The Incentive Effects of Interim Performance Evaluations

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September 1999. This version, August 2002.

Abstract

We study a dynamic moral hazard model where the agent does not fully observe his performance. We consider the effects on incentives and on selection of providing feedback to the agent.

We show that, for a fixed incentive scheme, there is a wide range of cases, where the agent works harded if feedback is provided. However, we show that the optimal incentive scheme depends on whether the agent is given feedback.

When the principal chooses the optimal incentive scheme, then it is cheaper to provide incentives when feedback is not provided.

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1 Introduction

We consider how organization decide whether, and to what extent, to provide feedback to individuals on how their performance to date has been evaluated.

We study a dynamic model with moral hazard where the agent does not fully observe her performance. In this setting the principal has a choice of whether to conduct an interim performance evaluation (IPE) and whether to reveal the outcome of this IPE to the agent.

To the extent that feedback helps individuals do their jobs better, or plan their future better, it is beneficial. But what effects does performance feedback have on incentives? What effects does it have on sorting, i.e., ensuring that the more able advance faster than the less able?

There are several examples where IPEs are potentially important. Associates in law firms and consulting firms know that a substantial part of their rewards takes the form of a potential promotion to partner. Long before the promotion decisions are made, some information about their prospects is revealed to these associates. Sometimes this information is revealed through a formal process of periodic evaluations by the partners. Sometimes the information revelation process is informal. A particularly stark example of an IPE is the case of midterm exams. Most courses require (sometimes multiple) midterm exams, and, if given the choice, students appear to favor having a midterm exam than having the entire grade based on the final exam.

Furthermore, there are several environments where it is easy to think of analogues to IPE's. In patent races, we can think of the effects of interim information on the progress made by *rivals*': if for instance the social planner can communicate this information to firms, what are the effects on innovation and on social welfare? There is also an interesting contrast between sealed-bid and ascending auctions such as the English auction. The latter provides interim information to bidders. Other application include multi-stage sports competitions and pre-election polling.

There has been little attention devoted to IPEs in the economics literature. There is extensive discussion of IPEs in the human resource management literature but there is no consensus, and little formal analysis.

We study the effects of IPE's on incentives to exert effort post IPE, incentives to exert effor prior to the IPE, and on the optimal structure of the incentive scheme that the principal wants to offer to the agent. We assume that output is *not* observable by agents themselves. Furthermore, when individuals have heterogeneous abilities, IPE's affect how well contests *sort* agents according to ability as well as tailoring of effort to ability.

We consider an environment with two periods. In each period the agent exerts an effort that determinines the probability of success. The agent does not observe the outcome. The principal observes the outcome but does not observe the agent's effort choice. We consider a model with a risk-neutral agent and limited liability. We discuss two scenarios. In the first scenario, when choosing second period effort the agent does not know the first period outcome. In the second scenario, the agent knows the first period outcome before choosing second period effort.

We first consider an environment where an incentive scheme consisting of rewards conditional on the possible outcomes is fixed and is the same in the two scenarios. In this case we show that in some circumstances total expected efforts are higher when information is revealed to the agent. However, the agent earns more money in the revelation scenario because he can taylor his effort to exploit differences in marginal compensation. Thus, the cost to the principal is higher in the revelation scenario. As a consequence, even if revelation raises the agent's expected effort, we cannot conclude that the principal prefers to reveal information to him.

Furthermore, if the principal were to choose the incentive schemes optimally, i.e. to minimize the expected cost of inducing a given level of expected effort, he would choose different schemes in the two scenarios. When interim evaluations are not provided, the optimal incentive scheme rewards the agent if and only if he succeeds twice. By contrast, when interim evaluations are given, it is optimal to offer a strictly positive reward for a single success, while offering an even greater marginal reward for a second success.

Armed with these characterizations, we then assess the desirability of providing interim performance evaluations when incentive schemes can be designed optimally. In this setting, we show that it is better not to reveal any information, i.e. the expected cost of inducing any given level of expected effort is lower in the no-revelation scenario.

Related literature

There is a large literature on dynamic agency problems. Rogerson (1985) studies a repeated moral hazard problem with risk aversion but not limited liability. He assumes that first-period output is observed by the agent. Furthermore, he studies the cost minimizing way of implementing a specified contingent effort plan. We make assumptions about how a contingent effort plan is 'aggregated' by the principal. A weak assumption is that the principal cares only about expected effort within each period; a stronger assumption is that the principal only cares only about total expected effort over both periods. Given these assumptions, we derive the optimal effort vector (and of course make comparisons between the cases where interim information is and is not provided). Holmstrom and Milgrom (1987) show that, under some circumstances, the optimal contract is linear in the final outcomes. In their paper, as in the accounting literature on earnings management, the agent (privately) learns how he's doing and optimally reacts by choosing his subsequent efforts. Thus, in this literature, IPEs are not addressed: the principal knows strictly less than the agent. A number of papers (e.g., Fudenberg, Holmstrom, and Milgrom 1990, Chiappori et al 1994) investigate the conditions under which the optimal contract in a long term agency relation can be implemented through a sequence of short-term (spot) contracts. In our setting, a sequence of spot contracts would be strictly worse for the principal than the optimal long-term contract. This is true whether IPEs are provided or not, and it is due to the limited liability assumption.

The closest papers are the following. In Prendergast (1992), the firm privately learns workers' abilities after the first period and decides whether or not to signal high ability to the worker. The main result of the paper concerns the desirability of fast-track promotions. In his model, the cost of IPEs is inefficiency in job assignment. The benefit is the induced tailoring of effort (training) to ability. Gibbs (91) provides a discussion of interim evaluations on subsequent efforts when the agent has to pass a minimal threshold in order to receive any compensation. Lazear (99) performs a similar analysis, focusing on tournaments.

2 Model

There are two periods. In each period t, there are only two possible outcomes: success or failure. The outcome in period t is denoted by $X_t \in \{f, s\}$. The probability of a success in period t is equal to the effort e_t in that period: $P(X_t = S) = e_t$. Conditional on effort choices, outputs are independent across periods.

In each period the cost of effort e_t is denoted by $c(e_t)$, where c is increasing, three times differentiable, convex, with $c(0) = c'(0) = 0$.

The agent is assumed to be risk neutral.

An incentive scheme for the agent is characterized by transfers conditional on all possible outcomes: $w(f, f), w(f, s), w(s, f), w(s, s)$. Given that the agent is risk neutral, the problem is uninteresting unless we assume that there is a limited liability constraint. We assume that $w(x, y) \geq 0$ for $x, y = f, s$.

