SUBJECTIVE PERFORMANCE MEASURES IN OPTIMAL INCENTIVE CONTRACTS*

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Incentive contracts often include important subjective components that mitigate incentive distortions caused by imperfect objective measures. This paper explores the combined use of subjective and objective performance measures in (respectively) implicit and explicit incentive contracts. We show that the presence of sufficiently effective explicit contracts can render all implicit contracts infeasible, even those that would otherwise yield the first-best. We also show, however, that in some circumstances objective and subjective measures are complements: neither an explicit nor an implicit contract alone yields positive profit, but an appropriate combination of the two does. Finally, we consider subjective weights on objective measures.

I. INTRODUCTION

I.A. Motivation

Business history is littered with firms that got what they paid for. At the H. J. Heinz Company, for example, division managers received bonuses only if earnings increased from the prior year. The managers delivered consistent earnings growth by manipulating the timing of shipments to customers and by prepaying for services not yet received [Post and Goodpaster 1981]. At Dun & Bradstreet, salespeople earned no commission unless the customer bought a larger subscription to the firm's credit-report services than in the previous year. In 1989 the company faced millions of dollars in lawsuits following charges that its salespeople deceived customers into buying larger subscriptions by fraudulently overstating their historical usage [Roberts 1989]. In 1992 Sears abolished the commission plan in its auto-repair shops, which paid mechanics based on the profits from repairs authorized by customers. Mechanics misled customers into authorizing unnecessary repairs, leading

*We are very grateful for helpful discussions with Gary Becker, David Besanko, James Brickley, Bengt Holmstrom, Kevin Lang, George Milkovich, Kevin M. Murphy, Canice Prendergast, James Rebitzer, Andrei Shleifer, Richard Thaler, Karen Van Nuys, and Michael Waldman, as well as for useful comments from participants at numerous seminars. We also appreciate financial support from the Division of Research at Harvard Business School (Baker and Murphy) and the NSF (SES-9010759) and an A. P. Sloan Research Fellowship (Gibbons).

California officials to prepare to close Sears' auto-repair business statewide [Patterson 1992].

In each of these cases, employees took actions to increase their compensation, but these actions were seemingly at the expense of long-run firm value. At Heinz, for example, prepaying for future services greatly reduced the firm's future flexibility, but the compensation system failed to address this issue. Similarly, at Dun & Bradstreet and Sears, although short-run profits increased with the increases in subscription sizes and auto repairs, the long-run harm done to the firm's reputations was significant (and plausibly much larger than the short-run benefit), but the compensation system again ignored the issue. Thus, in each of these cases, the cause of any dysfunctional behavior was not pay-for-performance per se, but rather pay-for-performance based on what we call a distortionary performance measure.

Many firms mitigate the effects of distortionary objective performance measures by augmenting objective measures with subjective assessments of performance. Investment bankers involved in corporate finance, for example, could be measured by several objective performance measures, such as fees generated. Nonetheless, compensation at most investment banks relies heavily on subjective assessments of other factors, such as the "quality of the deals, the bankers' contributions to customer satisfaction, training of younger associates, and marketing" [Eccles and Crane 1988, p. 166]. Even in the sales and trading function of an investment bank, where many objective aspects of an individual's contribution to firm value are easily measured on a daily basis, banks again deliver a significant amount of a trader's compensation through a subjectively determined bonus [Eccles and Crane, p. 170].

Lincoln Electric, the dominant manufacturer of arc welding equipment, provides another example of the combined use of objective performance measurement and subjective performance assessment [Fast and Berg 1975]. Lincoln has been called "the holy shrine of incentive pay" [Perry 1988, p. 51], in part because the firm creates strong incentives through piece-rate pay based on objective performance measures. A second element of Lincoln's compensation package also creates strong incentives, however: in a typical year, half a worker's pay comes from a bonus based on management's assessment of the worker's cooperation, innovation, dependability, and other subjective aspects of performance.

