# Information Acquisition and the Organization of Expertise in the Presence of Communication

Flavia Roldán*
Public-Private Sector Research Center, IESE Business School†
(PRELIMINARY AND INCOMPLETE, Comments are welcome)

January, 2009

**Abstract**

A decision-maker has to elicit information from informed multiple experts about a policy's value. The principal may prevent communication among agents. However, it may be in the principal's interest to allow communication among them. We assume that communication lets some synergies among experts emerge but also opens the possibility of collusion among them. We study the optimal design of contracts focusing on the organization of the expertise. We show that, from principal's point of view, communication dominates to no communication when the synergy's effects prevail over the collusion problem. Then, for the case of two experts is better to form a single team. However, when experts are more than two, under some circumstances, partial communication may dominate. Therefore, a set of several teams may be better than a single one.

**JEL Classification Numbers**: D81; D82: L23

**Keywords:** information acquisition;communication; cooperation; collusion; expertise; organization, teams

*I am grateful to Antonio Cabrales for his advice, guidance and support. I have greatly benefited from comments and useful suggestions of Carlos Ponce, Antonio Romero, Guillermo Caruana, José Penalva and Juan José Ganuza. The usual disclaimers apply.

†Address for Correspondence: *Flavia Roldán:* Public-Private Sector Research Center, IESE Business School, Av. Pearson 21, (08034), Barcelona, Spain, E-mail: froldan@iese.edu

# 1 Introduction

Many decisions in real life are complex and involve a multiplicity of aspects. In these cases decision-makers rarely have the time or the skills to gather, to process, and to summarize all the relevant information to take better decisions. Therefore, it is usually observed that they base their decisions on the information provided by specialized experts who are hired for that specific goal. In this research, the particular way information is produced plays an important role and, in particular, as Arrow pointed out (1969, p.30) "Knowledge arises from deliberate seeking, but it also arises from observations incidental on other activities".

More precisely, the goal of this article is to examine the following economic framework. An uninformed principal ("she"), must elicit information from unbiased agents (experts, "he") who must, in turn, decide whether or not to collect costly but precise information (this is what Arrows calls "deliberate seeking"). After that, if the agents communicate between them each one will obtain a better or more precise signal about the piece of information initially acquired (this is for us Arrows' remark about "Knowledge...also arises from observations incidental on other activities"). Finally our simple framework also incorporates opportunistic considerations: We assume that communication opens the possibility of collusion among the agents against the main interest of the principal.

Since communication has conflicting consequences, the main question addressed in this paper is: Should principals promote or impede communication among experts? This issue is studied in a multiagent-principal framework when communication among agents allows not only cooperation in favor of the principal but also collusion against her.

In our setting, the principal has to decide whether to implement a policy which has two possible observable outcomes: success or failure. She gains access, through agents, to noisy signals. The signals are independent conditional on the policy's outcome. Each signal has two possible values: "high" or "low" and in order to undertake the policy, all signals must be "high".

Each expert must gather information and send to the principal a report about the true state of the policy. These tasks have special features: to gather information is costly, and since reports are soft information, they are fully manipulable.[1] Therefore, experts must be given incentives to both gather and truthfully transmit precise information.

We study and compare the principal's net surplus under different organizational forms.

First, we compare the principal's net surplus under no communication and communication case, but when it only involves its detrimental effect, i.e., potential collusion. In such a case, the principal is better off by avoiding communication among agents since it only imposes additional constraints to her problem.

[1] That is, the signal observed by agents and their reports need not coincide. Additionally, experts are protected by limited liability.

Then, we consider the case in which communication may have conflicting consequences. When the number of experts is equal to two, the principal can organize them into one single alliance and thus to allow communication or, alternatively, prevent communication among them. In the first case, the principal bases her decision on one single report provided by the team. In the second case, she bases her decision on the two reports produced by each isolated expert.

On the one hand, when agents communicate with each other, signals are more precise than in the absence of communication. This fact has not only a positive direct impact on the principal's surplus but also it makes the informational problem less severe. Moreover, when experts are organized into an alliance, they are able to coordinate their effort's choices in collecting information. Hence, that coordination between them reduces the agency cost.

In contrast, when the principal prevents communication between agents, she sacrifices signal's precision. However, in this circumstance, the principal takes advantage of multiple reports by cross checking them.

If the signal's precision sufficiently increases with communication, the principal is better off by organizing experts into one single team rather than avoiding communication between them.

However, if the number of experts is greater than two, is it still true that the principal is better off by allowing communication among experts and by forming one single team?

When the number of agents is greater than two, the principal can organize experts in alternative forms: i) to organize them such that no communication among agents can take place; ii) to organize experts in one single team, so that all of them are able to communicate and monitor each other; iii) the principal can form several groups or alliances of advisors such that only the members of the group can communicate with each other and monitor themselves.

To answer our question, it is worth pointing out the trade-off among all these alternative organizations. When agents work alone, the principal can take advantage of competition among them and she uses her ability to cross-check reports, even though neither synergy effects nor mutual monitoring can take place. On the other extreme organization, one single team, the principal fully exploit advantage of communication and the precision of the information provided by the alliance is greater than in any other case. Moreover, in this organization form, agents can monitor each other.

Alternatively to both organizations mentioned, the principal may organize experts into several teams. By doing that, she allows experts to exploit their complementarities and coordinate their effort's choice inside each team. Additionally, in this case, the principal is able to cross-check the reports provided by the multiple teams.

We show that, in some circumstances, the principal may be better off by forming a set of several alliances rather than by forming one single team, and in any case, communication dominates no communication from the principal's point of view. These results contribute with theoretical justifications to the rationality of having multiple teams with the same functions.

The current article is linked to three lines of research: endogenous acquisition of information, transmission of information and organization of expertise, specifically teams.

The literature focusing on information revelation obtains as a main result that if there are no costs of supplying information, perfect information transmission requires that the decision-maker and the expert have identical preferences. In this line of research, Wolinsky (2002) is close to this article. He studies the ability of the decision-maker to elicit information from multiple biased experts. The focus is on how the decision-maker can take advantage of *multiple experts*. He shows that in some circumstances, allowing *partial* communication among experts might result in revelation of more information than either full communication or no communication.

However, in all these papers, the focus is on strategic information revelation but not on information acquisition. In contrast, in the current article, the decision-maker elicits information from multiple unbiased experts where agents must decide whether or not to acquire information. Several authors analyze this issue in the literature. For example, Li (2001) and Szalay (2005) examine information acquisition when players have the same preferences but when *it is not possible to implement monetary incentives*. Li (2001) assumes that the precision of the signal that agents provide is increasing in effort and he shows that commitment to excessive conservatism in the decision-making of committees can be used to increase the incentives to acquire information. Szalay (2005) also considers that the probability to learn the state is increasing in effort and he shows that the principal finds optimal to let the agent choose the action but excludes actions from the choice set, which are optimal when no information is acquired. However, as in the current article, Gromb and Martimort (2007), consider the design of monetary incentives, and they study the implications of optimal incentives contracts for the organizational design of expertise. They assume a principal, who bases her decision on two signals about a project's value, and agents, who can draw independent signals at a fixed cost per signal. After receiving the signals, the agents recommends to either undertake the project or not. They show that it is optimal to reward the agent if his recommendation is confirmed by the state or *by another recommendation* (conflicting reports are penalized).[2] After that, they analyze when it is optimal, from the principal point of view, to have a single expert gathering two signals or two experts collecting one signal each.

In the present paper, unlike Gromb and Martimort (2007), we assume that the precision of the signals is not only increasing in effort (a fixed cost per signal) but it is also increasing in (horizontal) communication among agents. And, at this point, the organization of expertise becomes crucial. With *multiple agents*, how should experts be organized in order to ensure they refine their knowledge about the true state and fully disclose their signals? In the current article, in difference with Gromb and Martimort (2007), we analyze the optimal organization when the number of expert is *equal or greater* than two. This feature leads us to also apply team literature where we develop theoretical reasons supporting the optimality of having various teams even though it

[2] Köhler (2004) shows that this does not necessarily hold when the state and signal space are continuous.

seems redundant.

The traditional analysis of team work, initialized by Holmström (1982), emphasizes the existence of a free riding problem, which raises the incentive cost of the principal. However, in the literature there also are two strands that study cooperation between agents from another perspective. In one of them cooperation can be viewed as the possibility for an agent to help his fellow in accomplishing a task.[3]

A second strand in this literature, closer to this work, considers cooperation through the agent's possibility to side-contract on their action choices. Holmström and Milgrom (1990) and Itoh (1993) show that the principal benefits from letting the agents side contract on their effort choices, when they can perfectly observe each other's effort. Then, the principal is contracting with a consolidated unit, whose utility is the sum of it's members utilities, thus the employees can monitor each other's effort and coordinate their action. Nikolova (2005) analyzes the optimal mutual monitoring-incentive pay mix and she finds that the optimal mix depends on the agents' liability limit.

The paper proceeds as follows. Before introducing the model, we emphasize the main results of the paper by providing an example. Then, Section 2 presents the general setting and Section 3 contains an analysis of the optimal organization when communication does not improve the accurate of the signals obtained by advisors. Section 4 is devoted to the comparison of a single team with competing agents setup, when the number of agents is 2. And Section 5 studies an alternative organization form when expert are more than 2: forming groups of agents and investigating which is the optimal organization from the principal's point of view. Finally, Section 6 concludes. All proofs and calculations details are in the Appendix.

## An example: an intelligence problem

Consider the problem faced by the Director of Intelligence of country A. The Director has received an alert of sabotage against tabloid press and must decide whether or not to impose red alert. For that purpose, she hires two spies who must provide information about the likelihood of that sabotage. By now, assume that spies work isolated and the identity of the agents remains unknown to each other. Each spy must decide whether to collect intelligence data or not. After collecting data, he processes all this information and obtains a noisy signal about the probability that an attack occurs.