We will contrast two scenarios on the information that is available to the agent when he chooses effort. In the first scenario, which we call the N-scenario, when choosing effort in the second period, the agent does not observe the first period outcome. In this scenario, the agent's payoffs are as follows:

$$U^N(e_1, e_2) = w(s, s)e_1e_2 + w(s, f)e_1(1-e_2) + w(f, s)(1-e_1)e_2 + w(f, f)(1-e_1)(1-e_2) - c(e_1) - c(e_2)$$

In the second scenario, which we call the Y-scenario, the agent observes the first period outcome before choosing second period effort. Thus, in this scenario, the agent can choose a different effort in the second period depending on the first period outcome and the payoff of the agent in this scenario are

$$\begin{aligned} U^Y(e_1, e_2) &= w(s, s)e_1e_2(s) + w(s, f)e_1(1 - e_2(s)) + w(f, s)(1 - e_1)e_2(f) + w(f, f)(1 - e_1)(1 - e_2(f)) \\ &\quad - c(e_1) - e_1c(e_2(s)) - (1 - e_1)c(e_2(f)) \end{aligned}$$

3 Fixed-Incentives Scheme

3.1 Preliminaries

In this section, we discuss the effects of interim performance evaluations when the incentive scheme is the same in both scenarios. For now, we assume that the cost of effort function is quadratic: $c(e) = ce^2/2$. We also assume that the rewards only depend on the number of successes, i.e., $w(f,s) = w(s,f) \equiv w(s)$. This assumption is relaxed later. Since the probability of success for the agent will generally be affected by the revelation policy, the expected expenditure of the principal is different in the two scenarios, even though the incentive scheme $(w(f,f), w(s), w(s,s))$ is the same. We will also assume that the incentive scheme is monotonic: $w(f,f) \leq w(s) \leq w(s,s)$.[1] In this section we assume that $w(s,s) < c$ to guarantee interior solutions.[2]

3.2 Comparison

It is useful to start by assuming an exogenously fixed probability of success p in the first period. In the no-revelation scenario the agent chooses e to maximize

$$p(w(s,s)e + w(s)(1-e)) + (1-p)(w(s)e + w(f,f)(1-e)) - \frac{1}{2}ce^2. \tag{1}$$

Consider the revelation scenario. If the first period outcome is a success, the agent chooses e to maximize

$$w(s,s)e + w(s)(1-e) - \frac{1}{2}ce^2, \tag{2}$$

while, if the first period outcome is a failure, the agent maximizes

$$w(s)e + w(f,f)(1-e) - \frac{1}{2}ce^2. \tag{3}$$

Consider the problem faced by the agent in the second period in the two scenarios. We want to compare these efforts by first abstracting from differences in first period effort in the two scenarios. To do this, we fix a probability of success in the first period.

Lemma 1 *Fix the first period probability of success at the same level p in both scenarios. Then, expected effort in the second period is the same in the two scenarios.*

Proof: Immediate, noting that expression (1) is the expected value with weight p of expressions (2) and (3). ∎

[1] The optimal incentive scheme obtained in the next section is monotonic.

[2] Corner solutions will typically involve the same total effort choice in both scenarios. An important case which is ruled out by assuming that $w(s,s) < c$ is the case of $w(s,s) = c$ which turns out to be the optimal scheme in the case of no revelation. We will come back to this later.

Lemma 1 says that, the effect of information revelation on effort is only through its effect on first period effort since, given a level of first period effort, second period incentives are on average the same in the two scenarios.

Denote by $u^Y(s)$ and $u^Y(f)$ and $u^N(s)$ and $u^N(f)$ the continuation utilities associated with success and failure in the revelation and no revelation scenarios, respectively. In either scenario i, the difference in utilities in the two states in the second period $u^i(s)$ and $u^i(f)$ represents the marginal benefit from increasing effort in the first period. The following result says that, if the probability of success in the first period is no larger than 1/2, this marginal benefit is larger in the revelation scenario than in the no revelation scenario. This is the key to the effort comparison across the two scenarios.

Lemma 2 *Given an exogenously fixed probability of success p in the first period, suppose that the agent chooses effort optimally in the second period. Then* $u^Y(s)-u^Y(f) \geq u^N(s)-u^N(f)$ *if and only if* $p \leq \frac{1}{2}$. *Equality holds only if* $(w(s,s)-w(s)) = (w(s)-w(f,f))$ *or* $p = \frac{1}{2}$.

Proof: If the first period outcome is a success, the effort that maximizes expression (2) is

$$e_2^Y(s) = \frac{w(s,s)-w(s)}{c} \tag{4}$$

If the first period outcome is a failure, the effort that maximizes expression (3) is

$$e_2^Y(f) = \frac{w(s)-w(f,f)}{c} \tag{5}$$

Substituting these respectively into equations (2) and (3) we obtain

$$u^Y(s)-u^Y(f) = (w(s)-w(f,f)) + \frac{1}{2c}((w(s,s)-w(s))^2-(w(s)-w(f,f))^2) \tag{6}$$

To obtain the difference in utilities among the two states in the no-revelation scenario, first observe that, by maximizing expression (1) optimal second period effort for a fixed p is

$$e_2^N(p) = \frac{p(w(s,s)-w(s))+(1-p)(w(s)-w(f,f))}{c} \tag{7}$$

By substituting into payoffs in the two states, we obtain

$$\begin{aligned} u^N(s)-u^N(f) \quad = \quad & (w(s)-w(f,f)) + \frac{1}{c}\Big\{p\,[w(s,s)-w(s)]^2-(1-p)\,[w(s)-w(f,f)]^2 \\ & +(1-2p)\,[w(s,s)-w(s)]\,[w(s)-w(f,f)]\} \end{aligned} \tag{8}$$

Define $x = w(s,s)-w(s)$ and $y = w(s)-w(f,f)$. Then expression (6) is greater than (8) if and only if

$$px^2-(1-p)\,y^2+(1-2p)\,xy < \frac{x^2}{2}-\frac{y^2}{2}.$$

We can rewrite this inequality as

$$(p-\frac{1}{2})x^2+(p-\frac{1}{2})y^2-2(p-\frac{1}{2})xy<0,$$

or

$$(p-\frac{1}{2})(x-y)^2<0.$$

Hence the result. ∎

The next proposition shows that first period effort is higher in the revelation scenario.

Proposition 1 *Suppose that the agent is facing an incentive scheme defined by* $(w(s,s),w(s),w(f,f))$*. Then*

(i) First period effort is higher if information is revealed: $e_1^Y \geq e_1^N$*; with strict inequaltiy if the incentive scheme is nonlinear, i.e.,* $w(s,s)-w(s)\neq w(s)-w(f,f)$*.*

(ii) $E(e_2^Y) > \ (<)\ e_2^N$ *if and only if* $w(s,s)-w(s) > \ (<)\ w(s)-w(f,f)$*, i.e., expected second period effort is higher (lower) when information is revealed if the incentive scheme is convex (concave).*

Proof: **Part (i)**: In the revelation scenario the agent's objective is to choose e_1 to maximize $e_1u^Y(s)+(1-e_1)u^Y(f)-\frac{1}{2}c\,(e_1)^2$. The first order conditions are

$$u^Y(s)-u^Y(f)=ce_1^Y. \tag{9}$$

In the no revelation scenario, given the optimal choice of e_2^N giving rise to $u^N(s),u^N(f)$, the agent chooses e_1 to maximize $e_1u^N(s)+(1-e_1)u^N(f)-\frac{1}{2}ce_1^2$. The first order conditions are

$$u^N(s)-u^N(f)=ce_1^N. \tag{10}$$

Now observe that, since $c>w(s,s)-w(f,f)$, then

$$e_1^N=e_2^N=\frac{w(s)-w(f,f)}{c+w(s)-w(f,f)-(w(s,s)-w(s))}<\frac{1}{2}. \tag{11}$$

Suppose then that the first period probability of success is fixed at the optimal effort in the N-scenario, e_1^N. Lemma 2, guarantees that given this probability of success in the first period, the left-hand side of equation (9) exceeds the left-hand side of equation (10). Thus, first period effort must be higher in the Y-scenario.