I.B. Summary of Results

An ideal performance measure would reflect an employee's contribution to firm value, including both static externalities across business units and dynamic effects of current actions on long-run value. Basing pay on an employee's contribution to firm value would have prevented the seemingly dysfunctional behaviors at Heinz, Dun & Bradstreet, and Sears. Unfortunately, for most employees, contribution to firm value is not objectively measurable: market-adjusted stock-price performance may be a useful measure of a CEO's contribution but typically is an extremely noisy measure of the contributions of lower-level employees.

Although an employee's contribution to firm value usually is not objectively measurable, it often can be subjectively assessed by managers or supervisors who are well placed to observe the subtleties of the employee's behavior and opportunities. Even if such subjective assessments of an employee's contribution to firm value are imperfect, they may complement or improve on the available objective measures. Thus, an implicit contract based on subjective performance assessments may augment or replace an explicit contract based on objective performance measurements.

While an explicit contract can be enforced by a court, an implicit contract cannot, and so is vulnerable to reneging by the firm. Numerous observers of organizational pay practices have noted that trust between workers and supervisors is essential if subjective performance assessment systems are to be successful [Lawler 1971; Hamner 1975]. We formalize (part of) the notion of trust in performance evaluation by requiring that implicit contracts based on subjective performance assessments be enforced not by the courts but by the firm's concern for its reputation in the labor market [Holmstrom 1981; Bull 1987]. Thus, an implicit contract could also be called a self-enforcing contract.

In this paper we assume that objective performance measures are imperfect, so compensation contracts based solely on such measures create distorted incentives (in a sense made precise below). We develop two models of subjective performance assessment. In our first model the firm and the worker observe a subjective assessment of performance in addition to the imperfect objective measure. Naturally, such objective and subjective measures are often substitutes, sometimes strikingly so: in the first of two main results, we show that if the objective measure is sufficiently close to perfect, then no implicit contract is feasible because the firm's fallback position after reneging on an implicit contract is too attractive.

One interpretation of this first result complements Coase's [1937] suggestion that firms may arise where markets are sufficiently imperfect. Think of single-period explicit contracts as spot markets, and recognize that an important determinant of a firm's profitability is its reputation for honoring its long-term implicit contracts [Kreps 1990]. In these terms, our result shows that where spot markets are sufficiently close to perfect, firms lose their ability to write implicit contracts and (in our simple model) perform no better than spot markets. Like Coase, therefore, we suggest that firms exist (i.e., are importantly different from spot markets) when markets are sufficiently imperfect, but for a different reason. Whereas Coase argues that firms do not arise unless they improve on the market, we argue that firms with implicit contracts cannot arise even if the market offers a somewhat inferior alternative.

While our first result establishes a new sense in which explicit and implicit contracts may be substitutes (namely, the mere feasibility of the former may prevent any use of the latter), our second result shows that explicit and implicit contracts may instead be complements. We show that, in some circumstances, neither an explicit nor an implicit contract alone can generate nonnegative profit, but an appropriate combination of the two can. Furthermore, in a broader set of circumstances, if the objective measure becomes more accurate, then the optimal contract not only puts more weight on the objective measure but also puts more weight on the subjective measure because the improved objective measure increases the value of the ongoing relationship and so reduces the firm's incentive to renege. We interpret these two statements of our second result as consistent with Ichniowski, Shaw, and Prennushi's [1993] empirical finding that certain combinations of human-resource practices (such as group piece-rates [explicit contracts] and subjective bonus plans [implicit contracts]) are much more effective when implemented together rather than singly.

In our second model of subjective performance assessment, we assume that the firm can subjectively evaluate the incentive distortions caused by the imperfect objective performance measure. In this case, the optimal incentive contract attaches a subjective weight (or a subjective piece-rate) to the objective performance measure to "back out" or moderate the distortions that would be created by the optimal explicit contract. That is, the optimal contract is deliberately left vague: although there is an explicit understanding of how performance is measured, there is only an implicit understanding regarding how that objective performance measure is rewarded. We illuminate the trade-off between these objective and subjective piece-rates on the objective performance measure—increasing the objective piece-rate reduces the employer's incentive to renege on high total payoffs (by reducing the subjective portion of the high payoff), but typically also provides suboptimal incentives in some states of the world.