For example, one of the spies might obtain information from the interception of communications (telephone calls, e-mails, letters and so on). Then, he processes all of this data and he gets a signal although some of the individuals mentioned in the phone-calls or in the letters can not be declared "dangerous" because he has no proofs for that. The other spy concentrates his investigations on studying information about people who have entered and left the country in the past year. Similarly, he processes all this data, gets a signal, but he does not find any conclusive evidence that some of the individuals being investigated are involved in the attack against the yellow press.

[3] Itoh (1991), Macho-Stadler and Perez-Castrillo (1993) among others.

The Director of Intelligence receives one signal from each agent, and then, he will take a decision. If the spies supply conflicting signals, the Director's penalizes them, since the state of the world is only one (i.e., sabotage or not).

However, assume now, that the Director let the agents to communicate with each other. In such a case, they would mutually exchange their initial knowledge and some pieces of information that before were irrelevant would now become important for the investigation. For example, they would realize that the name of some of the individuals mentioned in the letters or in the phone-calls coincide with the people which have entered and left the country in the last few months and that could be enough evidence that these people are involved in the attack. Therefore, communication improves signal's precision.

Nevertheless, the spies may be corrupt and, since they are in communication, they may coordinate their reports to show that the sabotage is only a rumor spread by the yellow press itself. Then, the Director's problem now is whether to allow or not communication between the spies. If the benefit from sharing information outweigh the potential collusion cost, then it seems reasonable that both spies work together like a unique intelligence team.

**Intelligence Agencies.** Assume, that the Director has recruited more than two secret spies. What should the Director do so? How should the spies be organized?

She may not reveal the identity of her secret spies. By doing that, she lets the agents to work isolated and avoids communication among them. But, in such a case, she is not able to exploit the complementarities between them. Alternatively, she can fully exploit them by forming one single agency, though by this way she also opens the door to collusive behavior. An hybrid of these organizational forms is to create separate intelligence agencies to capture the same signal. She avoids communication among agencies but she allows it inside each team. By doing that, the Director can take advantage of the cooperation intra-team and, at the same time, can cross-check the reports provided by each agency (inter-teams), this last one as the tool to control the drawback of communication.

# 2 The General Setting

We consider the relationship between one risk neutral principal (minister) and two risk neutral agents (advisors).

The minister has to choose an action $a \in \{0, 1\}$, where 1 stands for implementing a policy, and 0 otherwise.

The outcome of that policy $y$ is either success or failure, that is $y \in \{0, 1\}$. The common prior for success is $\Pr(y = 1) = v < 1/2$.

When the policy is undertaken, it will have two possible observable monetary outcomes, i.e., $S > 0$ when $y = 1$, or $F < 0$ otherwise. If the policy is not undertaken, its outcome will not be observed.

To sum up, the minister's gross payoff depends on $a$ and on an unknown state of the world $y$, according to the following:

$$V(a,y)\begin{cases} S & \text{if } a=1 \text{ and } y=1 \\ F & \text{if } a=1 \text{ and } y=0 \\ 0 & \text{otherwise} \end{cases}$$

We assume that, without additional information, it is not efficient to implement the policy: $E[V(a,y)] = vS + (1-v)F < 0$. Therefore, in such a case, the minister's optimal decision is $a=0$, i.e., the status quo.

The principal, however, has neither the time nor the skills to gather and process all information related to the policy's success. Therefore, she consults unbiased agents (i.e., they respond only to monetary incentives).

The agent's output is *a precise report* about the true state of the world. The report's precision *initially* depends on the level of effort supplied by each advisor. Each one simultaneously chooses a level of effort $e_i \in \{0,1\}$, that is, he gathers and studies information about the policy's success, i.e. "work" ($e_i = 1$) or "shirk" ($e_i = 0$).

Exerting effort is costly, then $c(e_i = 0) = 0$ and $c(e_i = 1) = c > 0$.

When $e_i = 1$, expert $i$ gets a noisy signal $\sigma_i^\circ \in \{\underline{\sigma}_i^\circ, \overline{\sigma}_i^\circ\}$, where $\overline{\sigma}_i^\circ$ means that the policy's outcome $y$ is more likely to be a success and $\underline{\sigma}_i^\circ$ increases the likelihood that $y$ may be failure. (The superscript 0 stands for the signal the advisor gathers just after exerting some effort.)

We assume that noisy signals are independent conditional on the policy's outcome.

Let $p(\overline{\sigma}_i^\circ | y=1) = p(\underline{\sigma}_i^\circ | y=0) \equiv p^i(e_i), \forall i$ be the *initial* signal's precision of advisor $i$ when $e = e_i$.

*Assumption 1* $p^i(e_i) \in (0,1)$, *and* $p^i(e_i) = p^j(e_j)$, $\forall\ i,j$ *such that* $e_i = e_j$ *with* $p^i(e_i = 0) = v$ *and* $p^i(e_i = 1) = a > 1/2$, $\forall i$.

The Assumption says that all experts are equally precise, and if an agent chooses "shirk", i.e., $e_i = 0$, he produces a signal which has a precision equal to the prior. However, if the expert chooses "work" ($e_i = 1$), he gets a more precise signal.

After that, and before agents send the report to the principal, they may communicate with each other.

We assume that two alternative organizational structures can take place. In one of them, advisors are able to communicate with each other, and this will be the "communication work structure" (CWS henceforth). In the second alternative, advisors remain isolated and therefore, no exchange of information can occur. We call this kind of organization the "isolated work structure", IWS henceforth.

In the first situation, there are two forces at play in the communication phase. On the one hand, we assume that communication introduces the possibility of collusion between experts. That is, agents can jointly manipulate the information they get against the principal.

On the other hand, we assume that communication increases the precision of the signal that each agent receives. We can imagine that after agents exert some effort, they have a "rough" idea about the true state of the world. If they were able to communicate their *preliminary* knowledge with each other, they would obtain a more "polished" idea about the desirability of principal's actions. We can interpret it as the communication between experts allows some synergies between them to emerge.

Hence, the communication process produces a new signal $\sigma_i^1$ for $i = 1, 2$ which has, at least, an equal precision than if no communication takes place. (The superscript 1 stands for the signal that the agent obtains after the communication stage.)

Define $E_{-i} = \sum_{-i} e_{-i} \in [0, n-1]$ as the level of effort supplied by the other experts who communicate with expert $i$. In other words, $E_{-i}$ is the number of information sources of agent $i$.

Thus, when communication takes place, the final signal's precision depends not only on $e_i$ but also on $E_{-i}$. That is, $p^i = p^i(e_i, E_{-i})$. The next assumption describes the relationships between all these variables.

*Assumption 2*

**i)** $p^i(1, E_{-i}) > p^i(0, E_{-i}) = v$ *for all* $E_{-i}$.

**ii)** $p^i\left(e_i, E''_{-i}\right) \geq p^i\left(e_i, E'_{-i}\right)$ *for all* $E''_{-i} > E'_{-i}$ *and with strict inequality for* $e_i = 1$.

**iii)** $p^i\left(e_i, E'''_{-i}\right) - p^i\left(e_i, E''_{-i}\right) < p^i\left(e_i, E''_{-i}\right) - p^i\left(e_i, E'_{-i}\right)$ *for all* $E'''_{-i} > E''_{-i} > E'_{-i}$ *and for* $e_i = 1$.

The first part of the Assumption says that the communication is only useful if the experts have an initial idea ($\sigma_i^\circ$) of what "they are talking about". In terms of our example, when experts communicate with each other but at least one of them has no idea about the "subject" of the talk, the chat is useless and the communication does not improve the signal's precision. That is, $p^i(0, E_{-i})$ is equal to the common prior.

The second part of the assumption says that the signal's precision is an increasing function in the number of information sources that each agent has. And, it is *strictly* increasing in $E_{-i}$ when the agent puts some effort into processing the initial information, i.e., $e_i = 1$. In other words, the marginal productivity of his own effort increases as $E_{-i}$ increases.

And finally, Part *iii*) states that the signal's precision is a concave function in $E_{-i}$. That is, the marginal productivity of communication $\left(p^i\left(e_i, E''_{-i}\right) - p^i\left(e_i, E'_{-i}\right)\right)$ decreases with the number of the sources of information.

Hence, communication as cooperation may improve the principal's welfare, however the other force, communication as collusion, may go in the opposite direction.

On the contrary, if agents do not communicate with each other, the principal avoids the collusion problem but she cannot take advantage of the synergy effects between agents (communication as cooperation).

After that, the principal asks experts to send reports. Given these messages, the principal updates her belief about the future state of $y$ and chooses an action. At the end, the state of the world is realized, the transfers are paid, and payoffs are realized.

Finally, we assume that advisors are protected by limited liability and they have the same preferences. Thus, the expert's payoff function is

$$t(\cdot) - c(e_i) \geq 0$$

where $t(\cdot)$ is the transfer that the agent receives from the principal, which we will discuss further.

The principal's net payoff will be

$$V(a, y) - t(\cdot)$$

It is worth remarking that experts produce soft information which is non-verifiable and fully manipulable. Therefore, the principal must solve two kinds of problems: to design a contract such that advisors exert effort and also truthfully reveal their private information.

# 3 The benchmark case: IWS versus CWS without synergy effects and with collusion

We will show that if there are no synergy effects between experts when they communicate with each other, then the principal is better off when she avoids communication between them. In other words, when communication does not improve the quality of signals, it only imposes additional constraints on the principal's problem.

We first characterize the optimal contract in each situation.

A contract for an expert consists of transfers from the principal and a decision rule whether to undertake the policy based on the agent's reports. Before introducing the benchmark case, it is useful to present some notation and definitions.

**Definition 1** *Denote by $p(\sigma)$ the likelihood of $\sigma \in \{\underline{\sigma}, \overline{\sigma}\}$, and by $p(\sigma\sigma)$ the likelihood of $(\sigma\sigma) \in \{\underline{\sigma}, \overline{\sigma}\}^2$.*

For example, when an advisor exerts effort, $p(\bar{\sigma}) = p(\bar{\sigma}|y=1)\, p(y=1) + p(\bar{\sigma}|y=0)\, p(y=0) =$ $= av + (1-a)(1-v)$.[4]

Likewise, since signals are independent conditional on policy's outcome, $p(\bar{\sigma}\bar{\sigma}) = a^2 v + (1-a)^2 (1-v)$.