Part (ii): In order to compare second period efforts, observe that at the optimum, from equation (7),

$$e_2^N=\frac{e_1^N(w(s,s)-w(s))+(1-e_1^N)(w(s)-w(f,f))}{c}$$

and, from equations (4) and (5),

$$Ee_2^Y = \frac{e_1^Y(w(s,s) - w(s)) + (1 - e_1^Y)(w(s) - w(f,f))}{c}$$

Since, by part (i), $e_1^Y > e_1^N$, then we have that $Ee_2^Y > e_2^N$ if and only if $(w(s,s) - w(s)) > (w(s) - w(f,f))$ ∎

Proposition 1 says that first period effort is higher under revelation. However, part (ii) of the Proposition says that second period effort could be eiher higher or lower in the revelation scenario than in the no-revelation scenario depending on the convexity of the incentive scheme.

We now want to complete the effort comparison by comparing total expected efforts over the two periods in the two scenarios. In order to make the comparison, we need the following Lemma.

Lemma 3 *Given an exogenously fixed probability of success p in the first period, suppose that the agent chooses effort optimally in the second period. In the revelation scenario, expected optimal effort in the second period changes less than one for one with p.*

Proof: We need to obtain expected second period effort in the Y-scenario as a function of p. In order to do this, multiply by p the right-hand side of equation 4, multiply the right-hand side of equation 5 by $(1-p)$ and add the resulting expressions to obtain

$$E\left(e_2^Y|p\right) = \frac{p(w(s,s) - w(s)) + (1-p)(w(s) - w(f,f))}{c} \qquad (12)$$

Thus,

$$\left|\frac{dE(e_2^Y|p)}{dp}\right| = \left|\frac{(w(s,s) - w(s)) - (w(s) - w(f,f))}{c}\right| < 1.$$

∎

The next proposition shows expected total effort is higher in the revelation scenario and shows that first period effort is higher than second period effort in the Y scenario.

Proposition 2 *Suppose that the agent is facing an incentive scheme defined by* $(w(s,s), w(s), w(f,f))$. *Then*

(i) Total expected effort is higher if information is revealed: $e_1^Y + E(e_2^Y) \geq e_1^N + e_2^N$*;with strict inequality as long as* $w(s,s) - w(s) \neq w(s) - w(f,f)$.

(ii) In the revelation scenario,, first period effort is higher than second period effort: $e_1^Y \geq E(e_2^Y)$*; with strict inequality as long as* $w(s,s) - w(s) \neq w(s) - w(f,f)$.

Proof: **Part (i):**

$$\begin{aligned} e_1^Y - e_1^N &\geq \left|E(e_2^Y|e_1^Y) - E(e_2^Y|e_1^N)\right| \\ &\geq E(e_2^Y|e_1^N) - E(e_2^Y|e_1^Y) \\ &= e_2^N - E(e_2^Y|e_1^Y). \end{aligned}$$

where the inequality in the first line comes from Lemma 3, and the third line comes from Lemma 1. Therefore, $e_1^Y + E(e_2^Y) > e_1^N + e_2^N$.

Part (ii): Observe first that $e_1^N = e_2^N$. Furthermore, by Lemma 1, if we evaluate the expectation of second period effort in the revelation scenario according to the probability e_1^N, we obtain $Ee_2^Y = e_1^N$. Finally, by Lemma 1, Ee_2^Y increases less than one for one with increases in p. Thus, $e_1^Y > Ee_2^Y$. ∎

Corollary 1 *The expected cost of effort to the agent is higher in the Y scenario.*

Proof: From the above Proposition we have

$$e_1^N \leq \frac{e_1^Y + E(e_2^Y)}{2}.$$

Thus, using first monotonicity, and then concavity, of c, we can write

$$\begin{aligned} c\left(e_1^N\right) &\leq c\left(\frac{e_1^Y + E(e_2^Y)}{2}\right) \\ &\leq \frac{1}{2}c\left(e_1^Y\right) + \frac{1}{2}c\left(E(e_2^Y)\right) \\ &\leq \frac{1}{2}c\left(e_1^Y\right) + \frac{1}{2}E\left(c(e_2^Y)\right) \end{aligned}$$

whence

$$2c\left(e_1^N\right) \leq c\left(e_1^Y\right) + E\left(c(e_2^Y)\right)$$

∎

For future reference, observe that the optimum first period effort in the revelation scenario is

$$e_1^Y = \frac{(w(s) - w(f,f))2c + (w(s,s) - w(f,f))(w(s,s) + w(f,f) - 2w(s))}{2c^2} < \frac{1}{2}. \tag{13}$$

3.3 Discussion

Proposition 2 shows that there is a wide class of incentive schemes that lead the agent to exert more effort in the case where information is revealed to the agent. It would be tempting to conclude from this result that a principal who is interested in eliciting effort from the agent would choose to conduct interim performance evaluations and give all possible feedback to the agent. However, such a conclusion would be premature. In the revelation scenario, the expected wage bill is also higher. To see this, observe that the wage bill is equal to the expected utility of the agent plus the expected cost of effort. The expected utility of the agent is obviously higher in the revelation scenario and, by corollary 1 the total cost of effort is also higher in the revelation scenario. The inequalities are strict if the incentive scheme is nonlinear. Thus, it is not clear whether the principal would prefer to conduct interim performance evaluations. Furthermore, if the principal chooses the compensation scheme as well as the revelation policy, we have to consider the possibility that the optimal scheme in the no revelation scenario may be quite different from the optimal scheme in the revelation scenario.

One exception to this discussion is the case of a subprincipal (say a division manager) who has no control over the compensation scheme, but can choose whether to conduct interim performance evaluations. If the division manager is rewarded on the basis of total output and not on the wage bill, he would choose to reveal information.

4 Optimal Incentive Schemes

We now allow the principal to choose the incentive scheme optimally in the two scenarios, we compare the properties of the incentive schemes in the two scenarios, and we look at which scenario is preferred by the principal. We dispense with the assumption of a quadratic cost function and the assumption that the incentive scheme must depend only on the number of successes. It is clear that in the optimal incentive scheme, $w(f,f)=0$. Thus, from now on we will focus only on the remaining three values of the compensation scheme.