I.C. Outline

Our two models integrate and extend two benchmark models from the literature: one concerning implicit contracts and another concerning explicit contracts. In Section II we develop our first model and analyze these two benchmarks. In subsection II.A we describe the economic environment for our model (i.e., the information structure, preferences, production and contracting possibilities, and chronology of events), and in subsections II.B and II.C we present the two benchmark models.

The first benchmark is Baker's [1992] model of an explicit contract. Unlike agency models such as Holmstrom's [1979], Baker assumes that the worker's contribution to firm value is too complex and subtle to be objectively measured, and so cannot be the basis of an enforceable contract. Any explicit contract therefore must be based on an imperfect objective measure of the worker's contribution—such as the quantity but not the quality of a worker's output—but using such a measure causes workers to take suboptimal actions.[1] Naturally, the slope of the optimal explicit contract falls as the distortions caused by the objective performance measure increase.

The second benchmark is a repeated-game model of an implicit contract, much like Bull's [1987]. The firm would like the worker to be cooperative, innovative, and dependable, and offers to pay the worker a bonus based on these subjective aspects of performance. If the firm has no concern for its reputation, its incentive is to claim that the worker performed poorly and so deserves no bonus. If the firm values its reputation, however, it must weigh the temptation to stiff the worker today against the present value of the benefits from future cooperation, innovation, and dependability, and the

1. Holmstrom and Milgrom's [1991] model is similar in spirit to Baker's. An analogous analysis of implicit and explicit contracts could be built on their model rather than on Baker's.

costs of future bonuses. A feasible subjective bonus plan must be self-enforcing: the bonus must be sufficiently small that the firm has no incentive to renege. If the firm's discount rate is sufficiently low, then the present value of being trustworthy is large enough that an implicit contract can achieve the first-best outcome; otherwise, the best feasible implicit contract requires a smaller bonus and so produces second-best incentives.

In Section III we combine the benchmark models from subsections II.B and II.C to analyze the optimal interplay between subjective performance assessments and objective performance measures in implicit and explicit contracts. In each period, part of compensation is an explicit contract based on the objective measurement of an imperfect proxy for the worker's contribution, and part is a bonus based on a subjective assessment of the worker's contribution to firm value. In the latter part of this section, we relax our assumption that the subjective assessment is noncontractible but otherwise perfect; our qualitative results extend to such imperfect subjective assessments.

In Section IV we explore the use of subjective weights on imperfect objective performance measures. Here we assume that, after the worker's performance has been observed, the employer or supervisor can subjectively assess the distortions caused by the objective performance measure. (In practice, such ex post judgments seem likely to be incomplete or imprecise, but in this exploratory analysis we assume they are perfect.) Although the firm would like to use its subjective assessment to eliminate all the distortions in the objective performance measure, it faces the same reputation problem as in Section III: the firm cannot credibly promise to deliver very high subjectively determined payoffs.

Finally, in Section V we discuss further work, including the issue of supervisor bias, the use of multiple evaluators, and the optimal mix of explicit and implicit contracts in promotions, job security, and other (noncompensation-related) aspects of the employment relationship.

II. Benchmark Models

II.A. The Economic Environment

We consider a repeated game between a single firm and a single worker.[2] In each period the worker chooses an unobservable action

2. The single worker we consider could just as well be an infinite sequence of workers, each of whom lives for one period, provided that each period's worker learns the history of play before the period begins.

a, which stochastically determines the worker's contribution to firm value y. To keep things as simple as possible, we assume that y equals either zero or one. It is then natural to define the worker's action to be the probability that $y = 1$: prob $\{y = 1 | a\} = a$, where $a \in [0,1]$. As discussed in the Introduction, we assume that the worker's contribution to firm value is too complex and subtle to be verified by a third party and so cannot be the basis of an enforceable contract. That is, y cannot be objectively measured. On the other hand, we assume that y can be subjectively assessed (as explained below).