**Definition 2** *Let $v(\sigma)$ be the probability of success conditional on $\sigma$, and $v(\sigma\sigma)$ be the probability of success conditional on $\sigma\sigma$.*

Hence, $v(\sigma) = \frac{p(\sigma|y=1)p(y=1)}{p(\sigma)}$.[5]

[4] Recall, we assume that $\Pr(\bar{\sigma}|y=1) = \Pr(\underline{\sigma}|y=0)$.

[5] Thus, for example, $v(\underline{\sigma}\overline{\sigma}) = \frac{p(\underline{\sigma}\overline{\sigma}|y=1)p(y=1)}{p(\underline{\sigma}\overline{\sigma})} = v$.

## 3.1 Isolated Work Structure

We consider now, an isolated work structure of advisors. That is, we are assuming that agents do not communicate with each other. In turn, this implies that the signal each agent obtains, $\sigma_i^\circ$, as well as whether they put in some effort are not observable by other parties, i.e. neither by the principal nor by the other expert.

The timing is as follows. The principal offers each expert a contract. Each one accepts or rejects it. If he accepts, he decides whether to gather information, and then sends a message. Given these messages, the principal updates her belief about the future state of $y$ and chooses an action. Finally, the state is realized, the transfers are paid, and payoffs are realized.

### Optimal Contracts

Since signals and efforts are not observable by the principal, the transfers can only be based on reports and on the policy's outcome.

It is important to remark that the policy is undertaken only when both reports are positive. This is because, after the principal receives either conflicting or two negative signals and updates her beliefs ($v(\underline{\sigma}\underline{\sigma}) < v(\underline{\sigma}\overline{\sigma}) = v$), the optimal action will be to not undertake the policy.

Therefore, when $a = 0$, reports are not verifiable. However, we will see that the principal can use the correlation between them to extract informational rents from experts.

Thus, $\bar{t}$ is the transfer received by the expert if the policy is undertaken and is a success, $\underline{t}$ is the transfer when the policy is undertaken but it fails.

If the policy is not taken on, $t_0$ is the transfer when both signals are negative and, in case of conflicting reports, the expert reporting $\bar{\sigma}$ receives $t_g$, and the other, whose report is $\underline{\sigma}$, receives $t_b$.

The contract that the principal offers must provide advisors with incentives to gather information and report it accurately.

In the optimal contract, each expert should prefer to gather information rather than remain uninformed.

That is, the agent will prefer to gather information rather than to remain uninformed and report $\underline{\sigma}$:

$$p(\bar{\sigma}\bar{\sigma})\left[v(\bar{\sigma}\bar{\sigma})\,\bar{t} + (1 - v(\bar{\sigma}\bar{\sigma}))\,\underline{t}\right] + p(\underline{\sigma}\underline{\sigma})\,t_0 + p(\underline{\sigma}\bar{\sigma})\,(t_b + t_g) - c \geq p(\underline{\sigma})\,t_0 + p(\bar{\sigma})\,t_b \quad (1)$$

or report $\bar{\sigma}$:

$$p(\bar{\sigma}\bar{\sigma})\left[v(\bar{\sigma}\bar{\sigma})\,\bar{t} + (1 - v(\bar{\sigma}\bar{\sigma}))\,\underline{t}\right] + p(\underline{\sigma}\underline{\sigma})\,t_0 + p(\underline{\sigma}\bar{\sigma})\,(t_b + t_g) - c \geq p(\bar{\sigma})\left[v(\bar{\sigma})\,\bar{t} + (1 - v(\bar{\sigma}))\,\underline{t}\right] + p(\underline{\sigma})\,t_g \quad (2)$$

Likewise, when an expert observes $\bar{\sigma}$, he should not prefer to report $\underline{\sigma}$. Then,

$$p(\bar{\sigma}|\bar{\sigma})\left[v(\bar{\sigma}\bar{\sigma})\,\bar{t} + (1 - v(\bar{\sigma}\bar{\sigma}))\,\underline{t}\right] + p(\underline{\sigma}|\bar{\sigma})\,t_g \geq p(\bar{\sigma}|\bar{\sigma})\,t_b + p(\underline{\sigma}|\bar{\sigma})\,t_0 \quad (3)$$

And, when he observes $\underline{\sigma}$, he should not prefer to report $\bar{\sigma}$. That is:

$$p\left(\bar{\sigma}|\underline{\sigma}\right)t_b + p\left(\underline{\sigma}|\underline{\sigma}\right)t_o \geq p\left(\bar{\sigma}|\underline{\sigma}\right)\left[v\left(\bar{\sigma}\underline{\sigma}\right)\bar{t} + \left(1 - v\left(\bar{\sigma}\underline{\sigma}\right)\right)\underline{t}\right] + p\left(\underline{\sigma}|\underline{\sigma}\right)t_g \tag{4}$$

The contract also must satisfy the incentive participation and limited liability constraints

$$p\left(\bar{\sigma}\bar{\sigma}\right)\left[v\left(\bar{\sigma}\bar{\sigma}\right)\bar{t} + \left(1 - v\left(\bar{\sigma}\bar{\sigma}\right)\right)\underline{t}\right] + p\left(\underline{\sigma\sigma}\right)t_0 + p\left(\underline{\sigma}\bar{\sigma}\right)\left(t_b + t_g\right) - c \geq 0 \tag{5}$$

$$\bar{t}, \underline{t}, t_0, t_b, t_g \geq 0 \tag{6}$$

Hence, the principal's problem is

$$\min_{\bar{t},\underline{t},t_0,t_b,t_g} p\left(\bar{\sigma}\bar{\sigma}\right)\left[v\left(\bar{\sigma}\bar{\sigma}\right)\bar{t} + \left(1 - v\left(\bar{\sigma}\bar{\sigma}\right)\right)\underline{t}\right] + p\left(\underline{\sigma\sigma}\right)t_0 + p\left(\underline{\sigma}\bar{\sigma}\right)\left(t_b + t_g\right)$$

subject to (1)-(6).

This problem has been already solved by Gromb and Martimort (2007), henceforth GM, and for brevity we only report optimal transfers and the agency cost.

*The optimal transfers are*

$$\underline{t} = t_b = t_g = 0$$

$$\bar{t} = \frac{p\left(\underline{\sigma}\right)c}{v\left(1 - v\right)\left(2a - 1\right)a^2} \text{ and } t_0 = \frac{c}{\left(1 - v\right)\left(2a - 1\right)a}$$

*while the agency cost for the isolated work structure is ($T_{IWS}$)*

$$T_{IWS} = 2\frac{c\left[p\left(\underline{\sigma}\right) + \left(1 - v\right)\left(2a - 1\right)a\right]}{\left(1 - v\right)\left(2a - 1\right)a} \tag{7}$$

In this circumstance, as GM point out, a positive report is only rewarded when the other report is also positive and the policy's outcome is success ($\underline{t} = t_g = 0$). Additionally, conflicting reports are also penalized. Since signals are correlated, a negative report is only rewarded when the other report is also negative ($t_b = 0$).

Because of the current principal's ability to cross-check reports, the expert's informational rent is reduced and the agency cost is less than if there were a single agent gathering two signals. GM say that in this case, there are "*economies of scale due to the agency costs*".

## 3.2 Communication Work Structure without synergy effects and with collusion

Now, we assume that after agents exert some level of effort to gather information, they can communicate with each other. By now, when communication takes place, agents can jointly manipulate their reports against the principal. The key point here is that communication allows agents to sign self-enforcement contracts contingent on observable variables for them.[6] The role of this sort of contract is only mutual risk sharing.

In this case, the optimal contract is also based on reports and on the policy's outcome. Although moral hazard constraints are the same as when no communication takes place, adverse selection constraints change and they reflect the principal's inability to distinguish all pairs of reports leading to the status quo. That is, communication, in this circumstance, only introduces additional constraints to the IWS.

The agency cost provided by GM for this case is

$$T_{CWS} = 2\left[\frac{c\left[1+(1-v)(2a-1)\right]}{(1-v)(2a-1)\,p(\underline{\sigma})}\right] \tag{8}$$

and $\bar{t}$, $t_0$, $t_b$, $t_g$ are strictly greater than zero.

## 3.3 IWS versus CWS without synergy effects: The cost of collusion

As we see from the above discussion, the principal can provide a contract which is robust to collusion between experts. However, doing that is costly.

That is, when the communication between experts is not possible, i.e., IWS, the principal has the ability to cross-check reports and penalize conflicting reports.

On the contrary, when agents are able to communicate with each other, the principal cannot discern between reports that lead to the status quo. In order to give incentives to reveal truthfully, the transfers to experts in case of conflicting reports will be the same as in case of two negative signals, i.e., $2t_0 = t_g + t_b$. Therefore, the principal cannot completely penalize divergent reports ($t_g \neq t_b \neq 0$). Thus, the potential collusion between experts makes this instrument less efficient.

Then, whether the principal must allow or forbid communication between agents depends on whether the agency's cost of IWS is greater or lesser than the agency's cost of CWS.

By simple manipulation, it is possible to see that

$$T_{CWS} - T_{IWS} = \frac{(2a-1)\,v + p(\bar{\sigma})\left[p(\underline{\sigma}) + a(2a-1)(1-v)\right]}{a(2a-1)(1-v)\,p(\underline{\sigma})} > 0$$

The above difference is how much the agency's cost increases due to collusion. We define that as the cost of collusion.

We characterize this difference by providing some intuition of it.

[6] Our context assumes that there are no frictions among agents. This differs from Jeon, D.-S and Menicucci, D. (2005). They study the optimal sale mechanism which takes into account not only individual incentive compatibility but also coalition incentive compatibility. They show that, although, in the optimal sale mechanism, marginal rates of substitution are not equalized across buyers of different types, they fail to realize the gains from arbitrage because of the transaction costs in coalition formation generated by asymmetric information.

