Principal’s Experience and the Authority Relation*

Nadav Levy†

November 2010

Abstract

I study how the principal’s experience affects the structure and efficiency of decision processes in his organization. Organization-specific experience augments the principal’s ability to verify recommendations presented to him by his agents and also make it easier for him to gather decision-relevant information. The effects of an increase in these two abilities on the decentralization of decision-making and on the agents’ initiative are shown to markedly differ. An increase in the principal’s verification ability leads to an increase in the share of the decisions made by the agent and to an increase in his initiative and is unambiguously beneficial. In contrast, an increase in the principal’s ability to gather information tends to lead to a larger share of the decisions made by the principal and discourages the agent’s initiative.

1 Introduction

A substantial body of evidence shows that the career experience of top managers has a significant effect on their present actions and on the characteristics of the organization over which they preside. For example, Barker and Mueller (2002) find that firms headed by CEOs with career experience in marketing or engineering/R&D tend to spend significantly more on

*Preliminary draft. Comments are welcome. I thank Larry Kranich, Illoong Kwon, Ady Pauzner, Yossi Spiegel and the participants and seminar audiences at IDC Herzliya and Tel Aviv University for helpful comments.

†School of Economics, Interdisciplinary Center Herzliya (IDC). E-mail: nadavlev@idc.ac.il
R&D and Xuan (2009) shows that the CEO job history has a significant effect on the capital allocation decisions in multidivisional firms.

From a practical perspective, understanding the role of such managerial firm-specific (or industry-specific) experience is important in order to determine the requirements for managerial positions.\footnote{Similar questions arise also in other contexts, for example, regarding the experience qualifications required from government cabinet ministers. In Israel, a heated public debate has erupted whether a politician lacking military background is qualified to serve as a defense minister. See, for example Ynet News "War report scathing for Olmert, Peretz" 29 April, 2007.} Should a search for a new CEO for example be limited to a narrow pool of internal candidates (with abundant firm-specific experience) or expanded to include also external candidates who may lack firm-specific experience?\footnote{Ford Motor Co. has recently hired Alan Mulally as its new CEO. Prior to that Mulally has served his entire career at Boeing. Commentators noted that the nature of the business and the industry at Ford and the challenges he will faced with are very different than those he has witnessed in Boeing. See for example BusinessWeek Online, September 7, 2006.} Because there is often a tradeoff between experience and other goals (external candidates may be more talented or have more general managerial experience), the exact benefits of experience must be well-understood.\footnote{It is interesting to note that the typical experience of a typical CEO have changed significantly over the years and in correlation with changes in other elements of their strategy. Fligstein (1987) argues that multidivisional firms have increasingly chosen CEOs with finance background, at the same time as many of those firms adopted a diversified conglomerate form and a strategy of growth into unrelated product areas. In his sample of about of the 100 largest firms in the US, he finds that the percentage of managers with exclusive finance background has risen from 11% in the 1950 to 28% in 1980. More recently, Murphy and Zabojnik (2007) have argued that there has been a shift in the relative importance of CEOs “managerial ability” (skills transferable across companies) and “firm-specific human capital”.} Understanding the role of experience is also important in order to quantify the benefits from organizational tools such as lateral job rotations, which are used by firms to develop managerial talent and provide managers with a diversity of career experiences.

In contrast to the ample empirical evidence, there is very little in terms of theoretical analysis of experience and its effects. In this paper, I consider one salient aspect: how does the principal’s experience affect his authority relations with his subordinates (agents)? Specifically, I ask what are the effects on the organization’s decision-processes, on the decentralization of decision-making from the principal to the agents and on the performance of the agents? The perspective I take follows the seminal work of Aghion and Tirole (1997), who argue that decision processes within organizations are equilibrium outcomes that do not necessarily follow formal hierarchical lines. Actual decision-making is delegated to parties with the relevant information and organization members invest effort in order to gain information and influence decisions over which they have different preferences. The allocation of real authority over decisions thus reflects the relative costs of gathering information to different parties. The experience of the principal figures to be a key factor in this regard, as it is central both to his ability to collect information by himself and also to his ability to disseminate and process
information presented to him by his subordinates. A main contribution of this paper is to show that these distinct abilities have very different implications on the authority relations between the principal and his subordinates.

The model presented in Section 2 considers a hierarchy, composed of a principal (e.g. CEO; secretary of defense) and a single agent (e.g. division manager; military chief of staff). A single decision has to be taken (development of new product; a response to a military aggression by a neighboring state) and various alternative courses of action need to be evaluated. The principal’s and agent’s preferences over the desired course of action are not fully aligned (a division manager disregards potential conflicts between the new product and those of other divisions; a chief of staff prefers a certain military alternative and may be less attuned to diplomatic considerations, number of casualties etc.) The decision process begins with the agent evaluating the alternatives. The agent then makes a recommendation to the principal. In some probability, the principal verifies without an additional cost the payoff associated with the recommended action. The principal then has to decide how much to invest in evaluating alternatives himself. The principal overrules the agent if he is able to come up with a superior alternative and goes along with the agent’s recommendation otherwise. Because of the sequential setup of the decision process the agent takes into consideration the effect that his recommendation could have, if verified, on the principal’s incentives to invest effort. As a result, the agent’s recommendation is a "compromise" between his own preferred alternative and the principal’s best option.

Section 3 considers how the principal’s experience changes the outcomes of this game. An experienced principal has accumulated throughout his career knowledge that is relevant to the decision in hand, possibly while serving in the same position as the agent or in a similar one (for example, an experienced CEO may have previously served as head of the same division as his agent, the current manager. In contrast, an inexperienced CEO may have a finance or legal background and thus lack much knowledge in the division business.) Experience matters in two distinct ways: First, due to his "technical" command of the subject, an experienced principal is more likely to verify the value of alternatives presented to him (verification ability). Thus, a CEO with background in manufacturing is better-suited to assess the validity of engineering estimates of the cost of a new project than a CEO who lacks such knowledge (who would therefore need to take the estimates at face value, i.e. as "cheap talk"). Second, an experienced principal could more easily evaluate by himself other alternatives that were not presented to him by the agent (evaluation ability). This is represented by a decrease in the principal’s marginal cost of effort.

I show that an increase in the principal’s experience, as manifested by an improvement in either one of these two abilities, induces the agent to recommend more favorable alternatives to the principal. The agent takes into account the effect his recommendation could have,
if verified, on the subsequent choice of effort by the principal and thus on the likelihood of the principal overruling him. An increase in the likelihood of verification or a decrease in the marginal cost of the principal’s effort both serve to strengthen the agent’s incentive to improve his recommendation.

However, the effects of an increase in the principal’s verification ability are markedly different than those of an increase in his evaluation ability with respect to the principal’s and agent’s respective efforts and to the agent’s real authority – the proportion of times in which the agent’s recommendation is followed. An increase in the verification ability leads the principal to exert less effort and the agent to exert more effort. The principal is thus more "trusting" of the agent and overrules him in less instances. Decision making becomes more decentralized. In contrast, an increase in the evaluation ability often leads to a decrease in the agent’s effort, to an increase in the principal’s effort and to a reduction in the agent’s real authority. Because of the dampening effect on the agent’s initiative, the overall implications on the principal of an increase in his evaluation ability are ambiguous, whereas an increase in the principal’s verification ability leads unambiguously to higher utility both to the principal and to the agent.