4.1 No revelation

Let us express the problem of an agent in the following way

$$\begin{aligned} & \max_{e_1,e_2} U\left(e_1,e_2\right) \\ = \quad & \max_{e_1,e_2} \alpha e_1+\beta e_2+\gamma e_1 e_2-c\left(e_1\right)-c\left(e_2\right). \end{aligned} \tag{14}$$

The α,β,γ's are synthetic parameters which, in our problem must be a function of $w(s,f)$, $w(f,s)$, and $w(s,s)$. Specifically, $\alpha=w(s,f)$, $\beta=w(f,s)$ and $\gamma=w(s,s)-w(s,f)-w(f,s)$. The limited liability assumption implies that α and β are restricted to be nonnegative. We

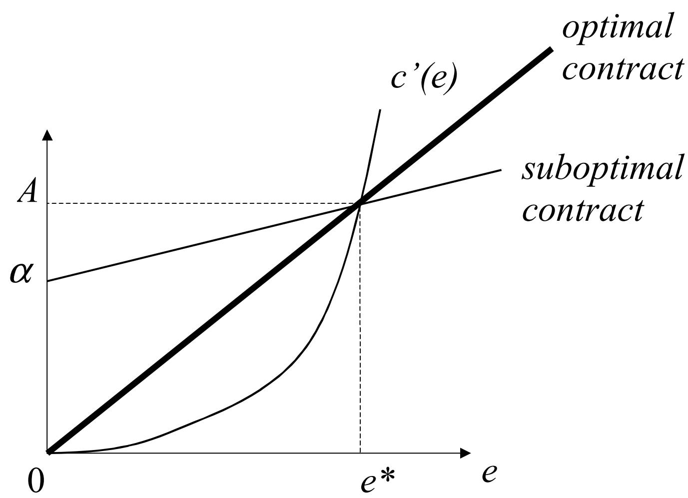

Figure 1:

now discuss how the principal would choose a compensation scheme that depends on e_1, e_2, and $e_1 \cdot e_2$, two linear terms and a mixed term. It will become clear how such a scheme can be implemented with the instruments available to the principal. We assume that $c'(0) = 0, c'(1) = \infty$. These conditions guarantee that the optimal e_1 and e_2 are interior.

Let us first solve for the case in which the principal sets $\beta = \alpha$, meaning that the reward for just one success is independent of whether the success happened in period 1 or 2 (we will soon show that this contract is indeed optimal for the principal.) Provided that problem (14) is concave in e_1, e_2 (requiring $c''' \geq 0$) the agent will choose the same effort in both periods. Denote this effort by e. Then problem (14) becomes

$$\max_e 2\alpha e + \gamma e^2 - 2c(e).$$

The first order conditions for the agent are

$$2\left[\alpha + \gamma e - c'(e)\right] = 0.$$

Denote the solution by e^*. Integrating this expression over e between zero and e^* yields the surplus that the principal must allow the agent in order to implement e^* in the two periods. The per-period surplus enjoyed by the agent is depicted in Figure 1 as the area between the thin straight line originating at α, and the curve $c'(e)$. Adding the cost of exerting effort, i.e., the integral under the curve $c'(e)$, yields the expected per-period cost to the principal of implementing e^*.

Any line going through e^* and with intercept greater than 0 corresponds to a contract that implements e^*. It is clear from Figure 1 that the contract that minimizes the per-period cost to the principal is the contract in which $\alpha = 0$. In this case the per-period cost is the area of the triangle $(0, c'(e^*), e^*)$. The expected total cost of implementing (e^*, e^*) is double the area of that triangle, i.e., exactly the area of the rectangle $(0, A, c'(e^*), e^*)$. Denoting with $R(e)$ the area of the rectangle with base of e and height of $c'(e)$,

$$R(e) \equiv \int_0^e c'(e)\,dy,$$

then the expected total cost to the principal of implementing e^*, e^* is simply $R(e^*)$.

Now, let us verify that indeed the optimal contract indeed entails $\alpha = \beta$. Suppose not, and without loss of generality suppose that it were optimal to set $\alpha < \beta$. Then it must be $e_1^* < e_2^*$. Write the agent surplus as

$$U(e_1^*, e_2^*) = U(e_1^*, 0) + \int_0^{e_2^*} \frac{\partial U(e_1^*, y)}{\partial e_2} dy.$$

In light of the first order conditions and of the fact that the compensation scheme is linear in e_2 we can rewrite the above equation as

$$U(e_1^*, e_2^*) = U(e_1^*, 0) + \int_0^{e_2^*} \left[c'(e_2^*) - c'(y)\right] dy.$$

Adding the agent's cost of effort yields the expense to the principal of implementing e_1^*, e_2^*. That equals

$$\begin{aligned} & \alpha e_1^* + \int_0^{e_2^*} c'(e_2^*)\,dy \\ = \quad & \alpha e_1^* + R(e_2^*). \end{aligned}$$

Notice that for a lesser expense of just $R(e_2^*)$ the principal can implement e_2^*, e_2^* (a strictly larger total effort) by setting $\alpha = \beta = 0$ and appropriately adjusting γ. This shows that it is suboptimal for the principal to set $\alpha < \beta$.

We collect this argument in the following proposition.

Proposition 3 *Assume $c''' > 0$. Under no revelation, the contract that implements a given total effort E at the lowest cost entails rewarding the agent only in the case of two successes. Thus, $w(s,f) = w(f,s) = 0$. The expected payment by the principal to the agent in the optimal contract implementing a total effort of E is $R(E/2) = c'(E/2) \cdot E/2$.*

To complete our characterization, we should consider what happens if the principal wants to implement different efforts in the two periods. This could happen if effort has different values in the two periods. The following Proposition characterizes the optimal incentive scheme in the case in which the principal wants to implement $e_1 < e_2$. The case $e_2 < e_1$ has the complementary properties.

Proposition 4 *Assume $c''' > 0$. Under no revelation, the contract that implements an effort profile $e_1 < e_2$ at the lowest cost entails setting $w(f,s) = 0, w(s,f) > 0$ and$w(s,s) > w(s,f) > 0$ (unless $e_1 = 0$).*

4.2 Comparison with Revelation Scenario

In the case of revelation, the agent is able to condition the choice of the second period effort level on the outcome of the first period effort. The principal, similarly, can give different second period incentives depending on whether the first period effort resulted in success. The problem of an agent can be written as

$$\begin{aligned} & \max_{e_1, e_2^F, e_2^S} U\left(e_1, e_2^F, e_2^S\right) \qquad (16) \\ = & \max_{e_1, e_2^F, e_2^S} \left[\delta e_1 - c\left(e_1\right)\right] + \left(1 - e_1\right)\left[\zeta e_2(f) - c\left(e_2(f)\right)\right] + e_1\left[\theta e_2(s) - c\left(e_2(s)\right)\right]. \end{aligned}$$

Our goal is to show that for any constellation of $e_1^*, e_2^*(f)$, and $e_2^*(s)$ giving rise to a total exepcted effort E, the same total expected effort can be implemented more cheaply in the no revelation scenario.

