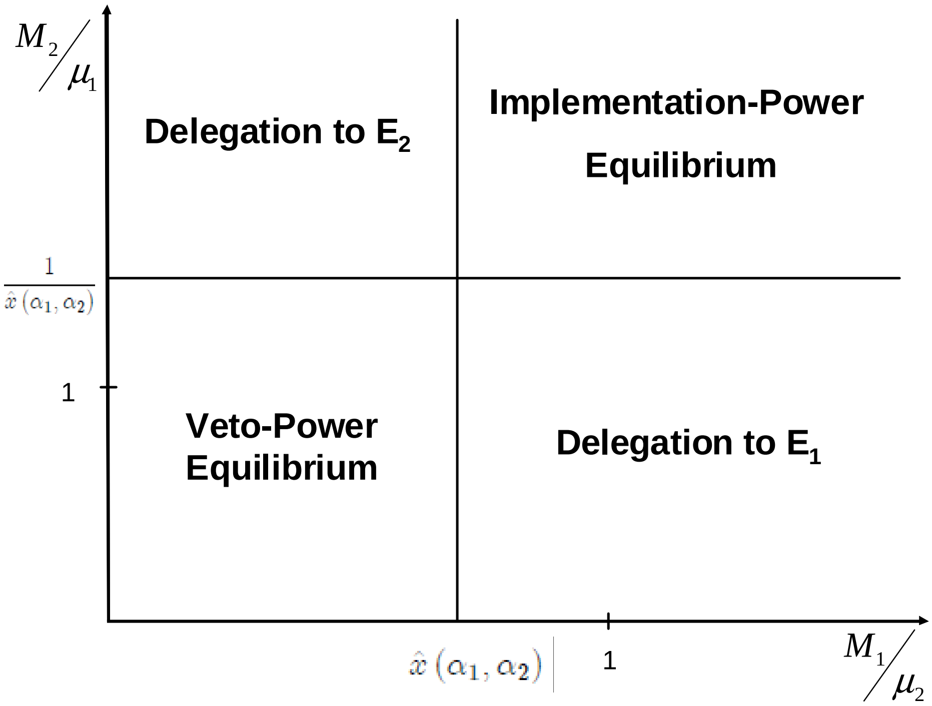
The existence of multiple experts may improve communication. Because decision is binary, the experts only try to convince the decision-maker that the project has either a positive or a negative value and their message do not need to try to convey a specific value for the project. In the end, it is best (at least it is a weakly dominant strategy) for the experts to "tell the truth", i.e., inform the decision-maker truthfully on whether they would prefer to implement the project. Therefore, DM's faces a problem only when the experts disagree in which case he can take the decision on the basis of his prior beliefs.

Either these beliefs coincide with one of the expert's preferred decision (and this occurs when U^{+-} and U^{-+} have opposite signs), in which case one expert is sufficient to elicit the best information. However, these beliefs may not coincide with one expert's preference for all projects, for instance when DM would then decide to implement all projects whenever the experts disagree, in which case DM uses the experts only to identify projects on which they all agree. Information is then better than when DM uses one expert only, and communication is then useful (at least for the decision-maker).

To illustrate this result, here is a simple example where θ is bidimensional, $\theta = (\theta_1, \theta_2)$ and each θ_k is uniformly and independently distributed over $[-\mu_k, M_k]$ with $\mu_k > 0$ and $M_k > 0$. The players' net gains are the following : $u_P(\theta) = \theta_1 + \theta_2$ and $u_k(\theta) = \theta_k + \alpha_k \theta_{-k}$ for $k \neq -k$. Think for instance of a supra national authority (DM) having to decide over a trans-national merger on the basis of information reported by two "nationally biased" national authorities (E_1 and E_2). Without loss of generality we assume that $1 \geq \alpha_1 \geq \alpha_2$, i.e., each authority E_k puts more weight on the impact of the merger in her own country (θ_k) and authority E_2 is more biased. The result of proposition 3 can be summarized as follows:

- The supra-national authority always delegates the decision to E_1 when she is not too biased, i.e., $\alpha_1 < \frac{1}{2-\alpha_2}$

- Otherwise $\left(\alpha_1 \in \left[\alpha_2; \frac{1}{2-\alpha_2}\right]\right)$, the supra national authority's ex-ante preferred equilibrium also depends on the distribution of θ and is represented in Figure 1.