In Section 4, I consider two extensions to the base model. First, I endogenize the principal’s choice when to exert effort (either after the agent as in the base model, or simultaneously with him). In addition, I posit that exerting effort late in the decision process is more expensive, due to time constraints. I show that inexperienced managers (where experience is measured here by the verification ability only) tend to intervene in the decision process in early stages, whereas experienced managers prefer to wait and allow the agent to move first. Second, I extend the base model to include two agents who serve under the same principal (e.g. two division managers and a CEO). While the two agents are assigned to independent areas, their actions are strategically interdependent because the principal’s efforts in the two areas are cost substitutes. I show that an increase in the principal’s experience (again restricted to the verification ability) induces both agents to improve their recommendations to the principal. However, the area in which the principal is more experienced becomes more "prominent". The principal curbs effort in the area in which he is experienced, which allows him to focus more effort the other area. This encourages the agent assigned to the first area to exert more effort but discourages the other agent’s initiative and leads to a decline in his real authority.

Relation to the literature

As discussed above, this paper follows the tradition of the authority model introduced by Aghion and Tirole (1997). Papers in this literature\(^4\) commonly assume that due to contract

\(^4\)Other notable papers in this literature include Burkart, Gromb and Panunzi (1997) and Aghion, Dewatripont and Rey (2004) among others.
incompleteness, the degree of real authority that agents exert over decisions is a central factor in determining their initiative and have a strong impact on organizational outcomes. A crucial difference with the Aghion-Tirole setup is that they assume that the principal and agent exert effort simultaneously. As the agent’s recommendation is only considered when the principal has failed to become informed, it will be followed whether it can be verified or not. Consequently, as long as the parties are sufficiently congruent the agent always recommend his favorite outcome. In contrast, in our sequential setup, the agent’s decision regarding the recommended value to the principal is strategic and is sensitive to the principal’s characteristics such as the likelihood whether the recommendation is verified or not.

A recent paper by Armstrong and Vickers (2010) has a setup that is relatively similar to the current one. An agent observes several projects (the agent may need to exert effort) and chooses one project to present to the principal, who can verify its value to both players. Monetary incentives are ruled out and the principal’s and agent’s ranking of projects differ. Armstrong and Vickers however consider the delegation of the decision right to the agent and study the properties of the optimal "permission set" of projects by the principal, who commits to approve only projects in this set.

This paper is also related to a lesser extent to a large literature on the communication between an informed agent and uninformed decision maker, where the informational structure is exogenous. Crawford and Sobel (1982), considers communication to be cheap talk. They find that communication is coarse and the informational value of communication decreases in the degree to which the preferences of the decision maker and agent diverge. Finally, in the literature on audit mechanisms, surveyed in Laffont and Martimort (2002), an uninformed principal can commit to a costly random audit which would verify the agent’s report. However in contrast to here, the agent payoff can be made contingent on the audit and the agent thus always reports truthfully.

2 The model

Consider an hierarchy composed of an agent (A) and a principal (P). The hierarchy has to make a single decision. In addition to the CEO/division manager and secretary of defense examples discussed in the introduction, the setup can also apply to the relationships between a board of directors and a CEO, between a university tenure committee and an academic department (regarding the tenure decision for faculty) and other examples.

The agent is assigned to evaluate a large number of alternative courses of action. We take $\mathbb{R}_+$ to be the set alternatives. Each alternative yields a monetary payoff $v$ to the principal and a nonmonetary payoff $u$ is to the agent. The agent’s payoff stems from private benefits that may take the form of signaling his ability, enhancement of public image, perks, acquisition of
While the potential payoff possibilities are commonly known, it is initially unknown to both the principal and the agent which alternative is associated with which payoff. Specifically, we assume that there exists a set $\Omega \subset \mathbb{R} \times \mathbb{R}$ of payoff pairs $(v, u)$ known to both the principal and the agent. An alternative $t \in \mathbb{R}_+$ is assigned a payoff pair $(v_t, u_t) \in \Omega$ by function $f : \mathbb{R}_+ \to \Omega$ which is unknown ex ante to both players. Furthermore, for any $(v, u) \in \Omega$ there exists $t$ such that $f(t) = (v, u)$.

We further assume that the frontier of $\Omega$ is differentiable and can be represented by a concave function $u(v)$, such that $u' < 0$ and $u'' \leq 0$, defined over some interval $[\underline{v}, \overline{v}]$. We denote by $\underline{u} \equiv u(\overline{v})$ and $\overline{u} = u(\underline{v})$ the agent’s payoff from the principal best and worst alternatives on the frontier, respectively. We will argue below that it is the frontier $u(v)$ which matters for our analysis.

In addition to the alternatives above, we assume that an additional known default alternative can be taken which yields a payoff of zero to both the agent and principal. We assume that the preferences of the principal and the agent are sufficiently congruent so that each would prefer the other party’s preferred alternative over the default alternative. i.e.:

**Assumption 1** \( v \geq 0 \) and \( u \geq 0 \).

Figure 1 illustrates the set $\Omega$ and its frontier $u(v)$.

![Figure 1: The set $\Omega$ and the function $u(v)$](image-url)
In addition we assume that the set $\Omega$ contains many outcomes which are significantly worse to the players than the default option. Consequently, The parties would never pick an alternative randomly.

The principal and agent are risk neutral. However, the payoff to the principal $v$ is non-contractible. It is thus infeasible for the principal to use monetary incentives to motivate the agent. The agent is therefore paid a fixed wage which is normalized to zero, and exerts effort only to the extent that it affects his private benefits.

The agent first investigates the valuations of different alternatives. If successful ("becomes informed") the agent learns the function $f(\cdot)$ and thus the values $(v_t, u_t)$ associated with every alternative $t$ both to himself and to the principal. Otherwise the agent learns nothing. The agent can obtain a success probability $i_a$ by exerting effort with a disutility $c(i_a)$, where $c$ is increasing and strictly convex. (For brevity I will often refer to $i_a$ as the agent’s effort). To simplify the exposition we assume that $\lim_{i \to 1} c'(i) = +\infty$ and that $c'(0) = 0$ (Inada conditions). The agent’s utility if an alternative with a value $u$ is implemented and if exerting effort $i_a$ is thus

$$u - c(i_a).$$

If the agent has failed to learn $f(\cdot)$ he reports so. If successful, the agent recommends a single alternative $t$ to the principal. The recommendation is accompanied by supporting evidence. However, the principal may nevertheless not be able verify the value to himself of the proposed alternative from the information presented to him. Specifically, assume that the principal will either verify $v_t$ without incurring any cost with probability $x \in [0,1]$. In any case, the principal is unable to infer from the recommendation any additional information regarding payoffs from other alternatives that are not presented to him.

After receiving the agent’s recommendation, the principal decides on the amount of resources he would dedicate to evaluating alternatives by himself. At a disutility cost $\mu c(i_p)$, the principal can learn the entire function $f(\cdot)$ in probability $i_p$, where $\mu > 0$ is a marginal cost shifter.

If successful, the principal implements his preferred alternative and obtains a value $v$. Otherwise the agent’s recommendation is implemented. The principal’s utility is therefore

$$v - \mu c(i_p).$$

**Modeling the principal’s experience**

Consider next the role played by the principal’s experience. As discussed in the introduction, we envision the principal’s experience affecting two distinct abilities: first, an experienced

---

5It would not matter if the principal only learns the first component of $f$ - i.e. only the value $v_t$ associated with every alternative $t \in \mathbb{R}_+$. 

principal is more capable evaluating and verifying hard information presented to him in support of a specific alternative. This idea is captured here by assuming that the probability \( x \) that the principal is able to verify (without cost) the value of an alternative presented to him by the agent is an increasing function of the principal’s experience. This verification ability determines the likelihood that the agent would be able, by his choice of which alternative to present, to influence the principal’s effort choice.

Second, an experienced principal is likely to find it easier to evaluate by himself additional alternatives which were not presented to him by the agent (his evaluation ability is higher). Assume therefore that the marginal cost of the principal’s evaluation effort is decreasing in his experience. Specifically, the parameter \( \mu \) is lower the more experienced is the principal.