Proposition 5 *Assume $2c''(e) + ec'''(e) > 0$. Achieving a total expected effort of E under revelation has an expected cost to the principal of more than $R(E/2)$. Thus, it is less costly to implement any given total expected if information is not revealed.*

Proof: **Case** $e_1^* > E/2$.

From the first order conditions with respect to e_1 we have

$$\frac{\partial U\left(e_1, e_2^*(f), e_2^*(s)\right)}{\partial e_1} = c'\left(e_1^*\right) - c'\left(e_1\right).$$

We can then express the agent's surplus as

$$\begin{aligned} U\left(e_1^*, e_2^{*F}, e_2^{*S}\right) &= U\left(0, e_2^*(f), e_2^*(s)\right) + \int_0^{e_1^*} \frac{\partial U\left(e_1, e_2^*(f), e_2^*(s)\right)}{\partial e_1} de_1 \\ &= U\left(0, e_2^*(f), e_2^*(s)\right) + \int_0^{e_1^*} \left[c'\left(e_1^*\right) - c'\left(e_1\right)\right] de_1. \end{aligned}$$

Adding to this expression the cost of effort, which is at least $c\left(e_1^*\right)$, yields the cost to the principal of implementing $(e_1^*, e_2^*(f), e_2^*(s))$. The cost to the principal is therefore not smaller than

$$\begin{aligned} & U\left(0, e_2^*(f), e_2^*(s)\right)+R\left(e_1^*\right) \\ > & U\left(0, e_2^*(f), e_2^*(s)\right)+R(E / 2) . \end{aligned}$$

The inequality follows from the assumption that $e_1^* > E/2$. The term $U\left(0, e_2^*(f), e_2^*(s)\right)$ represents the expected surplus of an agent who has exerted no effort in the first period; it is nonnegative by individual rationality. This shows that a total expected effort of E is cheaper to achieve via no revelation.

Case $e_1^* \leq E/2$.

Write the agent's surplus as

$$\begin{aligned} & U\left(e_1^*, e_2^*(f), e_2^*(s)\right) \\ = & U\left(e_1^*, 0,0\right)+\int_0^{e_2^*(f)} \frac{\partial U\left(e_1^*, e_2(f), 0\right)}{\partial e_2^F} d e_2(f)+\int_0^{e_2^*(s)} \frac{\partial U\left(e_1^*, e_2^*(f), e_2(s)\right)}{\partial e_2^S} d e_2(s) \end{aligned}$$

Make use of the first order conditions to rewrite the agent's surplus as

$$U\left(e_1^*, 0,0\right)+\left(1-e_1^*\right) \int_0^{e_2^*(f)}\left[c^{\prime}\left(e_2^*(f)\right)-c^{\prime}\left(e_2(f)\right)\right] d e_2(f)+e_1^* \int_0^{e_2^*(s)}\left[c^{\prime}\left(e_2^*(s)\right)-c^{\prime}\left(e_2(s)\right)\right] d e_2(s).$$

Adding the cost of effort to this expression yields the cost to the principal of implementing $\left(e_1^*, e_2^*(f), e_2^*(s)\right)$, which is

$$\delta e_1^*+\left(1-e_1^*\right) R\left(e_2^*(f)\right)+e_1^* R\left(e_2^*(s)\right) .$$

The function $R(e)$ is strictly convex when $2 c^{\prime \prime}(e)+e c^{\prime \prime \prime}(e)>0$. This means that the average area of the two rectangles in Figure 2 is larger than the area of the rectangle with average base. Then the cost to the principal of implementing $\left(e_1^*, e_2^*(f), e_2^*(s)\right)$ is strictly greater than

$$\delta e_1^*+R\left(\left(1-e_1^*\right) e_2^*(f)+e_1^* e_2^*(s)\right) .$$

Since by assumption $e_1^* \leq E/2$, it must be $\left(1-e_1^*\right) e_2^*(f)+e_1^* e_2^*(s) \geq E/2$. Therefore, the previous expression is greater than

$$\delta e_1^*+R(E / 2) .$$

The term $R(E/2)$ represents the cost of implementing E in the no revelation scenario. Since $\delta \geq 0$, that cost is smaller than the cost to the principal of implementing $\left(e_1^*, e_2^*(f), e_2^*(s)\right)$ under revelation. ∎

Note that the proof of Proposition 5 can be readily adapted to prove the following

Proposition 6 *Suppose the principal wants to implement an effort of e_1 in the first period and an expected effort of E_2 in the second period. This can be done at lower cost when information is* ***not*** *revealed to the agent.*

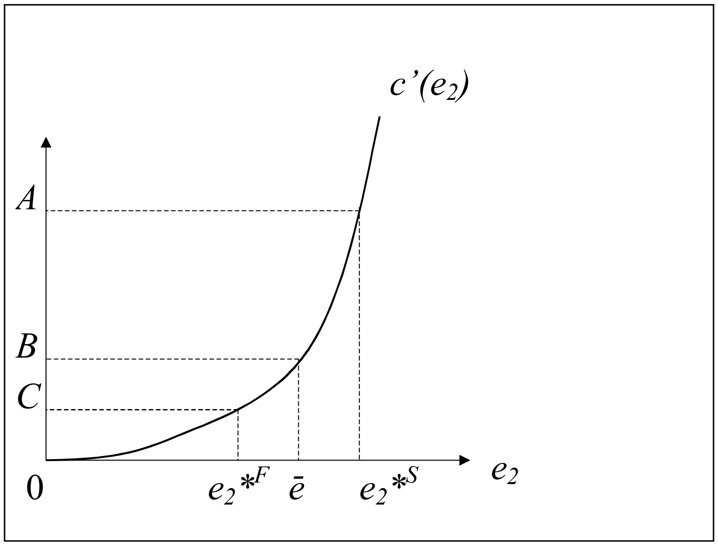

Figure 2:

4.3 The Optimum Under Revelation

The analysis of the comparison of the two scenarios has not explored the characteristics of the optimal scheme in the revelation scenario. We shall now describe some properties of the optimal incentive scheme in this scenario

Proposition 7 *Suppose the principal wants to implement an effort of $e_1 > 0$ in the first period and an expected effort of E_2 in the second period. Then, for any $e_1 \in (0,1)$, the compensation scheme that minimizes the principal's expected cost induces the agent to exert a strictly positive effort after a faliure, but to work even harder after a success: $e_2(s) > e_2(f) > 0$.*

Proof: Given an incentive scheme described by $w(s,s), w(s,f)$ and $w(f,s)$, the agent's second period effort choices satisfy:

$$w(s,s) - w(s,f) = c'(e_2(s)) \text{ and } w(f,s) = c'(e_2(f)),$$

so the utility of the agent conditional on a success can be written as

$$u(s) = w(s,f) + c'(e_2(s))e_2(s) - c(e_2(s)) \tag{17}$$

and conditional on failure

$$u(f) = c'(e_2(f))e_2(f) - c(e_2(f)) \tag{18}$$

The agent's first period effort satisfies $u(s)-u(f) = c'(e_1)$. For any effort triple $(e_1, e_2(s), e_2(f))$ the principal chooses to induce, the necessary wage payments are determined by the equations above.