Supra-national authority's preferred equilibrium for $\alpha_1 \in \left[\alpha_2; \frac{1}{2-\alpha_2}\right]$

For a given μ_2 (resp., μ_1), U^{+-} (resp., U^{-+}) becomes positive when M_1 (resp., M_2) is large enough. Therefore, communication occurs (i.e., DM prefers to use both experts) only when mergers are more likely to be welfare-improving (resp., welfare-decreasing) in both countries, i.e., M_1 and M_2 are large (resp., small) relative to μ_1 and μ_2.

3.2 Two Rounds of Communication : Rebuttal Game

Krishna and Morgan (2001b) have shown that using several rounds of communication may help generate a fully revealing equilibrium when experts have opposite biases. The intuition is simple: using a second expert forces the first one to reveal more information. In turn, allowing the first expert to rebutt the second message forces the second expert to reveal more information. By playing one expert against the other, it then becomes possible to "convince" the experts to truthfully transmit information to the decision-maker. As we will show now, this result no longer holds when decisions are binary. We consider the following rebuttal game:

1. E_1 sends a public message $m_1(\theta)$ to DM.
2. E_2 sends a public message $m_2(m_1;\theta)$ to DM.
3. E_1 sends a public rebuttal message $r_1(m_1, m_2;\theta)$ to DM.
4. E_2 sends a public rebuttal message $r_2(m_1, m_2, r_1;\theta)$ to DM.

5. DM decides whether to implement the project or not.

Consider projects on which experts disagree, for instance $\theta \in \Theta^{+-}$, and partition Θ^{+-} into two subsets: Θ^{+-}_{+} and Θ^{+-}_{-} depending on the decision-maker equilibrium decision. Given that DM wants to implement the projects in Θ^{+-}_{+}, there must exist at least one rebuttal message $\widetilde{r}_1$ such that $d(m_1; m_2; \widetilde{r}_1; r_2) = 1$ for any messages m_2 and r_2. Similarly, since DM wants to reject all the projects in Θ^{+-}_{-}, there must exist at least one rebuttal message $\widetilde{r}_2$ for which $d(m_1; m_2; r_1; \widetilde{r}_2) = 0$ for any messages m_1 and r_1. However, these conditions contradict each other, and therefore the equilibrium decisions must be the same for all projects in Θ^{+-}. A similar analysis holds for Θ^{-+}. Finally, the two experts agree over projects in Θ^{++} or Θ^{--} and a single round of communication is enough to elicit the information. Therefore, adding a second round of communication – or any number of rounds – does not allow the decision-maker to elicit more information than with a single round of communication. The following proposition sums up this result:[16]

Proposition 4 *With binary decisions, the rebuttal game does not yield more informative PBE than the simplest communication game with two experts.*

Therefore,with binary decisions Krishna and Morgan's (2001b) result no longer holds and using several rounds of communication does not allow to obtain more information from experts.

4 Conclusion

In this paper, we study what the information transmission, from informed experts to an uninformed decision-maker consists in, when the decision-maker takes binary decisions. We show that when there is a single expert, delegation always ex-ante Pareto dominates centralization. Moreover, delegation is outcome equivalent to the best informative PBE of the simplest unilateral communication game. Any more complicated communication game with multistage multilateral communication does not lead to PBE which ex-ante Pareto dominate delegation. When there are multiple experts we show that the decision-maker can increase his expected welfare by communicating with the two experts. However, any more complicated communication game with multistage communication between the decision-maker and the experts does not lead to more information being revealed.

We believe that these results are important since there are many situations in which a decision-maker takes binary decisions. However, there are also many situations in between the two polar cases (continuous vs binary decisions). For instance, there are situations for which a decision-maker faces a period of time during which he can fine-tune, modify a project (he can take a continuous decision), but if at the end of the period the decision-maker has not entirely specified the project he can only decide whether to implement it as it is or not (he can take a binary decision). We leave this question open for future research.

[16] A more complete proof is presented in Appendix 5.3.

5 Appendix

5.1 Proof of Proposition 2

First suppose that the outcome of the face-to-face meeting does not affect DM's decision. In that case, E can also choose to always send the same pair of messages (i, A_E). Given that the face-to-face meeting is uninformative, it is indeed optimal for DM not to take it into account. Moreover, if DM's final decision does not depend on the message sent by E, E can optimally choose to always send the same message. The communication game is thus uninformative and DM optimally chooses to base his decision on his priors. The multi-stage multilateral communication game thus admits a non-informative equilibrium (i.e., outcome-equivalent to *centralization*).