Proofs of all lemmas and propositions not in the text are relegated to the appendix.

3 Analysis

3.1 Preliminaries

Starting from the last stage, consider first the principal’s choice of effort to put into evaluating alternatives by himself. Denote by \( i_p(v) \) the principal’s effort, conditional of verifying the agent’s recommended alternative to be worth \( v \) to him. If the principal’s investigation succeeds, he implements his ideal alternative and gain \( \overline{v} \). If not, he approves the agent’s recommendation. Therefore

\[
i_p(v) = \arg \max_{i_p} i_p \overline{v} + (1 - i_p) v - \mu c(i_p).
\] (1)

If the principal is unable to verify the agent’s recommendation (with probability \( 1 - x \)), his effort choice \( i_p(v^*) \) is based on his belief \( v^* \) regarding the value of the agent’s recommendation. If the agent has failed, the principal’s effort is \( i_p(0) \).

The first-order condition to the principal’s problem is \( \overline{v} - v - \mu c'(i_p) = 0 \). Let \( h = (c')^{-1} \). Then

\[
i_p(v) = h(\frac{\overline{v} - v}{\mu}).
\] (2)

As \( c'' \geq 0 \) then \( h' > 0 \) and thus \( i_p'(v) \leq 0 \). In addition we assume the following

Assumption 2 \( \partial \left[ i_p'(v) \right] / \partial \mu \geq 0 \)

This plausible assumption says that the responsiveness of the principal’s effort choice to the recommendation \( v \) is decreasing in the cost parameter \( \mu \), is satisfied in many parametric
Next, consider the agent’s recommendation. If informed, the agent only recommends an alternative \( t \) associated with payoffs \((v_t, u_t)\) that lie on the frontier of the set \( \Omega \), i.e. in \( \{(v, u(v)) \mid v \leq v \leq \overline{v}\} \). To see this, observe that the agent would not recommend an alternative if another alternative exists which yields higher payoff to himself and at least the same payoff to the principal. Similarly, if another alternative exist with the same value to the agent and a higher value to the principal, the agent would prefer to recommend that alternative as he may then induce the principal to reduce his effort to evaluate alternatives himself (in the case the principal has verified the recommendation). Hence recommendations that are not on the frontier are never optimal.

It is natural to refer to the agent as choosing directly the value \( v \) to offer the principal. His decision takes into account the effect on the principal’s subsequent effort choice, in case the principal’s is able to verify the value of the recommendation (in probability \( x \)). Denote the value to the principal of the agent’s optimal recommendation by \( v^* \). Under rational expectations, the principal anticipates \( v^* \) correctly even if unable to verify it. The agent’s maximization problem is therefore

\[
\overline{U} = \max_{v \in [\underline{v}, \overline{v}]} x \cdot [(1 - i_p(v)) \cdot u(v) + i_p(v) \cdot u] + (1 - x) \cdot [(1 - i_p(v^*)) u(v) + i_p(v^*) u]. \tag{3}
\]

\( \overline{U} \) is the expected gross payoff to the informed agent (without deducting the sunk cost of his effort). We assume that \( \overline{U} \) is concave as a function of \( v \). Since the principal’s effort is \( i_p(v^*) \) whether he verified the recommendation or not, the informed agent’s gross payoff is

\[
\overline{U} = [1 - i_p(v^*)] u(v^*) + i_p(v^*) u. \tag{4}
\]

Whether the solution to (3) is on the interior of \([\underline{v}, \overline{v}]\) depends on the model’s parameters. For example, if the probability of verification \( x \) is very small, the agent stands very little chance to influence the principal’s effort choice. He will therefore recommend his favorite alternative (with value \( \underline{v} \) to the principal). If \( x \) is larger however, the agent’s wishes to raise his recommendation \( v^* \) above \( \underline{v} \), in order to dissuade the principal from evaluating alternatives too vigorously.

The next condition is sufficient for the agent to benefit from raising his recommendation above \( \underline{v} \) (interior solution).

\[\text{\textsuperscript{6}}\text{It is straightforward to show that } \partial [i'_p(v)] / \partial \mu = \frac{1}{\mu} [i''_p(v) \cdot (\overline{v} - v) - i'_p(v)]. \text{ Consider for example the parametric family of cost functions } c(i) = i^k / k \text{ for } k > 1. \text{ It follows that } i_p(v) = \left( \frac{\overline{v} - v}{\mu} \right)^{1/(k-1)}. \text{ Substituting for } i'_p \text{ and } i''_p \text{ above we get } \partial [i'_p(v)] / \partial \mu = \left( \frac{\overline{v} - v}{k-1} \right)^{-1} > 0.\]
Assumption 3 \(-x \cdot i'_p (v) [u (v) - u (\overline{v})] + [1 - i_p (v)] u' (v) > 0.\)

Under Assumption 3, the optimal recommendation \(v^*\) is in the interior of \([v, \overline{v}]\) and is characterized by the first-order condition to (3). This condition can be rearranged as follows:

\[-x \cdot i'_p (v^*) [u (v^*) - u] = - (1 - i_p (v^*)) u' (v^*). \tag{5}\]

The intuition for this key equation is as follows. The agent faces a tradeoff: a more favorable recommendation to the principal (higher \(v\)) results in lower payoff to the agent in the case in which the principal’s investigation fails (whether the principal was able to verify the recommendation or not). This occurs in probability \(1 - i_p (v^*)\). The marginal loss in expected utility from a small increase in the recommendation is the term on the right. On the other hand, a higher recommendation also entices the principal’s to lower his effort if he is able to verify its value (probability \(x\)). The term on the left-hand side is the expected marginal benefit to the agent of increasing his recommendation along the frontier and in the direction of \(\overline{v}\). As the principal puts less effort, there are more instances (by \(-i'_p (v)\)) in which the principal is uninformed and the agent’s recommendation is implemented. In these cases, the agent gains additional \(u (v) - u\) units of utility. The recommendation is increased until this marginal benefit of increasing the recommendation just equals the marginal loss.

Finally, the agent’s effort choice \(i^*_a\) in the first stage is determined as follows:

\[i^*_a = \arg \max_{i_a} i_a U + (1 - i_a) [i_p (0) \cdot u] - c (i_a). \tag{6}\]

The agent’s choice of effort takes into account his own subsequent choice regarding the alternative to recommend if successful and anticipates the principal’s effort choice conditional on the recommendation.

3.2 The effects of a change in the principal’s experience

We now turn to investigate the effect of a change in the principal’s experience on the parties’ efforts and on the (de-facto) decentralization of decision making within the hierarchy. Specifically, we measure the agent’s real authority by the proportion of times in which his recommendation is followed and is not overruled by the principal.

Each one the effects of experience discussed in the previous section is considered in turn, beginning with the effect of an increase in the principal’s evaluation ability, measured by a reduction in the marginal cost of the principal disutility from effort \(\mu\).

**Proposition 1** When the principal’s is more capable of evaluating alternatives by himself (\(\mu\) lower).
i. The principal’s effort \( i_p(v) \) is higher for any alternative worth \( v \) presented to him which he is able to verify.

ii. The value to the principal of the alternative recommended by the agent \( v^* \), is strictly higher.

iii. If the principal’s effort \( i_p(v^*) \) does not decrease, the agent’s effort \( i_a^* \) decreases.\(^7\)

An increase in the principal’s ability to evaluate alternatives by himself serves as a "disciplining device" and reduces the agent’s opportunism when informed. Because the principal’s effort will be higher for any given \( v \) (part 1 of the proposition), it is less likely he will remain uninformed, and thus the marginal cost to the agent of recommending a higher \( v \) is lower. The principal’s choice of effort is also more responsive to the agent’s recommendation. The principal is thus able to elicit from the agent a recommendation with higher payoff to himself, in order to dissuade him from evaluating other alternatives too vigorously.