The principal's objective is to minimize expected wage paymentssubject to inducing a period 1 effort e_1 and period 2 expected effort $E_2 = e_1e_2(s) + (1 - e_1)e_2(f)$. The principal's expected total cost is

The total cost to the principal is

$$TC = U + c(e_1) + E(c(e_2))$$

where $U = e_1u(s) + (1 - e_1)u(f)$ and $E(c(e_2) = e_1c(e_2(s)) + (1 - e_1)c(e_2(f))$. TC can be rewritten as

$$\begin{aligned} TC &= e_1c'(e_1) + u(f) + E(c(e_2)) \\ &= e_1c'(e_1) + c'(e_2(s))e_2(s) + e_1(c(e_2(s)) - c(e_2(f))) \end{aligned} \tag{19}$$

using the agent's first order conditions above as well as expression 18. The principal chooses $e_2(s)$ and $e_2(f)$ to minimize TC subject to $e_1e_2(s) + (1 - e_1)e_2(f) = E_2$. Using this constraint to substitute for $e_2(s)$ in TC and differentiating with respect to $e_2(f)$ yields the first-order condition

$$c''(e_2(f))e_2(f) + (1 - e_1)(c'(e_2(f)) - c'(e_2(s)) = 0 \tag{20}$$

This implies that $e_2(s) > e_2(f)$ since $c'' > 0$.

Moreover, since at $e_2(f) = 0$ the left hand side of equation 20is strictly negative, it follows that $0 < e_2(f) < e_2(s)$. ∎

Proposition 7 shows that in the revelation scenario, the principal will choose to distort the effort of the agent in the second period away from what would be optimal in the absence of moral hazard. Specifically, the agent is induced to work harder after a success than after a failure despite the fact that this variation in effort per se raises the agent's ecpected effort costs. This distortion is optimal because it makes it cheaper for the principal to provide incentives for effort in the first period: The marginal reward to e_1 is $u(s) - u(f) = w(s, f)+[c'(e_2(s))e_2(s)-c(e_2(s))]-[c'(e_2(f))e_2(f)-c(e_2(f))]$, so for any e_1, the larger the gap between $e_2(s)$ and $e_2(f)$, the smaller the value of $w(s, f)$ required to make $u(s)-u(f) = c'(e_1)$.

An implication of Proposition 7 is that the probability of success is positively correlated across periods.

If the principal wants to implement a total expected effort of E and does not care directly about how the agent allocates his effort across periods, then we can show that, at the optimum, $0 < e_2(f) < e_1 < e_2(s)$.

Proposition 8 *Suppose the principal wants to implement a total expected effort of* $E = e_1 + e_1 e_2(s) + (1 - e_1) e_2(f)$. *Then, the compensation scheme that minimizes the principal's expected cost induces the agent to choose efforts satisfying* $0 < e_2(f) < e_1 < e_2(s)$

Proof: By Proposition 7, we already know that $0 < e_2(f) < e_2(s)$. We first show that $e_1 > e_2(f)$. The principal chooses $e_1, e_2(s)$, and $e_2(f)$ to minimize expression 19 subject to $e_1 + e_1 e_2(s) + (1 - e_1) e_2(f) = E$. Using this constraint to substitute for $e_2(s)$ in 19 and differentiating with respect to e_1 yields the following first-order condition

$$c'(e_1) + c''(e_1)e_1 - c'(e_2(s))(1 + e_2(s) - e_2(f)) + (c(e_2(s)) - c(e_2(f))) = 0. \qquad (21)$$

The first-order condition with respect to $e_2(f)$ is the same as when e_1 is exogenously given, namely equation 20. Subtracting 20 from 21 yields

$$\begin{aligned} & c'(e_1) + c''(e_1)e_1 - (c'(e_2(f)) + c''(e_2(f))e_2(f))) \\ = \; & c'(e_2(s))(e_2(s) - e_2(f)) - (c(e_2(s)) - c(e_2(f))) + e_1(c'(e_2(s)) - c'(e_2(f))) > 0 \end{aligned}$$

because $e_2(s) > e_2(f)$ and c is strictly convex. Since $c'(e) + c''(e)e$ is strictly increasing if $c''' \geq 0$, it follows that $e_1 > e_2(f)$. Furthermore, it follows from $0 < e_2(s) - e_2(f) < 1$, $c''' \geq 0$, and equation 21 that

$$2c'(e_1) < c'(e_1) + c''(e_1)e_1 = c'(e_2(s))(1 + e_2(s) - e_2(f)) - (c(e_2(s)) - c(e_2(f))) < 2c'(e_2(s))$$

and therefore, since c is strictly convex, $e_1 < e_2(s)$. ∎

4.4 Ability

We now add to the model a component of ability. Agents can be more or less able. Ability translates into higher value of effort to the principal: effort exerted by a more able agent is more valuable to the principal. Formally, the value to the principal of effort e from agent of ability a is given by the function $v(e, a)$ which is increasing in a. In this formulation, a good agent is not more likely than a bad agent to succeed, nor is his effort cheaper.

After the first period effort has been exerted, the principal draws a signal that is informative about the agent's ability. This signal is separate from and independent of the signal about effort, which as before is thought of as success or failure.

As before, we allow the contract to be conditional on the agent's revealed ability. The question for the principal is whether, in this new scenario, there should be interim evaluations. If so, what kind of evaluation should this be, i.e., should it reveal to the agent how well his effort turned out and/or reveal the signal about his ability?

We show that, while an the interim evaluation is generally preferable to no interim evaluation, the subject of the evaluation should be the ability of the candidate, not how well his or her effort turned out. Formally, we show that revealing how the effort turned out is dominated by not revealing.

To this end, we first study the case in which ability is revealed but effort is not. We examine the case in which the agent is rewarded only for two successes.