First of all, let us note that as $v$ increases the collusion's cost also increases. That is, as the prior of success increases, agents are more tempted to report good news $(\bar{\sigma}\bar{\sigma})$. Then, they must be given more incentives to report bad news when they really observe it, i.e., $t_0 \geq v\bar{t}$.

Second, let us observe that the cost of collusion is decreasing in $a \in (1/2, 1]$.[7] This is because, when agents are more precise, it is easier for the principal to give experts incentives to report good news when they observe that, i.e., $v(\bar{\sigma}\bar{\sigma})\,\bar{t} = \frac{a^2 v}{p(\bar{\sigma}\bar{\sigma})}\bar{t} \geq t_0$.

The following Proposition is immediate from the above discussion.

**Proposition 1** *Assumes communication only involves collusion among agents and there are no synergy effects. The principal is better off avoiding communication among agents, since the agency cost of IWS is less than the agency cost of CWS.*

# 4 IWS versus CWS with Synergy Effects and Collusion

We assume that when agents communicate with each other, there are two opposite forces at work. On the one hand, communication allows some synergies between experts to emerge. We assume that experts are working together and this common 'workplace' allows them to exploit some complementarities.

On the other hand, communication between experts has another effect. Experts can jointly manipulate their reports in their own interest. Therefore, communication lets agents collude against the principal, and hence they may take decisions that improve their welfare but not necessarily the well-being of the principal.

Alternatively, if there is no communication among experts, i.e., the isolated work structure (IWS), the principal can avoid the collusion problem, but she cannot take advantage of the cooperation between agents.

In this section, we will show that if synergy effects are sufficiently large, the principal is better off when agents communicate with each other.

## 4.1 Communication Work Structure with synergy effects and collusion

Now, we analyze the principal's problem when the principal has to elicit information from unbiased experts and, at the same time, she wants to exploit the synergy effects between them that emerge when they are communicated.

In this environment, we study, from principal's point of view, which is the best way to exploit the complementarities among experts, i.e., by asking each of them for

[7] The collusion cost goes to infinity as $a$ goes to $1/2$, and it goes to $\frac{v(1+2(1-v))}{(1-v)^2} < \infty$ when $a$ tends to 1.

one report or, alternatively, by asking for only one joint report from agents who are communicated.

In the following the superscript $S$ stands for the presence of synergy effects. Therefore, for example, $p^S(\bar{\sigma}\bar{\sigma})$ denotes the likelihood of $\bar{\sigma}\bar{\sigma}$ given that agents were communicated and synergy effects exist. Likewise, $v^S(\bar{\sigma}\bar{\sigma})$ denotes the probability of success conditional on $\bar{\sigma}\bar{\sigma}$ under the presence of synergy effects between experts.

### 4.1.1 CWS with synergy effects: two reports

Let us assume the principal organizes the advisors in a common workplace. There, they are able to communicate with each other.

The principal offers a contract to each expert which must produce a report $\sigma \in \{\underline{\sigma}, \bar{\sigma}\}$.

Each alliance's member simultaneously decides whether to "work" or "shirk". If he decides to exert effort, he obtains a signal $\sigma_i^\circ \in \{\underline{\sigma}_i^\circ, \bar{\sigma}_i^\circ\}, \forall i = 1, 2$, satisfying $p(\sigma_i^\circ = \bar{\sigma}_i^\circ | y = 1) = p(\sigma_i^\circ = \underline{\sigma}_i^\circ | y = 0) = a$, $\forall i$, where $a \in (1/2, 1]$. Signals, which each expert captures, are conditionally independent.

After gathering information, experts can communicate, without cost, with each other. This communication stage delivers, as its outcome, a set of new signals. Each expert gets a new signal, $\sigma_i^1 \in \{\underline{\sigma}_i^1, \bar{\sigma}_i^1\}$ such that $p^S(\sigma_i^1 = \bar{\sigma}_i^1 | y = 1) = p^S(\sigma_i^1 = \underline{\sigma}_i^1 | y = 0) = \epsilon$, $\forall i$, where $\epsilon > a \in (1/2, 1]$.

After the communication phase, the principal asks each agent for one report. Given these messages, the principal updates her belief about the future state of $y$ and chooses an action. Finally, the state is realized, the transfers are paid, and payoffs are realized.

It is worth emphasizing the information available to each agent in each phase:

**i** Whether the expert gathers information or not is observable neither by the principal nor by other alliances' members.

**ii** The signal $\sigma_i$ is not observable by the principal but it is observable by other experts in the communication phase.

Then, as before, transfers are based on reports and on the policy's outcome. For the sake of simplicity, in the following, we assume that $\underline{t} = 0$.[8]

### Optimal Contracts

The principal must provide incentives to each expert to acquire information and also reveal it truthfully.

Moral hazard incentive constraints on gathering information are such that each expert will not prefer to remain uninformed and report $\underline{\sigma}$:

$$p^S(\bar{\sigma}\bar{\sigma})\, v^S(\bar{\sigma}\bar{\sigma})\, \bar{t} + p^S(\underline{\sigma}\bar{\sigma})\,[t_g + t_b] + p^S(\underline{\sigma}\underline{\sigma})\, t_0 - c \geq p(\bar{\sigma})\, t_b + p(\underline{\sigma})\, t_0 \qquad (9)$$

[8]In the IWS part, we have shown that $\underline{t} = 0$ is optimal.

or $\bar{\sigma}$, that is,

$$p^S(\bar{\sigma}\bar{\sigma})\,v^S(\bar{\sigma}\bar{\sigma})\,\bar{t}+p^S(\underline{\sigma}\bar{\sigma})\,[t_g+t_b]+p^S(\underline{\sigma}\underline{\sigma})\,t_0-c\geq p(\bar{\sigma})\,v(\bar{\sigma})\,\bar{t}+p(\underline{\sigma})\,t_g \tag{10}$$

Additionally, when experts, who are communicated, observe $\bar{\sigma}\bar{\sigma}$, they should not prefer to report neither $\underline{\sigma}\bar{\sigma}$ nor $\underline{\sigma}\underline{\sigma}$:

$$2v^S(\bar{\sigma}\bar{\sigma})\,\bar{t}\geq\max\{2t_0,t_g+t_b\} \tag{11}$$

and, when they observe $\underline{\sigma}\underline{\sigma}$, they should prefer to report that rather than $\underline{\sigma}\bar{\sigma}$ or $\bar{\sigma}\bar{\sigma}$

$$2t_0\geq\max\left\{t_g+t_b,2v^S(\underline{\sigma}\underline{\sigma})\,\bar{t}\right\} \tag{12}$$

Finally, if they observed $\underline{\sigma}\bar{\sigma}$, they must report that rather than $\underline{\sigma}\underline{\sigma}$ or $\bar{\sigma}\bar{\sigma}$

$$t_g+t_b\geq\max\{2t_0,2v\bar{t}\} \tag{13}$$

The other constraints to the principal's problem are: (i) the incentive participation constraint for each alliance's members,

$$p^S(\bar{\sigma}\bar{\sigma})\,v^S(\bar{\sigma}\bar{\sigma})\,\bar{t}+p^S(\underline{\sigma}\bar{\sigma})\,[t_g+t_b]+p^S(\underline{\sigma}\underline{\sigma})\,t_0-c\geq 0 \tag{14}$$

and (ii) the limited liability constraints

$$\bar{t},t_0,t_g,t_b\geq 0 \tag{15}$$

Then, the principal‘s program is:

$$\min p^S(\bar{\sigma}\bar{\sigma})\,v^S(\bar{\sigma}\bar{\sigma})\,\bar{t}+p^S(\underline{\sigma}\bar{\sigma})\,[t_g+t_b]+p^S(\underline{\sigma}\underline{\sigma})\,t_0$$

subject to (9)-(15).

**Lemma 1**

*The optimal transfers $\bar{t},t_0,t_g,t_b$ are strictly positive and the agency cost for the two report case $T^S_{CWS(2)}$ is*

$$T^S_{CWS(2)}=2\left[\frac{c\,[1+(1-v)\,(2\epsilon-1)]}{(1-v)\,[(2\epsilon-1)-p(\bar{\sigma})\,(2a-1)]}\right] \tag{16}$$

*The principal's net surplus is*

$$\epsilon^2vS+(1-\epsilon)^2\,(1-v)\,F-T^S_{CWS(2)}$$

The principal lets agents communicate with each other because she wants to exploit the synergy effects between them. However, this is costly on account of the potential collusion against her.

Thus, when no communication is possible, the principal uses the check of cross reports to provide incentives to reveal the truth after they exert effort. Because of that, $t_b = t_g = 0$.

Now, when she allows experts to communicate with each other, she partially loses her ability to cross check reports, and due to that, in the optimal contract $2t_0 = t_g + t_b \neq 0$. In order to induce agents to reveal the truth, she must distort transfers to experts, and in turn this will increase the agency's cost.

Nevertheless, let us recall that the principal also has gains from this organization of expertise: to increase the quality of the signals provided by agents. Thus, it is easy to see that $T^S_{CWS(2)}$ decreases as the communication increases the signal's precision, i.e., it decreases as $(\epsilon - a)$ increases.

### Synergy Effects

We are assuming that communication increases the agent signal's precision because there exists some synergy between them that emerges when they are communicated. This fact not only increases the expected principal's surplus (i.e., $\epsilon^2 vS + (1-\epsilon)^2 (1-v) F$) but it also reduces the minimum cost to provide experts with incentives.

We can see that by taking the difference between (8) and (16), that is:

$$T_{CWS} - T^S_{CWS(2)} = \frac{2(\epsilon - a)\left[1 + (1-v)(2a-1)p(\bar{\sigma})\right]}{(1-v)(2a-1)p(\bar{\sigma})\left[(2\epsilon - 1) - (2a-1)p(\bar{\sigma})\right]} \geq 0$$

The gains due to the reduction in the agency's cost become greater as the communication increases the quality of the signals that each agent obtains. When $\epsilon = a$, there are no gains from communication; and when $\epsilon$ goes to 1, $T_{CWS} - T^S_{CWS(2)}$ is strictly positive.[9]

### CWS with synergy effects: one joint report

Now, we introduce some changes to the expert's organization described in the preceding section. First, the principal organizes the agents in a common workplace and in this common place, they are able to observe each other from the beginning. That is, each expert knows not only the signal that the other gets, but also whether the other agent exerts effort or not.