Similarly, *delegation* is an equilibrium of this multi-stage communication game if and only if it is an equilibrium of $G(\Theta)$. If DM decides to implement (resp., to reject) a project whenever E reports $m = m^+$ (resp., m^-), E optimally chooses to send the message m^+ (resp., m^-) when $\theta \in E^+$ (resp., E^-). Finally, implementing (resp., rejecting) a project following a message $m = m^+$ (resp., m^-) is optimal for DM if and only if $E_\theta\left(1_{\{\theta\in E^+\}}u_{DM}(\theta)\right) > 0$ (resp., $E_\theta\left(1_{\{\theta\in E^-\}}u_{DM}(\theta)\right) < 0$).

Now let us show that there might exist other equilibria for which the face-to-face meeting is informative but that they are all ex-ante Pareto-dominated by one of the two above-mentioned equilibria. Without loss of generality, suppose that these PBE are such that $\beta_1 < \beta_2 < ... < \beta_N$ and $N \geq 2$.[17] We first consider the case $\beta_1 = 0$, in which E can always ensure that her preferred action is implemented by initially reporting $i = 1$. Any such PBE would therefore be outcome-equivalent to delegation, and we thus focus in what follows on $\beta_1 > 0$.

When E initially reports i, her expected utility is:

$$U_E(\theta, i) = \beta_i d_i^* u_E(\theta) + (1-\beta_i)\max[0, u_E(\theta)],$$

where d_i^* denotes DM's optimal decision in the non-informative equilibrium of $G(\Theta_i)$, that is:

$$d_i^* = \begin{cases} 1 & \text{if } E_\theta\left(1_{\{\theta\in\Theta_i\}}u_{DM}(\theta)\right) > 0, \\ 0 & \text{if } E_\theta\left(1_{\{\theta\in\Theta_i\}}u_{DM}(\theta)\right) < 0. \end{cases}$$

Let us denote $I_0 = \{i | d_i^* = 0\}$ and $I_1 = \{i | d_i^* = 1\}$. If I_0 and I_1 are both non-empty, the expert can always ensure that her preferred action is implemented. Indeed, it suffices to choose $i \in I_1$ (resp., I_0) whenever $\theta \in E^+$ (resp., $\theta \in E^-$). Any such PBE is therefore outcome-equivalent to delegation. Moreover, such a PBE exists if and only if for each $i \in I_0$ (resp., I_1), no project is ever implemented (resp., all project are implemented) in the non-informative equilibrium of

[17] It is always possible to divide a subset Θ_i into several subsets, $(\Theta_{i,j})_{j=1,...,J}$, with $\beta_{i,j} = \beta_i$ for all $j = 1, ..., J$. For all values of $\theta \in \Theta_i$, the expert is indifferent to report that θ belongs to any of the subsets $\Theta_{i,j}$ since this does not affect the final outcome. We can thus aggregate all of these subsets into the initial subset Θ_i without affecting the equilibrium outcome. We thus only focus on partitions which are such that all probabilities are different.

$G(\Theta_i)$, that is, for any $i \in I_0$ (resp., I_1), $E_\theta\left(1_{\{\theta\in\Theta_i\}}u_{DM}(\theta)\right) < 0$ (resp., > 0). Thus, we must have:

$$\sum_{i\in I_0} E_\theta\left(1_{\{\theta\in\Theta_i\}}u_{DM}(\theta)\right) < 0 \text{ and } \sum_{i\in I_1} E_\theta\left(1_{\{\theta\in\Theta_i\}}u_{DM}(\theta)\right) > 0,$$

that is:

$$E_\theta\left(1_{\{\theta\in E^-\}}u_{DM}(\theta)\right) < 0 \text{ and } E_\theta\left(1_{\{\theta\in E^+\}}u_{DM}(\theta)\right) > 0.$$

But these last two conditions imply that $G(\Theta)$ already admits a delegation-like PBE.