The worker's action also affects a second performance measure p. Like y, p equals either zero or one (although any other pair of values would do as well because p is not directly relevant to the parties' payoffs, as will become clear). Unlike y, however, p can be objectively measured, and so can be the basis of an explicit contract.

The objective performance measure p is an imperfect proxy for the worker's contribution to firm value, in the following sense. Before choosing an action, the worker receives private information (denoted by $\mu > 0$) about the difference between the effect of the worker's action on y and its effect on p. The probability that $p = 1$ is $\mu \cdot a$ (where we assume that the support of μ and the shape of the disutility function introduced below are such that $\mu \cdot a < 1$). Given μ and a, the events that $y = 1$ and that $p = 1$ are independent. We interpret μ as follows: there are days (i.e., values of μ) when high actions increase both y and p (μ around one), days when high actions increase y but not p (μ near zero), and days when small actions increase p but not y (μ much larger than one). To eliminate notation, we assume that $E\{\mu\} = 1$. Thus, on average, the performance measure p is an unbiased measure of contribution y.

Compensation contracts consist of a base salary s, an implicit-contract bonus b paid when the subjective assessment is $y = 1$, and an explicit-contract bonus β paid when the objective measure is $p = 1$. The worker's total compensation is therefore either s, $s + b$, $s + \beta$, or $s + b + \beta$. The timing of events within each period is as follows. First, the firm offers the worker a compensation package (s,b,β). Second, the worker either accepts the compensation package or rejects it in favor of an alternative employment opportunity with payoff w_a. Third, if the worker accepts, then the worker observes μ and chooses an action $a \geq 0$ at cost $c(a)$. The firm does not observe μ or the worker's action. Fourth, the firm and the worker observe the realization of the worker's contribution, y, and the firm and the worker (and, if necessary, a court) observe the realization of the objective performance measure p. Finally, if $p = 1$, then the firm pays the bonus β dictated by the explicit contract; if $y = 1$, then the firm chooses whether to pay the worker the bonus b specified in the implicit contract.

The firm's payoff when the worker's contribution is y and total compensation is I is $y - I$. The firm's discount rate is r; in our analysis the worker's discount rate is immaterial because it is the firm's reputation that is at stake. The worker's payoff from choosing an action with cost $c(a)$ and receiving total compensation I is $I - c(a)$. In order to compute various closed-form solutions, we assume that $c(a) = \gamma a^2$. The first-best action, which equates the expected marginal product of effort with its marginal cost, therefore satisfies $1 = c'(a^*)$, or $a^* = 1/(2\gamma)$.

Given an implicit contract b and an explicit contract β, if the worker believes the firm will honor the implicit contract, then the worker's problem after observing a realization of μ is

$$\max_a s + a \cdot b + \mu \cdot a \cdot \beta - \gamma a^2, \tag{1}$$

so the worker's optimal action is

$$a^*(\mu,b,\beta) = (b + \mu\beta)/2\gamma. \tag{2}$$

Since the first-best action is $a^* = 1/(2\gamma)$, effort will be less than the first-best level whenever $b + \mu\beta < 1$.

The worker will choose to work for the firm if his expected payoff (before observing μ) exceeds the alternative wage:

$$E_\mu\{s + a^*(\mu,b,\beta) \cdot b + \mu \cdot a^*(\mu,b,\beta) \cdot \beta - \gamma a^*(\mu,b,\beta)^2\} \geq w_a. \tag{3}$$

The firm's expected profit per period, given an implicit contract b and an explicit contract β but before the worker observes the realization of μ, is

$$E_\mu\{a^*(\mu,b,\beta) - [s + a^*(\mu,b,\beta) \cdot b + \mu \cdot a^*(\mu,b,\beta) \cdot \beta]\}. \tag{4}$$

The firm's optimal base salary s will be the lowest salary satisfying (3). Substituting this salary into (4) yields the firm's expected profit per period as a function of the implicit bonus b and the explicit piece-rate β, which we denote by $V(b,\beta)$:

$$V(b,\beta) \equiv E_\mu\{a^*(\mu,b,\beta) - \gamma a^*(\mu,b,\beta)^2 - w_a\}. \tag{5}$$