Second, the principal offers a contract to a coalition of $n$ experts which must produce a joint report $\sigma_A \in \{\underline{\sigma}_A, \bar{\sigma}_A\}$, where $A$ refers to an alliance, according to the following: (i) if each expert obtains $\bar{\sigma}$, they must report $\bar{\sigma}_A$, or (ii) $\underline{\sigma}_A$ otherwise.

Let $p(\sigma_A = \bar{\sigma}_A | y = 1) = p(\sigma_A = \underline{\sigma}_A | y = 0) = \epsilon^2$.

Given this message, the principal updates her belief about the future state of $y$ and chooses an action. Finally, the state is realized, the transfers are paid, and payoffs are realized.

[9] When $\epsilon = 1$, then $T_{CWS} - T^S_{CWS(2)} = \frac{2(1-a)[1+(1-v)(2a-1)p(\bar{\sigma})]}{(1-v)(2a-1)p(\bar{\sigma})[1-(2a-1)p(\bar{\sigma})]} > 0$.

Therefore, the information available to each agent in each phase is the following:

**i** Whether the expert gathers information or not is not observable by the principal but it is observable by other alliance's members.

**ii** The signal $\sigma_i$ is not observable by the principal but it is observable by other experts in the communication phase.

Transfers are based on reports and the policy's outcome. When experts report $\bar{\sigma}_A$, the policy is undertaken and each expert receives $\bar{t}$ if the policy is a success.[10] When experts report $\underline{\sigma}_A$, the policy is not taken on, and each one will receive $t_0$.

### Optimal Contracts

As before, the principal must provide incentives to the alliance to acquire information and also reveal it truthfully.

Moral hazard incentive constraints on gathering information are such that the alliance will not prefer that its members remain uninformed and report either $\underline{\sigma}_A$ or $\bar{\sigma}_A$. Therefore:

$$2\left[p\left(\bar{\sigma}_A\right)v\left(\bar{\sigma}_A\right)\bar{t}+\left(1-p\left(\bar{\sigma}_A\right)\right)t_0-c\right]\geq\max\left\{2t_0,2v\bar{t}\right\} \tag{17}$$

Moreover, the team will not prefer to base its report on only one signal. Then,

$$2\left[p\left(\bar{\sigma}_A\right)v\left(\bar{\sigma}_A\right)\bar{t}+\left(1-p\left(\bar{\sigma}_A\right)\right)t_0-c\right]\geq 2\left[p\left(\bar{\sigma}\right)v\left(\bar{\sigma}\right)\bar{t}+\left(1-p\left(\bar{\sigma}\right)\right)t_0\right]-c \tag{18}$$

Likewise, the adverse selection constraints are the following two. If each alliance's member observes $\bar{\sigma}$, the alliance should prefer to report $\bar{\sigma}_A$ rather than $\underline{\sigma}_A$. That is:

$$2v\left(\bar{\sigma}_A\right)\bar{t}\geq 2t_o \tag{19}$$

If alliance members observe either $\underline{\sigma}\underline{\sigma}$ or $\underline{\sigma}\bar{\sigma}$, the alliance should prefer to report $\underline{\sigma}_A$ rather than $\bar{\sigma}_A$. That is:

$$2t_o\geq 2v\bar{t}\ ^{11} \tag{20}$$

The other constraints to the problem are: (i) the incentive participation constraint for each alliance's members, which is

$$p\left(\bar{\sigma}_A\right)v\left(\bar{\sigma}_A\right)\bar{t}+\left(1-p\left(\bar{\sigma}_A\right)\right)t_0-c\geq 0. \tag{21}$$

and (ii) the limited liability constraints

$$\bar{t}\geq 0, t_0\geq 0 \tag{22}$$

[10] We assume that $\underline{t}=0$. In IWS, we have shown that $\underline{t}=0$ is optimal.

[11] It is easy to check that $v\left(\underline{\sigma}\underline{\sigma}\right)<v\left(\bar{\sigma}\underline{\sigma}\right)=v$. See footnote 2.

Hence, the principal's program is:

$$\min p(\bar{\sigma}_A) v(\bar{\sigma}_A) \bar{t} + (1 - p(\bar{\sigma}_A)) t_0$$

subject to (17)-(22).

**Lemma 2** *When $\epsilon - a > a - \frac{1}{2}$, the optimal transfers $\bar{t}$ and $t_0$ are strictly positive and, in this case, the agency's cost ($T^S_{CWS(1)}$) is*

$$T^S_{CWS(1)} = 2\left[\frac{c(1 + (1-v)(2\epsilon - 1))}{(1-v)(2\epsilon - 1)}\right]$$

*The principal's net surplus is*

$$\epsilon^2 vS + (1-\epsilon)^2 (1-v) F - T^S_{CWS(1)}$$

When $\epsilon - a > a - \frac{1}{2}$ the team of experts is always better off collecting $n = 2$ signals rather than only one. Therefore, if each advisor in the alliance is better off collecting one signal each, then each one will be better off reporting the truth, otherwise it would not pay for these signals. Hence, the adverse selection problem is implied by the moral hazard problem.

The agency's cost expression is intuitive. We can rewrite it as:

$$T^S_{CWS(1)} = 2\left[\frac{c(1 + (1-v)(2\epsilon - 1))}{[p(\bar{\sigma}_A | y = 1) - p(\bar{\sigma}_A)]}\right]$$

First recall that $p(\bar{\sigma}_A | y = 1) = \epsilon^2$. Therefore, as $\epsilon$ increases due to communication, it is less costly to induce agents to reveal good news ($\bar{\sigma}\bar{\sigma}$) when they observe it. That is, constraints (19) is relaxed, and in turn this also relaxes the moral hazard constraints. Thus, the agency's cost reduces as $\epsilon$ increases.

In contrast, as $v$ increases, $p(\bar{\sigma}_A)$ increases, and it is easier to correctly guess "good news" without observing it. Thus, constraint (20) is tightened. In turn, it implies that the moral hazard problem is more severe, hence, the agency cost will be higher.

#### 4.1.2 CWS: one joint report or two reports

In the present context, the principal, who now exploits the synergy effects between experts, allows communication between them. However, agents may collude against her and this is the cost of synergy effects.

Thus, when the principal lets agents communicate and asks for one report from each expert, she uses conflicting reports to provide incentives to agents to make an effort and to tell the truth but, in the presence of communication, this instrument is not fully efficient.

Then, the principal, who partly loses instruments to monitor to agents ($t_g \neq t_b \neq 0$) when they communicate with each other, can let experts monitor themselves, and thus reduce the agency's cost. That is, the principal asks agents for one joint report and also allows them to observe the other expert's effort and each other's signals.

**Proposition 2** *In the presence of communication and synergy effects between experts, the principal is better off letting the experts monitor themselves rather than using cross-check reports to monitor them.*

By simple manipulation, it is easy to see that $T^S_{CWS(2)} - T^S_{CWS(1)} > 0$.

## 4.2 IWS versus CWS with synergy effects and collusion

At this point, the question is: Is the principal better off making decisions based on $n$ isolated reports or on just one joint report? Is the principal better off allowing agents to communicate with each other or not?

When agents communicate with each other, signals are more precise than when no communication exists. This fact has not only a positive direct impact on the principal's surplus but it also makes the informational problem less severe. Additionally, when communication between agents exists and experts are organized into an alliance, they are able to coordinate their efforts. That is, the principal imposes less risk on the experts because in this case, the alliance's members can observe each other and therefore they are able to coordinate their effort choice in collecting information. Hence, the coordination between agents reduces the agency cost.

On the other hand, when no communication exists, the principal sacrifices precision but can take advantage of multiple reports and penalize conflicting messages.

Therefore, if the signal's precision increases sufficiently with communication, the principal prefers to allow communication between experts and to organize them as a team rather than to have no communication at all.[12]

**Proposition 3** *When $\epsilon - a > a - 1/2$, the principal is better off allowing communication between agents and asking for one joint report rather than not allowing any communication at all.*

Thus, when $\epsilon - a > a - 1/2$, we can show that $T_{IWS} > T^S_{CWS(1)}$.

In the next section, we study whether it is possible to extend this conclusion when the number of experts is greater than 2, i.e., is the principal always better off by forming one single alliance of advisors when $n > 2$?

[12] We can interpret that when the principal organizes experts as a team, the principal *delegates* in an alliance the decision of whether or not to undertake the policy, as in a decentralized structure. On the contrary, when experts are not able to communicate with each other, the principal takes the decision as in a centralized structure.

# 5 The optimal organization when $n > 2$

When the number of experts is greater than two, is it always true that the principal may take advantage of communication by one alliance of all experts? Furthermore, is it true that the principal may be better off by allowing communication among experts?

To address this question, one must realize that when the principal organizes the set of experts as a team, she can take advantage of communication and of mutual observability among experts, but she loses the ability to cross-check the expert's reports. On the other hand, when the principal can avoid communication between experts, the principal has the ability to cross-check reports but she will sacrifice precision.

Thus, when $n > 2$, we will show that principal may be better off by partitioning the set of experts into groups, recovering the ability to cross-check reports between groups and exploit the synergy among experts within them, even though by doing so she sacrifices some level in the precision of the signal.

## 5.1 Group of experts

Now, let us assume that $n > 2$ and the principal partitions the set of experts into groups. Let $G = \{G_1, G_2, ..., G_k\}$ denote the group structure. The principal asks each group for one joint report; hence $k$ denotes the number of reports received by the principal. Let $n_i$ denote the size of the group $i$ which, in turn, determines the potential level of cooperation among agents. That is, $E_{-i} \in [0, n_i - 1]$.

The timing is as follows. The principal offers each group a contract. If a group accepts it, each member's group must simultaneously decide whether to collect information at cost $c$. We assume that the group's members are able to observe whether each expert gathers information but it remains unknown to members of other groups. After that, a communication phase takes place in which only members of each group can communicate with each other. This phase delivers as an outcome a signal $\sigma_i^1$ for $i = 1, ..., k$ whose precision will be $p^i(e_i, E_{-i})$ where $e_i + E_{-i} \leq n_i$.