Proposition 9 *Suppose the principal give an interim evaluation that only reveals the agent's ability a but not whether the agent succeeded or failed in the first period. Suppose further that the agent is rewarded only for two successes. Then the cost of implementing any implementable plan $e_1^*, \mathbf{e}_2^*$ is $R(e_1^*) = E_a[R(e_2^*(a))]$.*

Remark 1 *By the equality, and since R is convex, we obtain $e_1^* \geq E_a[e_2^*(a)]$. Thus, the agent's expected effort (though not necessarily its value to the principal) is greater in the first period.*

Proof of the Proposition

Denote with $\gamma(a)$ the reward for two successes that implements $e_1^*, e_2^*(a)$. Notice that this reward depends on the ability of the agent as revealed by the signal a. Given this system of rewards, the agent's utility from taking plan $e_1, e_2(a)$ is

$$U(e_1, \mathbf{e}_2) = E_a[e_1 \cdot e_2(a) \cdot \gamma(a) - c(e_2(a))] - c(e_1)$$

Write

$$\begin{aligned} U(e_1^*, \mathbf{e}_2^*) &= U(0, \mathbf{e}_2^*) + \int_0^{e_1^*} \frac{\partial U(e_1, \mathbf{e}_2^*)}{\partial e_1} de_1 \\ &= E_a[-c(e_2^*(a))] + \int_0^{e_1^*} \left[c'(e_1^*) - c'(e_1)\right] de_1. \end{aligned}$$

Adding the expected cost of effort yields the cost to the principal of implementing the action plan, which equals $R(e_1^*)$. Conversely, write

$$\begin{aligned} U(e_1^*, \mathbf{e}_2^*) &= U(e_1^*, \mathbf{0}) + E_a\left\{\int_0^{e_2^*(a)} \left[c'(e_2^*(a)) - c'(e_2(a))\right] de_2(a)\right\} \\ &= -c(e_1^*) + E_a\left\{\int_0^{e_2^*(a)} \left[c'(e_2^*(a)) - c'(e_2(a))\right] de_2(a)\right\}. \end{aligned}$$

Adding the expected cost of effort yields the cost to the principal of implementing the action plan, which equals $E_a[R(e_2^*(a))]$.

Proposition 10 *Suppose the principal give an interim evaluation that only reveals the agent's ability a but not whether the agent succeeded or failed in the first period. Then it is optimal for the principal to reward the agent only for two successes.*

Proof of the Proposition

Consider any action plan $\widetilde{e}_1^*, \widetilde{\mathbf{e}}_2^*$ that can be implemented by rewarding more outcomes than just two successes, and denote the agent's utility by

$$U\left(\widetilde{e}_1^*, \widetilde{\mathbf{e}}_2^*\right) = \widetilde{\alpha}\widetilde{e}_1^* - c\left(\widetilde{e}_1^*\right) + E_a\left[\widetilde{\beta}\left(a\right) \cdot \widetilde{e}_2^*\left(a\right) - c\left(\widetilde{e}_2^*\left(a\right)\right)\right] + E_a\left[\widetilde{\gamma}\left(a\right) \cdot \widetilde{e}_1^* \cdot \widetilde{e}_2^*\left(a\right)\right].$$

Performing the usual transformations yields

$$U\left(\widetilde{e}_1^*, \widetilde{\mathbf{e}}_2^*\right) = \widetilde{\alpha}\widetilde{e}_1^* + E_a\left[R\left(\widetilde{e}_2^*\left(a\right)\right)\right] = E_a\left[\widetilde{\beta}\left(a\right) \cdot \widetilde{e}_2^*\left(a\right)\right] + R\left(\widetilde{e}_1^*\right).$$

Now we construct $e_1^*, \mathbf{e}_2^*$, an action plan that is implementable by rewarding only two successes and has greater or equal expected value as $\widetilde{e}_1^*, \widetilde{e}_2^*$. Start from a reward scheme that only rewards two successes and in which the vector $\gamma\left(a\right)$ is chosen so that the resulting vector of second period efforts $\widetilde{\mathbf{e}}_2^*$. Now, look at the resulting first period effort level. Two scenarios are possible. Either the first period effort is larger or equal than $\widetilde{e}_1^*$, in which case we denote the resulting action plan by $e_1^*, \mathbf{e}_2^*$. The action plan $e_1^*, \mathbf{e}_2^*$ gives the agent greater expected value than $\widetilde{e}_1^*, \widetilde{\mathbf{e}}_2^*$ and, by Proposition 9, costs $E_a\left[R\left(e_2^*\left(a\right)\right)\right] = E_a\left[R\left(\widetilde{e}_2^*\left(a\right)\right)\right]$. This cost is no greater than what it costs to implement $\widetilde{e}_1^*, \widetilde{\mathbf{e}}_2^*$, which proves our claim that it is optimal for the principal to reward the agent only for two successes.

In the second scenario, the first period effort associated with the reward scheme γ is smaller than $\widetilde{e}_1^*$. This means that the expected value to the principal under scheme γ is smaller than the expected value of $\widetilde{e}_1^*, \widetilde{\mathbf{e}}_2^*$. Then, increase the vector γ along all its components, and keep doing this until the resulting expected value of the effort taken by the agent equals the expected value of $\widetilde{e}_1^*, \widetilde{\mathbf{e}}_2^*$. Denote the resulting effort levels by $e_1^*, \mathbf{e}_2^*$. Notice that since by construction $e_2^*\left(a\right) > \widetilde{e}_2^*\left(a\right)$ for all a, therefore $e_1^* < \widetilde{e}_1^*$. But then the expected cost of implementing $e_1^*, \mathbf{e}_2^*$ which, by Proposition 9, equals $R\left(e_1^*\right)$, is smaller than $R\left(\widetilde{e}_1^*\right)$ and thus smaller than the cost of implementing $\widetilde{e}_1^*, \widetilde{\mathbf{e}}_2^*$.

Now we want to show that, assuming that the principal reveals the agent's ability in the interim evaluation, then a given expected value of effort can be more cheaply implemented by not disclosing in the interim evaluation whether the first period effort resulted in success or failure.

Proposition 11 *Given any action plan $e_1^{*R}, \mathbf{e}_2^*(f), \mathbf{e}_2^*(s)$ that is implementable with revelation of success, there is plan $e_1^*, \mathbf{e}_2^*$ that is implementable under no revelation and gives the principal an expected value at least as large.*

Proof of Proposition

Write

$$\begin{aligned} U\left(e_1^R, \mathbf{e}_2(f), \mathbf{e}_2(s)\right) &= \delta e_1^R - c\left(e_1\right) + \left(1 - e_1^R\right) E_a\left[e_2\left(f, a\right)\zeta\left(a\right) - c\left(e_2\left(f, a\right)\right)\right] \\ &\quad + e_1^R E_a\left[e_2\left(s, a\right)\theta\left(a\right) - c\left(e_2\left(s, a\right)\right)\right]. \end{aligned}$$

Denote $\overline{\mathbf{e}}_2^* = \left(1 - e_1^{*R}\right) \mathbf{e}_2^*(f) + e_1^{*R} \mathbf{e}_2^*(s)$ as the ability-indexed vector of expected efforts in period 2 in the case of revelation. Pick the vector $\gamma\left(a\right)$ so that the second period effort vector in the case of no revelation equals $\overline{\mathbf{e}}_2^*$. Then, look at the corresponding first period effort in the case of no revelation, e_1. If the resulting value of effort to the principal is greater with no revelation than with revelation, then the resulting allocation in the no revelation case is our candidate plan $e_1^*, \mathbf{e}_2^*$. We call this configuration Case A.

If, instead, the the resulting value of effort to the principal is smaller with no revelation than with revelation (which must mean that $e_1 < e_1^{*R}$), then increase all the components of the vector $\gamma\left(a\right)$ until the resulting value of effort to the principal is with no revelation equals that with revelation. The resulting vector of effort in the no-revelation case is our candidate plan $e_1^*, \mathbf{e}_2^*$. Note that by construction in this case we have $e_1^* < e_1^{*R}$. We call this configuration Case B.