II.B. An Explicit Contract Based on an Objective Performance Measure

In this subsection we ignore implicit contracts based on the subjective performance measure y, focusing instead on explicit contracts based on the imperfect proxy for the worker's contribution to firm value: the objective performance measure p. Given an explicit contract β, the worker's optimal action after observing the realization of μ follows from (2):

$$a^*(\mu,\beta) = \mu\beta/2\gamma. \tag{6}$$

The optimal contract again sets the salary s at the minimum value that satisfies (3), and now sets β to maximize the expected profit per period,

$$\max_{\beta} E_{\mu}\{a^*(\mu,\beta) - \gamma a^*(\mu,\beta)^2 - w_a\}. \tag{7}$$

Solving the first-order condition for (7), and recalling that $E\{\mu\} = 1$ and $E\{\mu^2\} = 1 + \mathrm{var}(\mu)$, implies that the optimal explicit-contract bonus is

$$\beta^* = \frac{E_{\mu}\{\mu\}}{E_{\mu}\{\mu^2\}} = \frac{1}{1 + \mathrm{var}(\mu)}. \tag{8}$$

We denote the resulting expected profit for the firm by $V(\beta^*)$:

$$V(\beta^*) = \frac{1}{4\gamma[1 + \mathrm{var}(\mu)]} - w_a. \tag{9}$$

The intuition behind this analysis is as follows. When the variance of μ is large, the marginal product of the worker's action on p (namely, μ) is a noisy reflection of the marginal product of the worker's action on y (namely, one). Consider the effect of setting $\beta = 1$ when the variance of μ is large: the worker will choose the first-best action when $\mu = 1$, but otherwise $a^*(\mu, 1)$ will vary wildly with μ. Given the convex cost function $c(a) = \gamma a^2$, the worker's expected cost $E_{\mu}\{c[a^*(\mu,1)]\}$ will be high, and the firm will have to compensate the worker for this expected cost in the salary defined by (3). The firm's optimal response is to offer a low value of β, thereby settling for weak incentives rather than strong but frequently dysfunctional incentives. (Compare this prescription to the seemingly dysfunctional incentive schemes at Heinz, Dun & Bradstreet, and Sears.) Since β^* and $V(\beta^*)$ fall as the variance of μ rises, we will say that the objective performance measure p is more distortionary when $\mathrm{var}(\mu)$ is higher.

II.C. An Implicit Contract Based on a Subjective Performance Assessment

To complement the previous subsection, we now ignore explicit contracts based on the imperfect objective performance measure, focusing instead on the incentives that implicit contracts can provide. Our analysis is much like Bull's, and is similar in some respects to those of Becker and Stigler [1974] and Shapiro and Stiglitz [1984]. In the latter models, however, incentives follow from the threat of terminating the relationship after poor performance, whereas in our model incentives follow from pay-for-performance with no threat of termination. Furthermore, in our model it is the firm that has an incentive to renege, not the worker. The main connection between our model and the Becker-Stigler and Shapiro-Stiglitz models is the role of the present value of the ongoing relationship in keeping one of the players honest.

The incentives provided by the implicit contract (s,b) depend on whether the worker "trusts" the firm to honor its implicit commitment to pay the bonus b after observing performance $y = 1$. If the worker believes the firm will not renege on the implicit contract, the worker's effort decision from (2) is

$$a^*(b) = b/2\gamma. \tag{10}$$

If salary is set at the minimum value satisfying (3), the firm's expected profit per period is

$$V(b) \equiv a^*(b) - \gamma a^*(b)^2 - w_a = \frac{b}{2\gamma} - \frac{b^2}{4\gamma} - w_a. \tag{11}$$

In a single-period employment relationship (or in the final period for a finite-lived firm), the firm will choose not to pay a bonus, so the worker (anticipating the firm's decision) will choose not to supply effort, so the firm (anticipating the worker's choice) does not pay a salary, so the worker chooses not to work for the firm. To formalize the role of trust in enforcing implicit contracts, we consider an infinitely repeated relationship.[3] We consider equilibria in which the firm and the worker play trigger strategies. Roughly speaking, the parties begin by cooperating and then continue to cooperate unless one side defects, in which case they refuse to cooperate forever after.[4] Such strategies have the virtue

3. The discount rate r can be reinterpreted so that the game is not infinitely repeated but instead concludes at an uncertain date: suppose that after each period is played a coin is flipped, and that if heads occurs then the game ends. If the probability of heads is q and the firm's actual discount rate is s, then $r = (s + q)/(1 - q)$.