Suppose now that I_1 is empty in which case, DM rejects all projects whenever the non-information equilibrium of $G(\Theta_i)$ is played in the continuation game (i.e., with probability β_i). Any project $\theta \in E^-$ will thus be rejected, and for any $\theta \in E^+$, E will simply minimize the probability that the project is not implemented by reporting $i = 1$ (in order to minimize β_i). For such a PBE to exist, we must have:

$$E_\theta\left(1_{\{\theta\in\Theta_i\}}u_{DM}(\theta)\right) < 0 \text{ for any } i,\ E_\theta\left(1_{\{\theta\in E^+\}}u_{DM}(\theta)\right) > 0 \text{ and } E_\theta\left(1_{\{\theta\in\Theta_1\cap E^-\}}u_{DM}(\theta)\right) < 0.$$

Since for any $i > 1$, $\Theta_i \cap E^- = \Theta_i$, we must also have:

$$E_\theta\left(1_{\{\theta\in E^-\}}u_{DM}(\theta)\right) = E_\theta\left(1_{\{\theta\in\Theta_1\cap E^-\}}u_{DM}(\theta)\right) + \sum_i E_\theta\left(1_{\{\theta\in\Theta_i\}}u_{DM}(\theta)\right) < 0.$$

Therefore, $G(\Theta)$ must already admit a delegation-like equilibrium which dominates this more informative equilibrium: indeed, delegation is always preferred by E, and DM's expected payoff in the more informative equilibrium is:

$$\beta_1 E_\theta\left(1_{\{\theta\in E^+\}}u_{DM}(\theta)\right) \leq E_\theta\left(1_{\{\theta\in E^+\}}u_{DM}(\theta)\right).$$

A similar argument holds when I_0 is empty, reversing the roles played by E^+ and E^-. Besides, DM's expected payoff is then:

$$E_\theta\left(1_{\{\theta\in E^+\}}u_{DM}(\theta)\right) + (1-\beta_1) E_\theta\left(1_{\{\theta\in E^-\}}u_{DM}(\theta)\right) \leq E_\theta\left(1_{\{\theta\in E^+\}}u_{DM}(\theta)\right),$$

and delegation is again ex-ante Pareto dominant.

5.2 Proof of Lemma 1

If E_1 and E_2 anticipate that the messages will not affect DM's decision, they may as well transmit uninformative messages (i.e., choose $m_1(\theta) = \widetilde{m}$, and $m_2(m_1,\theta) = \widehat{m}$). Given these strategies, it is indeed optimal for DM to base its decision on its prior beliefs, i.e., $d(\widetilde{m},\widehat{m}) = 1$ when $E_\theta(u_{DM}(\theta)) \geq 0$, and $d(\widetilde{m},\widehat{m}) = 0$ when $E_\theta(u_{DM}(\theta)) < 0$. Out-of-equilibrium beliefs can then be adjusted to sustain such an uninformative equilibrium, which thus always exist.

Consider now informative equilibria, and denote: $d^+ \equiv \max d(m_1(\theta), m_2(\theta, m_1(\theta)))$ and $d^- \equiv \min d(m_1(\theta), m_2(\theta, m_1(\theta)))$. We thus look for PBE with $d^+ > d^-$, and we must thus have:

$$\delta^*(\theta) \equiv d\left(m_1^*(\theta), m_2^*(\theta, m_1^*(\theta))\right) = d^+ \text{ for any } \theta \in \Theta^{++} \text{ and } \delta^*(\theta) = d^- \text{ for any } \theta \in \Theta^{--}.$$

Consider now two projects, θ_1 and θ_2, which both belong to Θ^{+-} and are such that, if he knew their true values, DM's optimal decision would be $d^*(\theta_1) = d^+$ and $d^*(\theta_2) = d^-$. Since E_2 wants to minimize the probability of project θ_1 implementation, we must have $d(m_1^*(\theta_1), m_2) = d^+$, $\forall m_2$. Similarly, since E_1 wants to maximize the probability of project θ_2 implementation, we must have that, $\forall m_1$, $\exists \overline{m}_2$ such that $d(m_1, \overline{m}_2) = d^-$. However, this last condition must also hold for $m_1 = m_1^*(\theta_1)$, and thus contradicts the first set of conditions. Therefore, DM's optimal decision (given the experts' reports) must be the same for all $\theta \in \Theta^{+-}$, that is, for any $\theta \in \Theta^{+-}$, $\delta^*(\theta) = d^{+-} \in [d^-, d^+]$. Similarly, for any $\theta \in \Theta^{-+}$, $\delta^*(\theta) = d^{-+} \in [d^-, d^+]$.