The probability that the principal overrules the agent and decides on the course of action by himself is \( i_p(v^*) \). The complement \( 1 - i_p(v^*) \) measures the agent’s real authority. As \( \mu \) decreases, the change in the overruling rate is thus

\[
-d [i_p(v^*)]/d\mu = -\partial i_p(v^*)/\partial \mu - i'_p(v^*) \cdot \partial v^*/\partial \mu
\]

Two opposing effects are at work: the direct effect has the principal put more effort (given the same recommendation), and points towards a higher rate of overruling. But the agent takes this into account and improves his recommendation; This indirect (strategic) effect induces the principal’s to reduce his effort. In general, it is difficult to determine which of the effects dominate. For parametric examples, calculations (presented in the appendix) show that the direct effect dominates and that the principal’s overrules the agent in more cases when more capable of evaluating alternatives himself.

Since the agent is "pushed" to recommend a better alternative to the principal, the return on the agent’s effort in the case he is not overruled diminishes. If in addition the overruling rate increases, the return to the agent’s investment (and consequently his effort) unambiguously goes down. The agent contribution to the hierarchy is thus "marginalized" twice: he is less active in evaluating alternatives and, if informed, his recommendations are carried out in less instances.

We now turn to the effect of an increase in the principal’s ability to verify the value of a specific alternative presented to him (his verification ability). Recall that we posit that the experienced principal is more likely to be able to verify the value of a recommendation

\(^7\)In fact, as the proof shows, \( i_a^* \) decreases under a broader set of conditions.
presented to him by the agent than an inexperienced one, and indicate this by an increase in
the probability of verification \( x \).

**Proposition 2** Suppose that the principal’s verification ability is improved (\( x \) higher). Then

i. The value \( v^* \) to the principal from the alternative recommended by the agent is higher.

ii. The principal’s effort \( i_p(v^*) \) is lower, and he overrules the agent in fewer cases.

iii. The agent’s effort \( i_a^* \) is higher.

iv. Both the principal’s and the agent’s utilities are higher.

An increase in the principal’s verification ability helps improve the communication between
himself and the agent (this can be readily seen by comparing the case of \( x = 0 \) to the
case of \( x = 1 \)). The proposition shows that this improvement which is the result of the
principal being more experienced leads to an outcome which is *superior for both of them*. Observe from the first-order condition (5) that the agent’s marginal benefit of increasing his
recommendation is increasing in the probability that it would affect the principal’s choice
of effort \( -x \). Understanding this, the experienced principal’s anticipates correctly that the
agent’s recommendation should be more favorable to him. He is thus "more trusting" of the
agent and puts less effort himself if unable to verify the agent’s recommendation. Consequently
the principal’s is more often uninformed and the agent’s real authority is higher. Even though
the agent’s recommendation is more favorable to the principal and thus less favorable to
himself, the agent is better off with an experienced principal than with an inexperienced one.
To understand why, note that, facing an experienced principal, the agent could have acted
exactly as he would optimally act with a less experienced principal. The agent would have
been better off facing the experienced principal under this strategy, as the principal puts less
effort himself when the recommendation is not verified. As the agent nevertheless chooses a
higher recommendation, it is clearly optimal for him to do so.

It is important to note the marked contrast in outcomes between Propositions 1 and 2.
While in both cases the agent improves his recommendation when facing a more experienced
principal, the effect on the agent’s effort and his real authority due to an improvement in the
principal’s verification ability is much different than the effect due to an improvement in the
principal’s evaluating ability. An increase in the principal’s ability evaluate the alternatives
more easily himself can lead to a "crowding out" of the agent’s effort, which is replaced by
the principal’s. It is therefore possible for both the principal and the agent to be adversely
affected as a result. In contrast, the agent’s real authority and effort go up and both principal
and the agent are benefitted from an increase in the principal’s verification ability.

12
4 Discussion and Extensions

The preceding section has demonstrated that the principal's experience can have very different effect on the outcomes, depending on whether it affects the principal's ability to verify information presented by the agent, or the principal's ability to evaluate the decision by himself. Which one of this effects is likely to be more prominent depends on the specific context. Note however that verification and evaluation are tasks of quite different magnitude. Specifically, verification of information regarding a specific alternative is a far less demanding and time-consuming than evaluating other alternatives from scratch (In analogy to the world of academics, one may think of the difference between "verifying that a proof to a claim is correct" to "proving the claim yourself"). It seems plausible that whereas the principal's experience will always have a significant effect on the verification ability, there may be cases in which its effect on the evaluation ability is rather limited. These are cases in which, by the nature of the situation, the principal's ability to "take over" the agent's responsibilities are quite limited irrespective of his experience (for example, because he is overloaded with other more urgent duties, because of the urgency of the decision etc.).

I proceed to explore a couple of extensions to the base model.

4.1 Experience and managerial style

On top of to the variation in the intensity of the principal’s involvement, different processes can also differ in the stage at which the principal intervenes. Indeed, it has been noted that managers can differ substantially in their decisions when to injects themselves into the decision process and how informed they wish to be kept at any point of time (Mintzberg (1973)). Consider for example the development of concept for a new product. The manager can closely supervise the decision process from its inception, and be involved all of the main design decisions. Alternatively, he may allow his subordinates to develop the concept without consulting him and then bring it to him to final authorization, at which stage he may either allow the project continue, require modifications or reject it altogether.

In this section, I incorporate into the model the principal's decision when to intervene and study how the optimal decision on this regard is related to the principal's experience (for the purpose of this section, experience is taken to affect only the principal's verification ability $x$ ). I extend the previous model in two ways: first, the principal's choice when to exert effort is endogenized. Specifically, I assume that the principal can choose to exert effort either at the same time as the agent or, as in the basic model, only after the agent has conducted his evaluation and submitted a recommendation. Second, I assume that the cost to the principal is higher if exerting effort at a late stage. Many decisions become more urgent as time passes (for example, a delay in the decision may result in the product not
arriving in time for the peak demand season; an exogenous deadline has to be met; better supply sources may be secured by competitors unless the firm acts fast etc.). Compared with the option of considering the alternatives in the early stages (and in a relatively unrushed manner) evaluating the alternatives late and over a short period of time requires a concentrated effort from the principal and would commend much of his attention, leading to a diversion of attention from his other duties which may suffer as a result.

Formally, denote the effort exerted by the principal in the ex ante stage (i.e. at the same time as the agent) by \( i_{p1} \) and by \( i_{p2} \) the effort he exerts after receiving the agent’s recommendation. The principal can exert effort only in one of the two stages and thus \( i_{p1} \cdot i_{p2} = 0 \). We furthermore assume that the agent is aware whether \( i_{p1} > 0 \) or \( i_{p1} = 0 \) when choosing his own effort although he is unable to observe the exact value of \( i_{p1} \) if it is positive.\(^8\) The cost of \( i_{p1} \) to the principal is \( \mu_1 c(i_{p1}) \) whereas the cost of \( i_{p2} \) is \( \mu_2 c(i_{p2}) \), where \( \mu_2 > \mu_1 \). Assume in addition that Assumption 3 holds for \( \mu = \mu_2 \).

Intuitively, the decision on the time of intervention depends on two opposing forces: Ignoring the increase in the cost of effort over time, the principal gains by allowing the agent to evaluate the alternatives first and make a recommendation. By doing so he establishes a "credible promise" to curb the principal’s intervention if the agent improves his recommendation. This also gives the agent stronger incentives to exert effort. Since the cost of the principal’s effort increases over time, however, there is an opposing effect which favors the principal exerting effort early, knowing that the cost of thorough evaluation in the late stage would be high.