Each alliance produces a report which is sent to the principal. She updates her belief about the future state of the policy and decides whether to undertake it.

Finally, the state is realized, the transfers are paid, and payoffs are realized.

To streamline the presentation, we follow an example for $n = 4$.

Assume that the principal partitions the set of agents into two groups. In one of them, group $A$, there are $n_A = m$ experts, and, in group $B$, there are $n_B = q$ experts such that $n = m + q$.

For simplicity, we assume both groups have the same number of members. Thus, $m = q = 2$, and after communication takes place, each agent gets a new signal $(\sigma_i, \forall i = A, B)$. The signal's precision are $\epsilon_A$ for agents belonging to group $A$ and $\epsilon_B$ for agents belonging to group $B$.

The principal asks each group to issue a report and she must provide incentives to each group to exert effort and tell the truth. For brevity, we only report the agency's cost. (Details can be found in the Appendix.)

**Lemma 3** *When $\epsilon - a > a - 1/2$, transfers are strictly positive and the total agency' cost is*

$$m\frac{c\left[p\left(\underline{\sigma}_A\underline{\sigma}_B\right)+\epsilon_A^m p\left(\underline{\sigma}_B\right)\right]}{\left[p\left(\underline{\sigma}_A\underline{\sigma}_B\right)-\left(1-\epsilon_A^m\right)p\left(\underline{\sigma}_B\right)\right]}+q\frac{c\left[p\left(\underline{\sigma}_A\underline{\sigma}_B\right)+\epsilon_B^q p\left(\underline{\sigma}_A\right)\right]}{\left[p\left(\underline{\sigma}_A\underline{\sigma}_B\right)-\left(1-\epsilon_B^q\right)p\left(\underline{\sigma}_A\right)\right]}$$

The intuition behind the above expression relies on the competition between groups. That is, group $A$'s agency cost[13] (the first term of the above expression) is decreasing not only in the quality of the signal of experts belonging its group but also in the precision of signals of experts in group $B$. When the signal's precision of group $B$'s members is not so high, it is harder to give incentives to group $A$'s members to tell the truth. Thus, as $\epsilon_B$ increases, it is easier to control experts in group $A$ by using group $B$'s report, and hence the agency's cost of group $A$ decreases.

Finally, we can compute the agency's cost for $n = 4$, $m = q = 2$, and $\epsilon_A = \epsilon_B = \epsilon$ as:

$$T_{CWS}^{G} = 4c\left[\frac{\left(2\left(1-v\right)\epsilon^2\left(2-\epsilon\right)+v\left(1-\epsilon^2\right)\right)}{\left(1-v\right)\epsilon\left(\epsilon-2\left(1-\epsilon\right)^2\right)}\right]$$

## 5.2 Comparison

In this part, we address the following questions: Is the principal better off allowing communication among experts or avoiding it? If communication improves the principal's welfare, which is the best way to organize the set of agents? One single team or groups of experts?

### 5.2.1 No Communication versus Communication

We explore whether the principal should allow communication or not.

**Proposition 4** *When $\epsilon - a > a - 1/2$, the principal is better off allowing communication between agents, at least, by partitioning the set of experts into groups and by asking each group for one joint report rather than not allowing communication at all.*

That is, when $\epsilon - a > a - 1/2$, by simple manipulation, it is easy to see that $T_{CWS}^{G} < T_{IWS}$.

Therefore, from the principal's point of view, communication is always better than no communication. The intuition is straightforward. When the principal decides between no communication at all among agents and communication within groups of experts, the principal's ability to cross check reports is present in both forms. However by allowing experts to communicate with each other, the signal's precision in case of communication is greater than the signal's precision in absence of communication among agents. Therefore, in terms of the principal's net surplus, communication is better than no communication.

[13] The same intuition for group $B$'s agency cost.

### 5.2.2 One Alliance of Experts versus Alliances of Experts

Now, turning our focus to the second question. Might the principal be even better off by organizing experts into one single team?

Let us define, for all $\epsilon \in (1/2, 1)$, $\theta^* (\epsilon)$ as the signal's precision level such that the principal's net surplus when agents form a single alliance is equal to the principal's net surplus when experts are organized in groups.

**Proposition 5** *When $\theta > \theta^*$, the principal is better off when she organizes the experts as one single team. In contrast, when $\forall \theta < \theta^*$, the principal is better off if she partitions the set of experts into groups.*

The result summarized in the last Proposition is intuitive. To understand it, the relevant question to be answered concerns the trade-off between one alliance and alliances of experts from the principal's point of view. It is worth noting that in this case the mutual monitoring is present in both settings. Therefore, mutual monitoring is not involved in the answer.

For the principal, one alliance is efficient because the signal's precision is higher than the signals's precision for each group of experts. However, teams of experts introduce competition among themselves, and it reduces agency costs. Competition improves efficiency by reducing the expected rents paid to agents and this savings may be substantial.

Therefore, only when $\theta$ is sufficiently high, the principal is better off by forming one large team rather than several teams. If not, she can take advantage of cross reports between groups even though she sacrifices the precision of the signal.

# 6 Conclusion

The aim of this article is to understand how the organization of expertise allows or avoids the production and transmission of accurate information by taking into account the incentive problems that may arise. This issue is studied in a multiagent-principal framework when communication among agents has conflicting consequences. We assume that communication allows cooperation between agents but also collusion among them. We concentrate on an uninformed principal who has to elicit information from unbiased experts. We study the optimal design of contracts in different communication settings and we focus on the organization of the expertise. Experts must decide whether to acquire costly information, and after that if the communication stage takes place, they send one aggregate report to the principal. In contrast, if there is no communication among experts, each one sends the principal one individual report.

Thus, if the principal organizes experts such that communication is not possible, she avoids the collusion problem but she cannot take advantage of the cooperation between agents. If communication takes place, it is better for the principal to form an alliance of experts and to elicit one aggregate report from it. When the advantages of cooperation outweigh the disadvantages of collusion, communication may improve the principal's welfare.

When the number of agents is greater than two, a new trade-off arises and more alternative organization forms are possible. That is, the principal can partition the set of experts into groups such that only the members of each group can communicate with each other. In this case, the principal can take advantage not only of cooperation within each alliance but also of multiple reports (competition among groups). Therefore a set of different alliances may dominate only one large alliance, and in any case, the principal is better off when experts communicate with each other.

The research presented here provides a framework to explain why, in some organization, we can observe "redundant" structures, i.e., multiple teams doing the same task. From our perspective, this strategy is not wasteful because redundancy (set of alliances) increases competition between groups, and alliances also impact on the quality of the knowledge that each one produces (each team increases the signal's precision). And both elements contribute to reducing the agent's informational rents.

From this article, there are some interesting avenues for research. One of them arises when we ask the following question: what happens if synergies vary between agents? When synergies between agent A and agent B differ from synergies between agent A and agent C, what is the optimal organization of expertise from the principal's point of view?

Another interesting, and more realistic, avenue to study emerges when we relax the assumption about the cost of communication. Up to now, we assume horizontal communication is costless. When we assume that communication among agents is costly (for example, communication is time consuming; sometimes, it is not easy to "translate" certain specific knowledge for an expert with different skills, and so on), experts must be given incentives not only to gather costly initial information but also they must be given incentives to communicate among themselves. Therefore, what is the optimal organization of expertise from the principal's point of view?

## Appendix

**Proof Lemma 1**

From (12) and (13), it is easy to see that $2t_0 = t_g + t_b$.

Assume that both moral hazard constraints (9) and (10) are binding. Additionally, let $t_0 = v\bar{t}$. Then (11) is slack.

The transfers are the following:

$$\bar{t} = \frac{c}{v\left(1-v\right)\left[\left(2\epsilon-1\right)-p\left(\bar{\sigma}\right)\left(2a-1\right)\right]}, \qquad t_0 = v\bar{t}$$

$$t_g = \frac{c\left[1-\left(1-v\right)\left(2a-1\right)\right]}{\left(1-v\right)\left[\left(2\epsilon-1\right)-p\left(\bar{\sigma}\right)\left(2a-1\right)\right]}, \text{ and } \quad t_b = \frac{c\left[1+\left(1-v\right)\left(2a-1\right)\right]}{\left(1-v\right)\left[\left(2\epsilon-1\right)-p\left(\bar{\sigma}\right)\left(2a-1\right)\right]}$$

and the agency's cost is in the text.

We can check that the other inequalities hold at these level of transfers. ■

**Proof Lemma 2**

Assume that $t_0 = v\bar{t}$ and both moral hazard constraints (17) and (18) are binding. Since $t_0 = v\bar{t}$, then (19) is slack.

The transfers are the following

$$\bar{t} = \frac{c}{v\left(1-v\right)\left(2\epsilon-1\right)},$$

$$t_o = \frac{c}{\left(1-v\right)\left(2\epsilon-1\right)}$$

and the agency's cost are in the text.

We can check that the other inequalities hold at these level of transfers. ■

**Proof Proposition 2**

By simple manipulation, we obtain

$$T^S_{CWS(2)} - T^S_{CWS(1)} = \frac{p\left(\bar{\sigma}\right)\left(2a-1\right)\left[1-\left(1-v\right)\left(2\epsilon-1\right)\right]}{\left(1-v\right)\left(2\epsilon-1\right)\left[\left(2\epsilon-1\right)-p\left(\bar{\sigma}\right)\left(2a-1\right)\right]} > 0 ■$$

**Proof Proposition 3**

Assume $\epsilon - a > a - 1/2$. Since $\epsilon \in (1/2, 1]$ then, $a$ must be in the interval $(1/2, 3/4]$.