4. More precisely, call the history of play *cooperative* if the firm has always offered the compensation package (s,b) to be determined below, the worker has always chosen to work for the firm, and the firm has always paid the bonus b when the worker's contribution was $y = 1$. The worker's strategy is to work for the firm provided that the history of play is cooperative (choosing alternative employment

of being simple to analyze but ignore two issues: optimal punishments and renegotiation, both of which are beyond the scope of this paper.[5]

We solve for the trigger-strategy equilibrium that maximizes the firm's expected profit. The key issue is how large a bonus the worker can trust the firm to pay. Our assumption that the salary s is base pay and the bonus b is paid only if $y = 1$ makes a difference here. The firm's temptation to stiff the worker would be larger if we had no base pay but paid a bonus of s when $y = 0$ and a bonus of $b + s$ when $y = 1$. On the other hand, the firm's temptation to stiff the worker would be smaller if we had base pay of $s + (b/2)$ and bonuses of $-b/2$ when $y = 0$ and $b/2$ when $y = 1$. In keeping with observed practice, we assume that the bonus cannot be negative.[6]

If the worker's contribution is $y = 1$, the firm must decide whether to pay the bonus b. The optimal choice depends on the firm's discount rate r. Given the worker's strategy, if the firm does not pay the bonus, then its payoff is $1 - s$ this period but zero

otherwise), and then to choose the action $a^*(b)$ to be determined below. Similarly, the firm's strategy is to offer the compensation package (s,b) provided that the history of play is cooperative (offering $s = b = 0$ otherwise), and to pay the bonus b when the worker's contribution is $y = 1$ provided that the history of play is cooperative (paying zero bonus otherwise).

5. On optimal punishments: Abreu [1988] shows that the highest equilibrium payoffs are supported by the strongest credible punishments. In our analysis in Section III the punishment for defecting (namely, playing the single-period equilibrium forever after) may not be the strongest credible punishment. Nonetheless, we expect that our qualitative results would hold in an Abreu-style analysis because our results hinge on the simple idea that greater cooperation is possible when the value of the ongoing relationship is larger.

On renegotiation: several authors have argued that the game that remains after one side defects is identical to the game as a whole, so equilibria available at the beginning of the game should also be available after one side defects, so the players should renegotiate from the punishment we propose to a new equilibrium with higher payoffs for both players, thus wrecking our original trigger-strategy equilibrium. Other authors have adopted different perspectives on renegotiation. (See Fudenberg and Tirole [1991, Chapter 5] for a literature review.) Because this literature is still in flux, and especially because the purely game-theoretic analyses of renegotiation abstract from institutions that would influence renegotiation in the labor market we consider, we do not adopt any of the existing approaches to renegotiation.

6. Allowing the bonus to be negative would complicate the analysis by creating a temptation for the worker to stiff the firm, analogous to the firm's temptation we analyze. It may be that the costs of these temptations are convex, so that it is more effective to tempt both sides slightly rather than one side greatly. Our analysis is correct if the firm faces an infinite sequence of workers, each of whom lives for one period (in which case the worker has no reason to resist temptation), and is approximately correct if an infinitely lived worker's discount rate is very large. MacLeod and Malcomson [1989, forthcoming] explore the range of equilibrium outcomes that can arise when the present value of the ongoing relationship is divided between the players so as to keep both honest, and also how an equilibrium division is selected depending on which player can more easily find a substitute for the other.

thereafter, whereas if the firm does pay the bonus, then its payoff is $1 - s - b$ this period but equal to the expected profit from the relationship thereafter. Thus, the firm should pay the bonus if and only if the present value of the expected profit beginning next period exceeds the size of the bonus:

$$V(b)/r \geq b, \qquad \text{or } V(b) \geq rb, \tag{12}$$

where $1/r$ is the present value of \$1 received next period and every period thereafter.