When the agent and the principal’s efforts are taken simultaneously, the principal has no alternative but to follow the agent’s recommendation when his own investigation fails and he remains uninformed. The agent’s recommendation would be followed in this case whether it can be verified or not. The outcome in this case is thus unaffected by the principal’s verification ability. In contrast, we know from the preceding section that the outcome if the principal moves ahead is more favorable to the principal the higher is his verification ability. This leads immediately to the next characterization, which shows how the timing of the principal’s effort depends on his experience.

**Lemma 1** There exists \( \bar{x} \in [0, 1] \) such that, for a principal with verification ability \( x \),

i. if \( x \leq \bar{x} \) there exists equilibrium in which the principal exerts effort at the same time as the agent ( \( i_{p1} > 0 \) ). The principal’s utility in this equilibrium is higher than in any other equilibria.

---

\(^8\)This assumption captures the idea that the agent is always aware (and not just in equilibrium) what is the form of the principal’s involvement.
ii. if $x > \bar{x}$ the principal exerts effort after the agent ($i_{p2} > 0$) in all equilibria.

From the proof of the lemma (in the appendix), it can be seen that the principal’s effort tends to be much higher if exerted early than if exerted late, even if comparing principals with similar levels of experience (i.e. with values of $x$ just above and below $\bar{x}$). The principal’s effort equals $i_p(v; \mu_1)$ if exerted at the same time as the agent and $i_p(v^*; \mu_2)$ if following his recommendation, where $i_p(v; \mu)$ is defined as in (2). Since $i_p(v; \mu_1) > i_p(v^*; \mu_1) > i_p(v^*; \mu_2)$, the agent’s real authority is substantially reduced if the principal exerts effort early.

The results of the previous section has shown that experienced managers are more trusting of their subordinates and tend to overrule them less. This tendency is reinforced when managers choose the time of intervention. Relatively inexperienced managers prefer to maintain tight control from early stages as they correctly perceive they would otherwise be faced with the option of exerting prohibitively costly effort late to come up with alternatives to their agent’s unsatisfactory recommendations. Early intervention implies that the principal’s role in the decision process is much more pronounced, as he exerts far more effort and the agent far less. Experienced managers in contrast are more confident in their ability to elicit favorable recommendations and thus less averse to intervening only late in the process.

4.2 Principal with several agents

In this section, I examine an environment in which the principal interacts with several agents (e.g., a CEO and several division heads), who are each assigned to a different task (e.g. different products, different geographical markets etc.). Tasks are independent from one another and do not compete on scarce resources. Therefore any interdependence between them stems only from the fact that the principal’s efforts in the different areas are cost substitutes.

Specifically, assume that there are two agents ($A_1$ and $A_2$) and a single principal ($P$). The principal’s cost of effort is:

$$c_p(i_{p1}, i_{p2}) = \frac{(i_{p1})^2}{2} + \delta i_{p1} i_{p2} + \frac{(i_{p2})^2}{2}, \quad \delta \in (0, 1).$$

The agents are each assigned to an independent task (area). Each task is characterized as in Section 2 and with identical parameters.

In the interim stage, an agent $i = 1, 2$, if informed, presents a recommendation with value $v_i$ to the principal for an action in his area. For simplicity, we assume that the agents first publicly report if uninformed. If both are informed, the agents simultaneously present their recommendations. Given $(v_1, v_2)$, the principal decides how much effort to exert to evaluate alternative courses of action in each of the two areas respectively. The principal’s effort
allocation problem is therefore
\[
\max_{i_{p1}, i_{p2}} i_{p1} \bar{v} + (1 - i_{p1}) v_1 + i_{p2} \bar{v} + (1 - i_{p2}) v_2 - c_p(i_{p1}, i_{p2}).
\]

The solution to maximization problem is
\[
i_{p1}(v_1, v_2) = \frac{(1 - \delta) \bar{v} - v_1 + \delta v_2}{1 - \delta^2},
\]
\[
i_{p2}(v_1, v_2) = \frac{(1 - \delta) \bar{v} - v_2 + \delta v_1}{1 - \delta^2}.
\]

Observe that the principal’s effort in each area is decreasing in the value of the recommendation made by the agent in charge of this area and increasing in the value of the recommendation of the other agent. The first effect is the same effect discussed in the single agent case. The second effect is novel and is due to the cost substitutability between the principal’s effort in both areas.

The next lemma shows that the agents’ recommendations are strategic complements.

**Lemma 2** Let \(v^*_1(v_2)\) and \(v^*_2(v_1)\) denote the agents’ best response functions in the interim stage when both agents are informed. Then \(\partial v^*_1/\partial v_2 > 0\) and \(\partial v^*_2/\partial v_1 > 0\).

The intuition for this result is as follows: an increase in \(v_2\) lowers the return to the principal’s effort in task 2. The reduced effort in task 2 lowers the principal’s marginal cost of effort in task 1. In analogy to the results of Proposition 1, this induces agent 1 to increase his own recommendation, \(v_1\).

We turn now to consider the effect of the principal’s experience in this setup. A salient aspect is the fact that principals are often more experienced in some areas which they oversee than in others. For example, this can be the result of a CEO functional experience as a division head. Alternatively, one area could be a mature business while the other a new field which the firm has little experience in.

To formalize this idea, we consider the effect of a change in the principal’s experience in only one of the areas. We assume that the change in experience in one area has an effect on the principal’s verification ability in that area, but not on his ability to evaluate by himself. Let \(x_i\) denote the probability that the principal is able to verify agent \(i\)’s recommendation, for \(i = 1, 2\). We know that, in the single-agent framework, an increase in \(x\) leads the agent to improve his recommendation and the principal to put less effort himself (Proposition 2). In the two-agents setup, the decrease in the principal’s effort in area \(i\) thus implies that the principal’s marginal cost of effort in task \(j\) is diminished. We can expect the effect on agent \(j\)’s behavior to be equivalent to that of a reduction in the marginal cost of principal’s
effort in the single agent case (Proposition 1). Indeed, the first part of Lemma 3 below shows that since \( \partial v^*_i / \partial x_i > 0 \) (by Proposition 2), and given the strategic complementarity between recommendations established above, \( \partial v^*_j / \partial x_i > 0 \) as well. Thus, both recommendations are improved if the principal is more experienced in only one area.

Next, we make the following assumption with respect to the ex ante choice of efforts \((i_{a1}, i_{a2})\).

**Assumption 4** Agents’ efforts are strategic substitutes.

The assumption states that the gain for an agent from becoming informed ("return of effort") is higher when the other agent is uninformed. This is likely to be the case for two reasons: first, the payoff in case the agent is uninformed is higher if the other agent is informed, because the principal can devote more of his own effort to the agent’s area (recall the partial congruency between the agent and principal, which implies that the agent wants the principal effort to be highest as possible in this case). Second, if the agent is informed, he is likely to be better off if the principal’s marginal cost of effort is higher, which is the case if the other agent is uninformed, and the principal has put additional effort in that area. The second part of Lemma 3 shows that, under this condition, when the principal experience in area \(i\) increases, the effort of agent \(j\) diminishes.

**Lemma 3** Suppose that the principal’s experience in area \(i\) increases \((x_i \text{ is higher})\). Then both agents’ recommendations, in case both are informed, increase. The agent in charge of area \(i\)’s effort increases, while the effort of the agent in charge of area \(j\) decreases.

An increase in the principal’s experience in one area results in an increase in "prominence" of the unit assigned to this area, at the expense of the other unit. Specifically, this unit enjoys more real authority and therefore its effort and overall contribution to the organization increase. The free monitoring "resources" are used by the principal to monitor the other unit’s area more closely. While this does discipline that unit to make more palatable recommendations, it also diminishes its initiative and effort.