Generically, we must have: $d^- = 0$, $d^+ = 1$ and d^{+-}, $d^{-+} \in \{0, 1\}$. This leads to the four following equilibria:

	$d^{-+} = 1$	$d^{-+} = 0$
$d^{+-} = 1$	Implementation-power	Delegation to E_1
$d^{+-} = 0$	Delegation to E_2	Veto-power

which exist under the following conditions.

- "Implementation-power" exists if and only if $d^- = 0$, $d^+ = d^{+-} = d^{-+} = 1$ are DM's optimal decisions, that is, if and only if $U^{++} + U^{+-} + U^{-+} \geq 0$.
- "Veto-power" exists if and only if $d^- = d^{+-} = d^{-+} = 0$, $d^+ = 1$ are DM's optimal decisions, that is, if and only if: $U^{--} + U^{+-} + U^{-+} < 0$.
- "Delegation to E_1" exists if and only if $d^- = d^{-+} = 0$, $d^+ = d^{+-} = 1$ are DM's optimal decisions, that is, if and only if: $U^{++} + U^{+-} \geq 0$ and $U^{--} + U^{-+} < 0$.
- "Delegation to E_2" exists if and only if $d^- = d^{+-} = 0$, $d^+ = d^{-+} = 1$ are DM's optimal decisions, that is, if and only if: $U^{++} + U^{-+} \geq 0$ and $U^{--} + U^{+-} < 0$.

5.3 Proof of Proposition 4

Consider first projects $\theta \in \Theta^{++}$ or $\theta \in \Theta^{--}$. In those two cases, both experts agree about the optimal outcome. Thus, for $\theta \in \Theta^{++}$, in equilibrium we must have either $\delta^*(\theta) = 1$ or $d(m_1, m_2, r_1, r_2) = 0$ for all possible messages (m_1, m_2, r_1, r_2).[18] Similarly, for any $\theta \in \Theta^{--}$, we must have either $\delta^*(\theta) = 0$ or $d(m_1, m_2, r_1, r_2) = 1$ for any (m_1, m_2, r_1, r_2).

Suppose now that there are two projects, θ_1 and θ_2, in Θ^{+-} such that DM's optimal decisions would differ if he were perfectly informed, i.e., $\delta^*(\theta_1) = 1$ and $\delta^*(\theta_2) = 0$. For project θ_1, DM's equilibrium strategy must prevent E_2 from deviating either at the message stage or at the rebuttal stage. Therefore, for any m_2, it will exist $\widetilde{r}_1(m_1, m_2)$ such that:

$$d(m_1^*(\theta), m_2, \widetilde{r}_1(m_1; m_2), r_2) = 1 \text{ for any } r_2.$$

[18] As before, $\delta^*(\theta)$ denotes the equilibrium decision for a project θ given the players' equilibrium strategies.

Moreover, for θ_2, DM's equilibrium strategy must prevent E_1 from deviating either at the message stage or at the rebuttal stage. Therefore, for any m_1, there must exist $\underline{m}_2(m_1)$, such that, for any r_1, there exists $\widetilde{r}_2(m_1, \underline{m}_2(m_1), r_1)$ such that:

$$d(m_1, \underline{m}_2(m_1), r_1, \widetilde{r}_2(m_1, \underline{m}_2(m_1), r_1)) = 0.$$

However, these two conditions are incompatible since, for instance for $\theta = \theta_2$, E_1 could profitably deviate by sending $m_1^*(\theta_1)$ rather than $m_1^*(\theta_2)$. Thus, DM's equilibrium decision must be the same for all $\theta \in \Theta^{+-}$. A similar argument holds for all $\theta \in \Theta^{-+}$, and therefore, any PBE of the rebuttal game must satisfy $\delta^*(\theta) = 1$ for any $\theta \in \Theta^{++}$, $\delta^*(\theta) = 0$ for any $\theta \in \Theta^{--}$, $\delta^*(\theta) = d^{+-} \in \{0,1\}$ for any $\theta \in \Theta^{+-}$ and $\delta^*(\theta) = d^{-+} \in \{0,1\}$ for any $\theta \in \Theta^{-+}$. Moreover, such equilibria will exist under the same conditions of existence as in a single-round communication game. Therefore, rebuttal does not yield more informative equilibria.

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