Assume $T_{IWS} < T^S_{CWS(1)}$. By simple manipulation, this implies that

$$\left(2\epsilon-1\right)p\left(\underline{\sigma}\right) - \left(2a-1\right)a < 0$$

or equivalently

$$\epsilon < \frac{p\left(\underline{\sigma}\right) + \left(2a-1\right)a}{2p\left(\underline{\sigma}\right)}$$

Since

$$2a - 1/2 > \frac{p\left(\underline{\sigma}\right) + \left(2a-1\right)a}{2p\left(\underline{\sigma}\right)} \quad \text{for } a \in (1/2, 3/4]$$

and given that, by assumption $\epsilon - a > a - 1/2$, then it cannot be true that $T_{IWS} < T^S_{CWS(1)}$. Therefore

$$T_{IWS} > T^S_{CWS(1)}$$

Additionally, given that, for all $\epsilon > a$, $\epsilon^2 vS + (1-\epsilon)^2 (1-v) F > a^2 vS + (1-a)^2 (1-v) F$ then

$$\epsilon^2 vS + (1-\epsilon)^2 (1-v) F - T^S_{CWS(1)} > a^2 vS + (1-a)^2 (1-v) F - T_{IWS} \blacksquare$$

**Proof Lemma 3**

*Principal's problem when $n > 2$*

For $i \in A$ and $j \in B$, the moral hazard incentive constraints for alliance $A$ to gather information is such that the alliance $A$ must not prefer to remain uninformed and to report either $\underline{\sigma}_A$ or $\bar{\sigma}_A$. Therefore:

$$\begin{aligned} & m\left[p\left(\bar{\sigma}_A\bar{\sigma}_B\right)v\left(\bar{\sigma}_A\bar{\sigma}_B\right)\bar{t}^i + p\left(\underline{\sigma}_A\underline{\sigma}_B\right)t^i_0 + p\left(\underline{\sigma}_A\bar{\sigma}_B\right)t^i_g + p\left(\bar{\sigma}_A\underline{\sigma}_B\right)t^i_b - c\right] \quad (23) \\ \geq \; & \max\left\{\begin{array}{c} m\left[p\left(\underline{\sigma}_B\right)t^i_0 + p\left(\bar{\sigma}_B\right)t^i_b\right], \\ m\left[p\left(\bar{\sigma}_B\right)v\left(\bar{\sigma}_B\right)\bar{t}^i + p\left(\underline{\sigma}_B\right)t^i_g\right] \end{array}\right\} \end{aligned}$$

And either the alliance $A$ must rely on only a subset $s$ of signals $(m > s)$, that is

$$\begin{aligned} & m\left[p\left(\bar{\sigma}_A\bar{\sigma}_B\right)v\left(\bar{\sigma}_A\bar{\sigma}_B\right)\bar{t}^i + p\left(\underline{\sigma}_A\underline{\sigma}_B\right)t^i_0 + p\left(\underline{\sigma}_A\bar{\sigma}_B\right)t^i_g + p\left(\bar{\sigma}_A\underline{\sigma}_B\right)t^i_b - c\right] \quad (24) \\ \geq \; & \max\left\{m\left[p\left(\bar{\sigma}_s\bar{\sigma}_B\right)v\left(\bar{\sigma}_s\bar{\sigma}_B\right)\bar{t}^i + p\left(\underline{\sigma}_s\underline{\sigma}_B\right)t^i_0 + p\left(\underline{\sigma}_s\bar{\sigma}_B\right)t^i_b + p\left(\bar{\sigma}_s\underline{\sigma}_B\right)t^i_g\right] - sc\right\} \end{aligned}$$

Regarding the adverse selection incentive constraints. If the alliance $A$ observes $\bar{\sigma}...\bar{\sigma}$, it should prefer reporting $\bar{\sigma}_A$ rather than $\underline{\sigma}_A$. That is:

$$m\left[p\left(\bar{\sigma}_B|\bar{\sigma}_A\right)v\left(\bar{\sigma}_A\bar{\sigma}_B\right)\bar{t}^i + p\left(\underline{\sigma}_B|\bar{\sigma}_A\right)t^i_g\right] \geq m\left[p\left(\bar{\sigma}_B|\bar{\sigma}_A\right)t^i_b + p\left(\underline{\sigma}_B|\bar{\sigma}_A\right)t^i_0\right] \quad (25)$$

If the alliance observes something rather than $\bar{\sigma}\bar{\sigma}\bar{\sigma}\bar{\sigma}...\bar{\sigma}$, it should prefer reporting $\underline{\sigma}_A$ than $\bar{\sigma}_A$. That is

$$m\left[p\left(\bar{\sigma}_B|\underline{\sigma}_A\right)t^i_b + p\left(\underline{\sigma}_B|\underline{\sigma}_A\right)t^i_0\right] \geq m\left[p\left(\bar{\sigma}_B|\underline{\sigma}_A\right)v\left(\bar{\sigma}_B\underline{\sigma}_A\right)\bar{t}^i + p\left(\underline{\sigma}_B|\underline{\sigma}_A\right)t^i_g\right] \quad (26)$$

And similarly for alliance $B$.

Hence, the principal's program is:

$$\min p\left(\bar{\sigma}_A\bar{\sigma}_B\right)v\left(\bar{\sigma}_A\bar{\sigma}_B\right)\sum_{i=A,B} n_i\bar{t}^i + p\left(\underline{\sigma}_A\underline{\sigma}_B\right)\sum_{i=A,B} n_i t^i_0 + p\left(\underline{\sigma}_A\bar{\sigma}_B\right)\sum_{i=A,B} n_i t^i_g + p\left(\bar{\sigma}_A\underline{\sigma}_B\right)\sum_{i=A,B} n_i t^i_b$$

subject to(23)-(26)

Thus,the moral hazard incentive constraints (23) can be rewritten as:

$$p\left(\bar{\sigma}_B|\bar{\sigma}_A\right)v\left(\bar{\sigma}_A\bar{\sigma}_B\right)\bar{t}^i+p\left(\underline{\sigma}_B|\bar{\sigma}_A\right)t_g^i\geq p\left(\bar{\sigma}_B|\bar{\sigma}_A\right)t_b^i+p\left(\underline{\sigma}_B|\bar{\sigma}_A\right)t_0^i+\frac{c}{p\left(\bar{\sigma}_A\right)} \tag{27}$$

$$p\left(\bar{\sigma}_B|\underline{\sigma}_A\right)t_b^i+p\left(\underline{\sigma}_B|\underline{\sigma}_A\right)t_0^i\geq p\left(\bar{\sigma}_B|\underline{\sigma}_A\right)v\left(\bar{\sigma}_B\underline{\sigma}_A\right)\bar{t}^i+p\left(\underline{\sigma}_B|\underline{\sigma}_A\right)t_g^i+\frac{c}{p\left(\underline{\sigma}_A\right)} \tag{28}$$

Therefore, when (23) holds, then (25) and (26) also hold.

In the following, assume (24) is slack.

Now, we use the same logic than GM(2007). Consider the following: For a given value $G$ of $p\left(\bar{\sigma}_B|\bar{\sigma}_A\right)v\left(\bar{\sigma}_A\bar{\sigma}_B\right)\bar{t}^i+p\left(\underline{\sigma}_B|\bar{\sigma}_A\right)t_g^i$, keeping both LHS(27) and the expected transfer unchanged, what is the value of $t_g^i$ minimizing the RHS(28). That is,

$$\min p\left(\bar{\sigma}_B|\underline{\sigma}_A\right)v\left(\bar{\sigma}_B\underline{\sigma}_A\right)\bar{t}^i+p\left(\underline{\sigma}_B|\underline{\sigma}_A\right)t_g^i$$

subject to

$$G=p\left(\bar{\sigma}_B|\bar{\sigma}_A\right)v\left(\bar{\sigma}_A\bar{\sigma}_B\right)\bar{t}^i+p\left(\underline{\sigma}_B|\bar{\sigma}_A\right)t_g^i \qquad \text{and} \tag{29}$$

$$t_g^i\geq 0 \tag{30}$$

The problem can be rewritten as

$$\min\frac{p\left(\bar{\sigma}_B|\underline{\sigma}_A\right)v\left(\bar{\sigma}_B\underline{\sigma}_A\right)}{p\left(\bar{\sigma}_B|\bar{\sigma}_A\right)v\left(\bar{\sigma}_A\bar{\sigma}_B\right)}\left(G-p\left(\underline{\sigma}_B|\bar{\sigma}_A\right)t_g^i\right)+p\left(\underline{\sigma}_B|\underline{\sigma}_A\right)t_g^i$$

subject to (30)

Observe that the coefficient for $t_g^i$ is $p\left(\underline{\sigma}_B|\underline{\sigma}_A\right)-\frac{p(\bar{\sigma}_B|\underline{\sigma}_A)v(\bar{\sigma}_B\underline{\sigma}_A)}{p(\bar{\sigma}_B|\bar{\sigma}_A)v(\bar{\sigma}_A\bar{\sigma}_B)}p\left(\underline{\sigma}_B|\underline{\sigma}_A\right)=$
$=\frac{1}{p(\underline{\sigma}_A)}\left[p\left(\underline{\sigma}_B|\underline{\sigma}_A\right)\epsilon-(1-\epsilon)^2p\left(\underline{\sigma}_B\bar{\sigma}_A\right)\right]>0$. Then, the minimum is obtained when (30) is binding. Similarly, for a given value $D$ of $p\left(\bar{\sigma}_B|\underline{\sigma}_A\right)t_b^i+p\left(\underline{\sigma}_B|\underline{\sigma}_A\right)t_0^i$ keeping both the LHS (28) and the expected transfer unchanged, what is the value of $t_b^i$minimizing the RHS(27). By a similar procedure, we obtain that $t_b^i=0$.