Roberts (2004) discusses the allocation of resources within firms between units in charge of exploration of new areas and units devoted to the exploitation of existing ones (p. 273). There is a stark asymmetry in the information that top-level executives have access to in the two areas. Exploitation groups are able to document their cases, and executives, who typically have significant experience in those areas, can easily process those. In contrast, exploration groups will have much more difficult time quantifying the expected cash flow from resources which are allocated to them. Roberts notes that this may tend to bias decisions in favor of the established, performance oriented businesses.
A Parametric example

In this section we provide a parametric example for the model outlined in Section 2. Let $c(i) = 0.5i^2$ and let $u(v) = \sqrt{1-v^2}$, $\nu = 0$ and $\overline{\nu} = 1$ (unit circle). It is straightforward to show that $i_p(v) = (1-v)/\mu$ in this case. Since the function $c$ does not satisfy the Inada condition we thus further assume that $\mu > 1$ to ensure $i_p(v) < 1$ for all $v$. Substituting into the first-order condition 5 , we get

$$x \left[1 - (v^*)^2\right] - (\mu - 1 + v^*)v^* = 0$$

from which it can be shown after some calculations that

$$v^* = \frac{\sqrt{\mu(\mu - 2) + (2x + 1)^2} - \mu + 1}{2(x + 1)}$$

and thus

$$i_p(v^*) = \frac{2(x + 1) + \mu - 1 - \sqrt{\mu(\mu - 2) + (2x + 1)^2}}{2(x + 1)\mu}.$$  

Some derivations show that the sign of $di_p(v^*)/d\mu$ equals that of

$$-\mu + (2x + 1) \left[(2x + 1) - \sqrt{(2x + 1)^2} - 1\right]$$

where as $\mu > 1$ the second term is smaller than $(2x + 1) \left[(2x + 1) - \sqrt{(2x + 1)^2} - 1\right] \leq 1$ for $x \in [0, 1]$. Thus, $di_p(v^*)/d\mu < 0$ for all $x$ and for all $\mu$.

B Proofs

Proofs of all lemmas and propositions not in the text follow.

Proof of Proposition 1. Assume that $\mu$ decreases.

i. $\partial i_p(v)/\partial \mu = -h'((\frac{u}{\mu}) \cdot (\overline{\nu} - v))/\mu^2 < 0$. Thus, as $\mu$ decreases $i_p(v)$ increases.

ii. Recall the first-order condition (5) which implicitly determines $v^*$.

$$-x \cdot i_p'(v^*) [u(v^*) - \overline{u}] + [1 - i_p(v^*)] u'(v^*) = 0.$$  

Differentiating this expression with respect to $v^*$ we obtain $\partial^2 \overline{U}/\partial v^2 - i_p'(v^*) u'(v^*)$, where the first term is the derivative taking $i_p(v^*)$ as given (as in the maximization
problem (3)) and the second term is the effect through \( i_p(v^*) \). As \( \partial^2 U/\partial v^2 \leq 0 \) by assumption, the full derivative is decreasing in \( v^* \). Suppose now that, beginning from an initial value by \( v^* \), \( \mu \) diminishes. Then \( i_p(v^*) \) increases and thus also the entire second term (which is negative). In addition, as \( \partial \left[ i_p'(v) \right]/\partial \mu \geq 0 \), the first term increases as well. Thus it is necessary for \( v^* \) to increase for the first-order condition to hold.

iii. Observe first that the agent’s effort is determined by the first-order condition to the maximization problem (6),

\[
c'(i_a^*) = U - i_p(0) \cdot u.\]

As \( c'' > 0 \), as \( \mu \) decreases, the change in \( i_a^* \) has the same sign as the change in \( U - i_p(0) \cdot u \).

Applying the envelope theorem to (3), it follows that

\[
\frac{\partial \left[ U - i_p(0) \cdot u \right]}{\partial \mu} = \frac{\partial i_p(v^*)}{\partial \mu} [u - u(v^*)] + (1 - x) \frac{\partial [i_p(v^*)]}{\partial \mu} [u - u(v^*)] - \frac{\partial i_p(0)}{\partial \mu} u.
\]

As \( \partial i_p(v)/\partial \mu < 0 \), then \( d[i_p(v^*)]/d\mu \leq 0 \) is sufficient for \( \partial \left[ U - i_p(0) \cdot u \right]/\partial \mu > 0 \). Moreover, substituting \( d[i_p(v^*)]/d\mu \) from (7) and rearranging, we obtain

\[
\frac{\partial \left[ U - i_p(0) \cdot u \right]}{\partial \mu} = \left[ \frac{\partial i_p(v^*)}{\partial \mu} + (1 - x) i_p'(v^*) \frac{\partial v^*}{\partial \mu} \right] [u - u(v^*)] - \frac{\partial i_p(0)}{\partial \mu} u.
\]

Thus, a weaker sufficient condition for \( i_a^* \) to increase when \( \mu \) decreases is \( \partial i_p(v^*)/\partial \mu + (1 - x) i_p'(v^*) \partial v^*/\partial \mu \leq 0 \). The condition is clearly satisfied if \( x \) is sufficiently large.

Proof of Proposition 2.

i. Recall the first-order condition (5) which implicitly determines \( v^* \).

\[
-x \cdot i_p'(v^*) [u(v^*) - u] + (1 - i_p(v^*)) u'(v^*) = 0.
\]

and recall from the proof of Proposition 1 that the expression on the left-hand side is decreasing as a function of \( v \). Denote the initial value by \( v^* \). As \( x \) increases, the left-hand side increased. Hence \( v^* \) has to increase for the first-order condition to hold.

ii. As \( \partial v^*/\partial x > 0 \) by part 1, then \( d[i_p(v^*)]/dx = i_p'(v^*) \cdot [\partial v^*/\partial x] < 0 \). The principal overruling rate \( i_p(v^*) \) is thus lower.

iii. The agent’s effort \( i_a^* \), satisfies \( c'(i_a^*) = U - i_p(0) \cdot u \). Observe first that the agent’s payoff if he fails, \( i_p(0) \cdot u \), does not depend on \( x \). Consider next the effect of a change in \( x \)
on $U$, the payoff if successful. Applying the Envelope Theorem to (3), the effect on this payoff of a change in $v^*$ is a second-order one. The effect through $i_p^*$ is a first-order effect. Thus
\[
\frac{\partial U}{\partial x} = (1 - x) \cdot d[i_p(v^*)]/dx \cdot [u - u(v^*)] > 0.
\]

The agent’s screening intensity $i_a^*$, is thus an increasing function of the difference $U - i_p(0) \cdot u$ and therefore increases in $x$.

iv. The principal’s ex ante utility is:
\[
V = i_a^*[i_p(v^*) \bar{v} + (1 - i_p(v^*)) v^* - \mu c(i_p(v^*))] + (1 - i_a^*)[i_p(0) \bar{v} - \mu c(i_p(0))]
\]

By the envelope theorem, as $\partial v^*/\partial x > 0$, then $i_p^* \bar{v} + (1 - i_p^*) v^* - \mu c(i_p^*)$ is increasing in $x$. As $i_a^*$ increases in $x$ as well and given that $i_p^*(v^*) \bar{v} + (1 - i_p(v^*)) v^* - \mu c(i_p(v^*)) > i_p(0) \bar{v} - \mu c(i_p(0))$, by revealed preference, we obtain the result.

The agent’s ex ante utility is the value of (6)
\[
U = i_a^* \bar{u} + (1 - i_a^*) i_p(0) \cdot u - c_a(i_a^*)
\]
By the envelope theorem, $\frac{\partial U}{\partial x} = i_a^* \cdot \frac{\partial \bar{u}}{\partial x} > 0$.  