Case A.

Write

$$\begin{aligned}
U\left(e_1^{*R}, \mathbf{e}_2^{*F}, \mathbf{e}_2^{*S}\right) &= U\left(e_1^{*R}, \mathbf{0}, \mathbf{0}\right) + \left(1 - e_1^{*R}\right) E_a\left[\int_0^{e_2^*(f,a)} \left[c'\left(e_2^*\left(f,a\right)\right) - c'\left(e_2\left(f,a\right)\right)\right] de_2\left(f,a\right)\right] \\
&\quad + e_1^{*R} E_a\left[\int_0^{e_2^{*S}(a)} \left[c'\left(e_2^*\left(s,a\right)\right) - c'\left(e_2\left(s,a\right)\right)\right] de_2\left(s,a\right)\right] \\
&= \delta e_1^{*R} - c\left(e_1^{*R}\right) + \left(1 - e_1^{*R}\right) E_a\left[\int_0^{e_2^*(f,a)} \left[c'\left(e_2^*\left(f,a\right)\right) - c'\left(e_2\left(f,a\right)\right)\right] de_2\left(f,a\right)\right] \\
&\quad + e_1^{*R} E_a\left[\int_0^{e_2^*(s,a)} \left[c'\left(e_2^*\left(s,a\right)\right) - c'\left(e_2\left(s,a\right)\right)\right] de_2\left(s,a\right)\right].
\end{aligned}$$

Adding the cost of effort yields the cost to the principal of implementing $e_1^{*R}, \mathbf{e}_2^*(f), \mathbf{e}_2^*(s)$, which is

$$\delta e_1^{*R} + \left(1 - e_1^{*R}\right) E_a\left[R\left(e_2^*\left(f,a\right)\right)\right] + e_1^{*R} E_a\left[R\left(e_2^*\left(s,a\right)\right)\right].$$

Because R is convex, this is greater than

$$\begin{aligned}
&\delta e_1^{*R} + E_a\left[R\left(\left(1 - e_1^{*R}\right) e_2^*\left(f,a\right) + e_1^{*R} e_2^*\left(s,a\right)\right)\right] \\
= \; &\delta e_1^{*R} + E_a\left[R\left(\overline{e}_2^*\left(a\right)\right)\right].
\end{aligned}$$

This is not smaller than $E_a\left[R\left(\overline{e}_2^*\left(a\right)\right)\right]$, the cost of implementing the plan $e_1^*, \mathbf{e}_2^*$ under no revelation. Since that plan gives the principal an expected value of effort at least as large as that in the revelation case, we have proved our claim.

Case B.

Write

$$\begin{aligned} U\left(e_1^{*R}, \mathbf{e}_2^*(f), \mathbf{e}_2^*(s)\right) &= U\left(0, \mathbf{e}_2^*(f), \mathbf{e}_2^*(s)\right) + \int_0^{e_1^{*R}} \left[c'\left(e_1^{*R}\right) - c'\left(e_1^R\right)\right] de_1^R \\ &= E_a\left[e_2^*\left(f,a\right)\zeta\left(a\right) - c\left(e_2^*\left(f,a\right)\right)\right] + \int_0^{e_1^{*R}} \left[c'\left(e_1^{*R}\right) - c'\left(e_1^R\right)\right] de_1^R. \end{aligned}$$

The first term is nonnegative by individual rationality. Adding the cost of effort, which is at least $c\left(e_1^{*R}\right)$, yields the cost to the principal of implementing $e_1^{*R}, \mathbf{e}_2^*(f), \mathbf{e}_2^*(s)$, which is therefore not smaller than

$$\int_0^{e_1^{*R}} \left[c'\left(e_1^{*R}\right)\right] de_1^R = R\left(e_1^{*R}\right).$$

Since by construction we have $e_1^* < e_1^{*R}$, this quantity is strictly greater than $R\left(e_1^*\right)$, which is the cost to the principal of implementing the plan $e_1^*, \mathbf{e}_2^*$ under no revelation. Since that plan gives the principal an expected value of effort at least as large as that in the revelation case, we have proved our claim.

Example 1 ***The Value of Interim Evaluations***. *Suppose that ability a can be 0 or 2, with equal probability. Suppose further that $v\left(e,a\right) = e \cdot a$. In the absence of interim evaluations about ability (we have shown already that interim evaluations about effort are suboptimal), whatever incentive scheme the principal offers that is a function of a will be perceived as its expected value by the agent. Thus, the agent's effort will not depend on information about his ability and the situation is like that in Proposition 3. So, the optimal plan for the principal is to implement the same effort in both periods, call it e^*, e^*. The expected value of this effort in the first period is e^*, in the second period is $\frac{1}{2} \cdot 2e^* + \frac{1}{2} \cdot 0 = e^*$, so the expected value in total is $2e^*$ and that is achieved at cost $R\left(e^*\right)$.*

Suppose now that the principal implements the following effort scheme with revelation of ability (but not of effort). The principal will pay the able agent γ in case of two successes, and zero otherwise. The unable agent receives zero in any case. It is clear that an agent who learns that he is unable will exert no effort in the second period. So, letting $\widehat{e}_2$ denote the agent's effort in the second period, the agent solves

$$\max_{\widehat{e}_1, \widehat{e}_2} \widehat{e}_1 \frac{1}{2}\left(\widehat{e}_2\gamma - c\left(\widehat{e}_2\right)\right) - c\left(\widehat{e}_1\right)$$

The resulting value of effort is $\widehat{e}_1 + \widehat{e}_2$. Pick γ so that $\widehat{e}_1 + \widehat{e}_2$ equals $2e^*$. The cost of implementing $\widehat{e}_1 + \widehat{e}_2$ is, by Proposition 9, $R\left(\widehat{e}_1\right)$. So, if we are able to show that $\widehat{e}_1 \leq \widehat{e}_2$ then it follows that $\widehat{e}_1 \leq e^*$ and so it is cheaper to implement $\widehat{e}_1 + \widehat{e}_2$ with revelation of ability rather than e^*, e^* without revelation. To verify that $\widehat{e}_1 \leq \widehat{e}_2$ inspect the first order conditions *that determine* $\widehat{e}_1$ *and* $\widehat{e}_2$*,*

$$\begin{aligned}\frac{1}{2}\left[\widehat{e}_2\gamma - c\left(\widehat{e}_2\right)\right] &= c'\left(\widehat{e}_1\right)\\ \gamma &= c'\left(\widehat{e}_2\right).\end{aligned}$$

Since $\widehat{e}_2 \leq 1$ *then* $\frac{1}{2}\left[\widehat{e}_2\gamma - c\left(\widehat{e}_2\right)\right] < \gamma$*, which implies that* $\widehat{e}_1 < \widehat{e}_2$*.*

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