Therefore, the principal problem can be rewritten as

$$_{\min}p\left(\bar{\sigma}_A\bar{\sigma}_B\right)v\left(\bar{\sigma}_A\bar{\sigma}_B\right)\sum_{i=A,B}k_i\bar{t}^i+p\left(\underline{\sigma}_A\underline{\sigma}_B\right)\sum_{i=A,B}k_it_0^i$$

subject to(27) and (28)

By simple manipulation we obtain:

i) The optimal collusion-proof contract when agents communicate with each others is (for $i \in A$ and $j \in B$)

$$\begin{aligned}
\bar{t}^i &= \frac{cp\left(\underline{\sigma}_B\right)}{v\epsilon_B^q\left[p\left(\underline{\sigma}_A\underline{\sigma}_B\right)-\left(1-\epsilon_A^m\right)p\left(\underline{\sigma}_B\right)\right]}, \bar{t}^j = \frac{cp\left(\underline{\sigma}_A\right)}{v\epsilon_A^m\left[p\left(\underline{\sigma}_A\underline{\sigma}_B\right)-\left(1-\epsilon_B^q\right)p\left(\underline{\sigma}_A\right)\right]} \\
t_o^i &= \frac{c}{\left[p\left(\underline{\sigma}_A\underline{\sigma}_B\right)-\left(1-\epsilon_A^m\right)p\left(\underline{\sigma}_B\right)\right]}, t_o^j = \frac{c}{\left[p\left(\underline{\sigma}_A\underline{\sigma}_B\right)-\left(1-\epsilon_B^q\right)p\left(\underline{\sigma}_A\right)\right]} \\
t_b^i &= t_b^j = t_g^i = t_g^j = 0
\end{aligned}$$

ii) The total agency's cost is in the text.

Additionally, we can check that under these transfers (24) is slack. That is, (24) can be written as

$$2\left[\epsilon^4 v\bar{t}^i + p\left(\underline{\sigma}_A\underline{\sigma}_B\right)t_0^i - c\right] \geq 2\left[a\epsilon^2 v\bar{t}^i + p\left(\underline{\sigma}_s\underline{\sigma}_B\right)t_0^i\right] - c$$

By replacing $\bar{t}^i$ and $t_0^i$ we obtain:

$$2\left[p\left(\underline{\sigma}_A\underline{\sigma}_B\right) - p\left(\underline{\sigma}_s\underline{\sigma}_B\right)\right]c \geq 2\left(a-\epsilon^2\right)p\left(\underline{\sigma}_B\right)c + \left[p\left(\underline{\sigma}_A\underline{\sigma}_B\right) - \left(1-\epsilon^2\right)p\left(\underline{\sigma}_B\right)\right]c$$

which holds when $\epsilon - a \geq a - \frac{1}{2}$ ■

**Proof Proposition 4**

The individual agency's cost when the principal organizes experts in two teams composed each one by two agents is:

$$c\left[\frac{\left(2\left(1-v\right)\epsilon^2\left(2-\epsilon\right)+v\left(1-\epsilon^2\right)\right)}{\left(1-v\right)\epsilon\left(\epsilon-2\left(1-\epsilon\right)^2\right)}\right]$$

The same cost under no communication is

$$\frac{c\left[p\left(\underline{\sigma}\right)+\left(1-v\right)\left(2a-1\right)a\right]}{\left(1-v\right)\left(2a-1\right)a}$$

By simple manipulation, we can see that, for $\epsilon - a > a - 1/2$:

$$\frac{\left(2\left(1-v\right)\epsilon^2\left(2-\epsilon\right)+v\left(1-\epsilon^2\right)\right)}{\epsilon\left(\epsilon-2\left(1-\epsilon\right)^2\right)} < \frac{\left[p\left(\underline{\sigma}\right)+\left(1-v\right)\left(2a-1\right)a\right]}{\left(2a-1\right)a}$$

Since, for all $\epsilon > a$, $\epsilon^4 vS + \left(1-\epsilon\right)^4\left(1-v\right)F > a^4 vS + \left(1-a\right)^4\left(1-v\right)F$, then

$$\epsilon^4 vS + \left(1-\epsilon\right)^4\left(1-v\right)F - T_{CWS}^G > a^4 vS + \left(1-a\right)^4\left(1-v\right)F - T_{IWS} \blacksquare$$

**Proof Proposition 5**

Let $n = 4$ *and* $m = q = 2$.

The principal's net surplus in CWS when experts are organized in teams is

$$p(\epsilon; v, S, F, c) = \epsilon^4 vS + (1-\epsilon)^4 (1-v) F - \frac{4c\left(2(1-v)\epsilon^2(2-\epsilon) + v(1-\epsilon^2)\right)}{(1-v)\epsilon\left(\epsilon - 2(1-\epsilon)^2\right)}$$

and the principal's net surplus in CWS when agents form one single team is

$$q(\theta; v, S, F, c) = \theta^4 vS + (1-\theta)^4 (1-v) F - \frac{4c\left(1 + (1-v)\left(\theta^4 - (1-\theta)^4\right)\right)}{(1-v)\left(\theta^4 - (1-\theta)^4\right)}$$

Then, first of all, when $\epsilon = \theta\ \forall \epsilon, \theta \in (1/2, 1)$, the principal's gross surplus for both kind of organization will be equal. That is,

$$\epsilon^4 vS + (1-\epsilon)^4 (1-v) F = \theta^4 vS + (1-\theta)^4 (1-v) F$$

However, by simple manipulation, we can verify that the agency's cost $T_{CWS(1)} > T^G_{CWS}$, $\forall c > 0$ and $v \in (0, 1/2)$.

Therefore, when $\epsilon = \theta$, $\forall \epsilon, \theta \in (1/2, 1)$

$$p(\epsilon; v, S, F, c) > q(\theta; v, S, F, c)$$

Second, by simple calculations, it is possible to check that $\frac{\delta p(\cdot)}{\delta \epsilon} > 0$ and $\frac{\delta q(\cdot)}{\delta \theta} > 0$.

Then, for each $\epsilon$, $\exists \theta^*(\epsilon)$ such that $p(\epsilon; v, S, F, c) = q(\theta^*(\epsilon); v, S, F, c)$.

Given that $q(\cdot)$ is an increasing function on $\theta$, then $\forall \theta > \theta^*(\epsilon)$, $q(\theta; v, S, F, c) > q(\theta^*(\epsilon); v, S, F, c) = p(\epsilon; v, S, F, c)$ and the principal will prefer organize the experts in one single team.

On the other hand,$\forall \theta < \theta^*(\epsilon)$, $q(\theta; v, S, F, c) < q(\theta^*(\epsilon); v, S, F, c) = p(\epsilon; v, S, F, c)$ and the principal will prefer organize the experts in groups. ■

# References


[1] Arrow, K.,1969. Classificatory Notes on the Production and Transmission of Technological Knowledge. The American Economic Review 59, 29-35.

[2] Bergemann, D. and Välimäki, J., 2007. Information in Mechanism Design. Mimeo, Cowles Foundation Yale University, Discussion Paper N$^o$ 1208.

[3] Cai, H., 2003. Costly Participation and Heterogenous Preferences in Information Committees. Mimeo, UCLA

[4] Crawford, V. and Sobel, J., 1982. Strategic Information Transmission. Econometrica 50, 1431-51.

[5] Demski, J. and Sappington, D., 1987. Delegated Expertise. Journal of Accounting Research 25, 68-89.

[6] Dewatripont, M. and Tirole, J., 1999. Advocates. Journal of Political Economy 117, 1-41.

[7] Dur, R. and Swank, O., 2005. Producing and manipulating information. Economic Journal 115, 185- 199.

[8] Gromb, D and Martimort, D., 2007. Collusion and the organization of delegated expertise. Journal of Economic Theory 137, 271-299.

[9] Gerardi, D. and Yariv, L., 2007. Information Acquisition in Committees. Mimeo, Cowles Foundation Discussion Paper 1411R.

[10] Goldfayn, E., 2006. Organization of R&D with Two Agents and Principal. Mimeo, Bonn ECon Discussion Paper 3/2006.

[11] Holmström, B., 1982. Moral Hazard in Teams. The Bell Journal of Economics 13, 324-340.

[12] ———— and Milgrom, R., 1990. Regulating Trade Among Agents. Journal of Institutional and Theoretical Economics 146, 85-105.

[13] Itoh, H., 1991. Incentive to Help in Multi-Agent Situations. Econometrica 13, 611-636.

[14] ———, 1993. Coalitions, Incentives and Risk Sharing. Journal of Economic Theory 60, 410-427.

[15] Jeon, D.-S and Menicucci,D., 2005. Optimal Second-degree Price Discrimination and Arbitrage: On the role of Asymmetric Information among Buyers. Rand Journal of Economics 36, 337-360.

[16] Köhler, W., 2004. Optimal Incentive Contracts for Experts. Mimeo, Bonn ECon Discussion Paper 6/2004.

[17] Krishna,V. and Morgan, J., 2001. A Model of Expertise. The Quarterly Journal of Economics 16, 747-775.

[18] Laffont, J.-J and Martimort, D., 1997. Collusion under Asymmetric Information. Econometrica 65, 875-911.

[19] ————————, 2000. Mechanism Design with Collusion and Correlation. Econometrica 68, 309-342.

[20] Li, H., 2001. A Theory of Conservatism. Journal of Political Economy 109, 617-636.

[21] Macho-Stadler, I. and Pérez-Castrillo, J.D., 1993. Moral hazard with several agents. The gains from cooperation. International Journal of Industrial Organization 11, 73-100.

[22] Mukhopadhaya, K., 2003. Jury Size and the Free Rider Problem. Journal of Law, Economics and Organization 19, 24-44.

[23] Nikolova, R., 2005. Mutual Monitoring versus Incentive Pay in Teams. Mimeo, CREST-LEI and LASER-LAEC.

[24] Ottaviani, M. and Sorensen, P.N., 2004. Professional Advice. Mimeo, London Business School and University of Copenhagen.

[25] Osband, K.,1989. Optimal Forecasting Incentives. Journal of Political Economy 97,1091-1112.

[26] Persico, N., 2004. Committee Design with Endogenous Information. Review of Economic Studies 71, 165-191.

[27] Szalay, D., 2005. The Economics of Clear Advice and Extreme Options. Review of Economic Studies 72, 1173-1198

[28] Szalay, D. and Arean, R. ,2005. Communicating with a Team of Experts. Mimeo,.HEC Lausanne and FAME.

[29] Wolinsky, A., 2002. Eliciting Information from Multiple Experts. Games and Economic Behavior 41, 141-160.