**Proof of Lemma 1.** It is useful to consider first an equilibrium of a one-stage game in which the principal and agent exert effort simultaneously. In the equilibrium of such game, the principal’s best alternative $\bar{v}$ is implemented if the principal becomes informed, and the agent’s best alternative (with value $v$ to the principal) is implemented if the principal remains uninformed and the agent is informed. The effort levels $(i_{p1}, i_a)$ are therefore determined as a solution to the system of equations:

\[
\begin{align*}
i_{p1} &= \operatorname{arg\,max}_{i_p} i_p \bar{v} + (1 - i_p) i_a \bar{u} - \mu_1 c(i_{p1}). \\
i_a &= \operatorname{arg\,max}_{i_p} i_p u + (1 - i_p) i_a v - c(i_a).
\end{align*}
\]

Consider next a potential equilibrium of the two-stage game with $i_{p1} > 0$. Because the choice of $P$’s effort is not observed by $A$ (except for whether it is positive or not), $i_{p1}$, if positive, is a best-response to $i_a$. Similarly, $i_a$ is a best response to $i_{p1}$. The effort levels in this case are therefore equal to those in the simultaneous game. Denote the value that would be obtained by the principal in such equilibrium by $V_1$. Because the principal’s experience $x$ does not come into play if $i_{p1} > 0$, $V_1$ is invariant in $x$. In contrast, if $i_{p1} = 0$, then the unique equilibrium of the continuation game is identical to that described in Section 2. Thus, if an
equilibrium with \( i_{p1} = 0 \) exists, we know from Proposition 2 that the payoff to the principal in this equilibrium, \( V_2(x) \), strictly increases in \( x \).

Denote therefore by \( \tilde{x} \) the level of \( x \) such that \( V_2(x) \geq V_1 \) if and only if \( x \geq \tilde{x} \) (note that \( \tilde{x} = 0 \) and \( \tilde{x} = 1 \) are possible). If \( x > \tilde{x} \), an equilibrium with \( i_{p1} > 0 \) cannot exist. The value obtained by the principal in such equilibrium, \( V_1 \), is strictly below \( V_2(x) \) which he would obtain if deviating to \( i_{p1} = 0 \). In all possible equilibrium thus \( i_{p1} = 0 \) and \( i_{p2} = i_p(v^*) \) as in the previous section. Such equilibrium can be supported for example by an out-of-equilibrium belief by the agent that the principal has chosen \( i_{p1} = 0 \) if he observes \( i_{p1} = 0 \). If \( x < \tilde{x} \), then there exists an equilibrium in which the principal and agent choose \( i_{p1} = \tilde{i}_{p1} \) and \( i_a = \tilde{i}_a \) respectively. If the principal where to deviate to \( i_{p1} = 0 \) he would obtain \( V_2(x) \) which is smaller than the equilibrium payoff \( V_1 \). If other equilibria with \( i_{p1} = 0 \) exist, the principal obtains a lower value in them. ■

**Proof of Lemma 2.** Denote agent 1’s payoff, conditional on both agents being successful, by \( U_{yy} \).

\[
U_{yy}(v_1, v_2) = x_1 x_2 \cdot [(1 - i_{p1}(v_1, v_2)) \cdot U(v_1) + i_{p1}(v_1, v_2) \cdot u] + x_1 (1 - x_2) \cdot [(1 - i_{p1}(v_1, v_2^*) \cdot U(v_1) + i_{p1}(v_1, v_2^*) \cdot u] + (1 - x_1) x_2 \cdot [(1 - i_{p1}(v_1^*, v_2)) \cdot U(v_1) + i_{p1}(v_1^*, v_2) \cdot u] + (1 - x_1) (1 - x_2) \cdot [(1 - i_{p1}(v_1^*, v_2^*)) \cdot U(v_1) + i_{p1}(v_1^*, v_2^*) \cdot u],
\]

and similarly define \( U_{yy} \) for agent 2. It is known (see for example Tirole (1988), p. 208) that \( v_1 \) and \( v_2 \) are strategic complements if and only if \( \partial^2 U_{yy} / \partial v_i \partial v_j > 0 \) for \( i = 1, 2 \) and \( j \neq i \).

As can be seen from (8), \( \partial i_{p1} / \partial v_i = -1 / (1 - \delta^2), \partial i_{p1} / \partial v_j = \delta / (1 - \delta^2) \) and \( \partial^2 i_{p1} / \partial v_i \partial v_j = 0, \) for \( i = 1, 2 \) and \( j \neq i \). After some derivations we obtain

\[
\frac{\partial^2 U_{yy}}{\partial v_1 \partial v_2} = -[x_1 x_2 \cdot \delta + (1 - x_1) x_2 \cdot \delta] \cdot U'(v_1) / (1 - \delta^2) = -x_2 \delta / (1 - \delta^2) \cdot U'(v_1) > 0.
\]

\[
\frac{\partial^2 U_{yy}}{\partial v_1 \partial v_2} = -[x_1 x_2 \cdot \delta + (1 - x_2) x_1 \cdot \delta] \cdot U'(v_2) / (1 - \delta^2) = -x_1 \delta / (1 - \delta^2) \cdot U'(v_2) > 0.
\]

Thus \( v_1 \) and \( v_2 \) are strategic complements and the best response functions are upward-sloping.

In addition, the local stability condition is satisfied at an intersection \((v_1^*, v_2^*)\) provided

\[
\frac{\partial^2 U_{yy}}{\partial (v_1)^2} \frac{\partial^2 U_{yy}}{\partial (v_2)^2} - \frac{\partial^2 U_{yy}}{\partial v_1 \partial v_2} \cdot \frac{\partial^2 U_{yy}}{\partial v_1 \partial v_2} > 0.
\]
Thus in the case both agents are informed 

\[ \frac{\partial^2 U_1^{yy}}{\partial (v_1)^2} = 2x_1 \cdot U' (v_1^*) + (1 - \pi_1 (v_1^*, v_2^*)) U'' (v_1^*) \]

\[ \frac{\partial^2 U_2^{yy}}{\partial (v_2)^2} = 2x_2 \cdot U' (v_2^*) + (1 - \pi_2 (v_1^*, v_2^*)) U'' (v_2^*) \]

Then

\[ \frac{\partial^2 U_1^{yy}}{\partial v_1 \partial v_2} \cdot \frac{\partial^2 U_2^{yy}}{\partial v_1 \partial v_2} = \left( \frac{\delta}{1 - \delta^2} \right)^2 \cdot x_1 x_2 \cdot U' (v_1^*) U' (v_2^*) \]

And as \( U' < 0 \) and \( U'' < 0 \),

\[ \frac{\partial^2 U_1^{yy}}{\partial (v_1)^2} \cdot \frac{\partial^2 U_2^{yy}}{\partial (v_2)^2} > 4x_1 x_2 \cdot U' (v_1^*) U' (v_2^*) \]

Thus, the condition is satisfied at any intersection \( (v_1^*, v_2^*) \) of the best-response functions, provided (sufficient condition) \( \delta/(1 - \delta^2) < 2 \) or \( \delta < 0.78 \). In this case the intersection is unique. ■

**Proof of Lemma 3.** Consider the first-order conditions characterizing the recommendations in the case both agents are informed \( (v_1^{yy}, v_2^{yy}) \)

\[ F_1 \equiv x_1 (U (v_1^{yy}) - y) + [1 - \pi_1 (v_1^{yy}, v_2^{yy})] \cdot U' (v_1^{yy}) = 0, \]

\[ F_2 \equiv x_2 (U (v_2^{yy}) - y) + [1 - \pi_2 (v_1^{yy}, v_2^{yy})] \cdot U' (v_2^{yy}) = 0. \]

For concreteness, consider the effect of a small increase in \( x_2 \). Differentiating the equations above and applying Cramer’s law we obtain \( \frac{\partial v_1^{yy}}{\partial x_2} = \frac{\partial F_1/\partial v_2 \partial F_2/\partial v_1}{\Delta} \) and \( \frac{\partial v_1^{yy}}{\partial x_1} = -\frac{\partial F_2/\partial v_2 \partial F_1/\partial x_1}{\Delta} \) where \( \Delta = \partial F_1/\partial v_1 \cdot \partial F_2/\partial v_2 - \partial F_1/\partial v_2 \cdot \partial F_2/\partial v_1 \). Observe that \( \Delta > [(1 + x_1)(1 + x_2) - \delta^2] \cdot U' (v_1^{yy}) U' (v_2^{yy}) > 0 \), that \( \partial F_1/\partial x_1 > 0 \) and \( \partial F_2/\partial x_2 > 0 \) and that \( \partial F_1/\partial v_2 > 0 \) and \( \partial F_2/\partial v_2 < 0 \). Thus

\[ \frac{\partial v_1^{yy}}{\partial x_2} > 0 \] and \( \frac{\partial v_1^{yy}}{\partial x_1} > 0 \).

Analogously, it can be shown that

\[ \frac{\partial v_2^{yy}}{\partial x_1} > 0 \] and \( \frac{\partial v_2^{yy}}{\partial x_2} > 0 \).

Finally observe for future reference that \( \frac{\partial v_1^{yy}}{\partial x_2} = \frac{\partial F_1/\partial v_2 \partial F_2/\partial x_2}{\Delta} \) and \( \frac{\partial v_2^{yy}}{\partial x_2} = \frac{-\partial F_1/\partial v_1 \partial F_2/\partial x_2}{\Delta} \). Thus

\[ \frac{\partial v_1^{yy}}{\partial x_2} = -\frac{\partial F_1/\partial v_1}{\partial F_1/\partial v_2} \cdot \frac{\partial v_1^{yy}}{\partial x_2} \]
where \( \frac{\partial F_i}{\partial v_1} = \frac{1+x}{\delta} + \frac{1-i_{p1}(v_{1y}^y, v_{2y}^y)}{\delta}, \quad \frac{\partial F_i}{\partial v_2} = \frac{U''(v_{1y}^y)}{U'(v_{1y}^y)}. \) Denote also \( i^y_{p1} = i_{p1}(v_{1y}^y, v_{2y}^y) \) and \( i^y_{p2} = i_{p2}(v_{1y}^y, v_{2y}^y). \)

Consider next the effect on the agents’ effort choice in stage 1. Denote by \( i^*_a(i_{a2}) \) and by \( i^*_a(i_{a1}) \) the agents’ best response in the effort choice game. These best-responses are implicitly defined by the first-order conditions:

\[
i_{a2} \cdot [U_1^{ny} - U_1^{my}] + (1 - i_{a2}) \cdot [U_1^{yn} - U_1^{mn}] = c'(i^*_a) \tag{9}
\]

\[
i_{a1} \cdot [U_1^{yy} - U_2^{my}] + (1 - i_{a1}) \cdot [U_2^{yn} - U_2^{mn}] = c'(i^*_a) \tag{10}
\]

where \( U_1^{ny} = i_{p1}(0, v_{2y}^y) \), \( U_1^{nn} = i_{p1}(0, 0) \) and \( U_1^{ym} = U_1^{yy}(v_{1y}^y, 0). \)

Observe that the efforts are strategic substitutes, i.e. \( i^*_a(i_{a2}) \) and \( i^*_a(i_{a1}) \) are downward-sloping if and only if \( U_1^{ny} - U_1^{my} < U_1^{yn} - U_1^{mn} \) and \( U_2^{yy} - U_2^{my} < U_2^{yn} - U_2^{mn} \). These conditions state that the gain to an agent from becoming informed is larger when the other agent is uninformed.

When agent 2 fails, the principal’s effort in area 2 is higher for every level of \( v_1 \), and so is his marginal cost of effort. Thus the conditions \( U_1^{yy} < U_1^{my} \) and \( U_2^{yy} < U_2^{my} \) are the equivalent of the agent’s gross payoff increasing in \( \mu \) in the single-agent model, which we have shown to hold in parametric examples. These conditions are sufficient, but not necessary for the best-responses to be downward-sloping, as \( U_1^{ny} > U_1^{mn} \) and \( U_2^{ny} > U_2^{mn} \). In case agent 1 fails, he is benefitted if agent 2 succeeds, as this "frees" the principal resources to exert effort in area 1.

Provided the best-responses are downward sloping (Assumption 4) we now show that agent 2’s effort \( i^*_a(i_{a2}) \) increases in \( x_2 \) whereas agent 1 effort \( i^*_a(i_{a1}) \) is decreasing.

We first show based on (9) that \( \frac{\partial i^*_a(i_{a2})}{\partial x_2} < 0 \). Note first that \( U_1^{yn} - U_1^{mn} \) does not depend on \( x_2 \). That \( U_1^{ny} \) is increasing in \( x_2 \) is immediate from the fact that \( v_{2y}^{ny} \) is increasing in \( x_2 \) (based on the results of Proposition 2) and the fact that \( \partial i_{p1}/\partial v_2 > 0 \). Finally \( U_1^{yy} = (1 - i^y_{p1}) U(v_{1y}^y) + i^y_{p2}u \). Thus

\[
\frac{\partial U_1^{yy}}{\partial x_2} = (1 - i^y_{p1}) U'(v_{1y}^y) \frac{\partial v_{1y}^y}{\partial x_2} + \frac{\partial i^y_{p1}}{\partial x_2} [u - U(v_{1y}^y)].
\]

where

\[
\frac{\partial i^y_{p1}}{\partial x_2} = \frac{\partial i_{p1}}{\partial v_1} \frac{\partial v_{1y}^y}{\partial x_2} + \frac{\partial i_{p1}}{\partial v_2} \frac{\partial v_{2y}^y}{\partial x_2} = \frac{\partial v_{1y}^y}{\partial x_2} \left[ -1 + \frac{1}{\delta} \cdot \frac{U''(v_{1y}^y)}{U'(v_{1y}^y)} \right] = \frac{\partial v_{1y}^y}{\partial x_2} \left[ x + (1 - i^y_{p1}) \cdot \frac{U''(v_{1y}^y)}{U'(v_{1y}^y)} \right] > 0
\]

Thus \( \partial U_{1y}^{yy}/\partial x_2 < 0 \). The left-hand side of (9) is thus increasing in \( x_2 \). As \( c'' > 0 \),
\[ \partial i^*_a (i_{a2}) / \partial x_2 < 0. \text{ Similarly, } \partial i^*_{a1} (i_{a1}) / \partial x_2 > 0. \text{ This follows from (10) given that } \partial U^y_2 / \partial x_2 > 0 \text{ and } \partial U^m_2 / \partial x_2 > 0. \]

Finally, define \( i^*_{a1} \) and \( i^*_{a2} \) as the solution to the system of equations (9)-(10). As the best-response functions are downward-sloping and given that \( \partial i^*_{a1} (i_{a2}) / \partial x_2 < 0 \) and \( \partial i^*_{a2} (i_{a1}) / \partial x_2 > 0 \), it follows \( i^*_{a2} \) increases and \( i^*_{a1} \) decreases in \( x_2 \). ■

References


Murphy, K. J. and Zabojnik, J.: 2007, Managerial Capital and the Market for CEOs, *SSRN eLibrary*.