The optimal implicit contract sets b to maximize expected profit per period, $V(b)$, subject to the firm's reneging constraint (12). Rather than deriving the closed-form solution to the firm's problem, it is more instructive to proceed graphically, as in Figures I and II. The figures plot the firm's expected profit $V(b)$ on the vertical axis and the implicit-contract bonus b on the horizontal axis, and also shows the line rb for various discount rates. For a given value of r, values of b where $V(b) \geq rb$ satisfy the reneging constraint and therefore are feasible bonus payments in self-enforcing implicit contracts. Three features of $V(b)$ are intuitive. First, as indicated by (11), $V(b)$ is quadratic in b. Second, at $b = 0$, (10) implies that the worker will not exert effort, so the firm's expected profit per period is $-w_a$. Finally, ignoring the reneging constraint, expected profit per period is maximized at $b^* = 1$, since $a^*(1) = 1/(2\gamma)$ is precisely the first-best action, a^*.

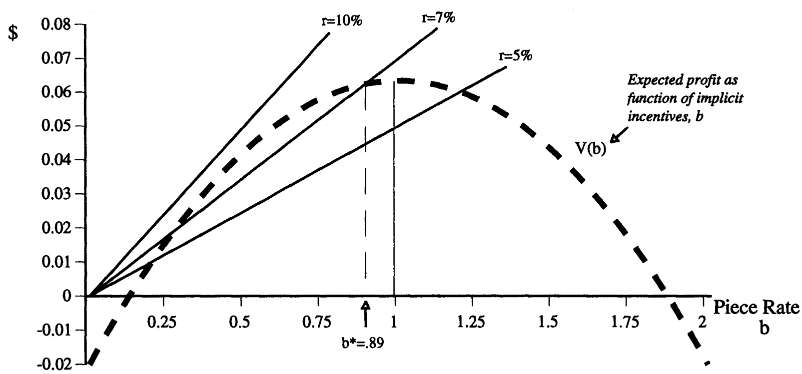

FIGURE I

Figure I shows that the optimal subjective piece-rate declines with the firm's discount rate. The figure depicts the expected profit per period (dashed lines) as a function of implicit incentives, $V(b)$ defined by (11), based on $\gamma = 3$ and $w_a = 0.02$.

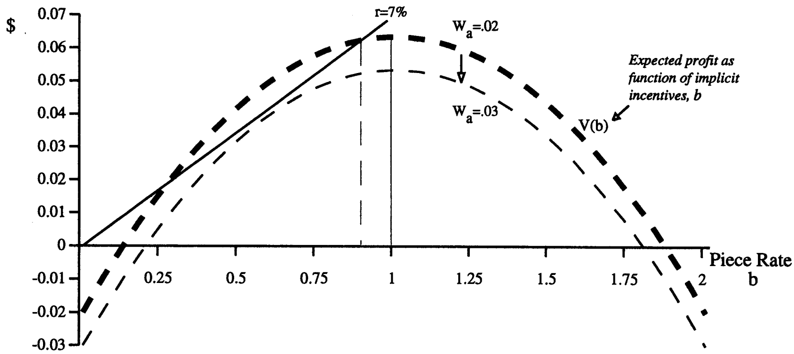

FIGURE II

Figure II shows that the optimal subjective piece-rate declines as the worker's alternative wage increases. The figure, which assumes that $\gamma = 3$, depicts the expected profit per period, $V(b)$, at two alternative wages, $w_a = 0.02$ and $w_a = 0.03$.

Figures I and II illustrate the two primary comparative-statics results from this section. The optimal bonus b^* decreases as the discount rate or the worker's alternative wage increases:

$$(13) \qquad \frac{\partial b^*}{\partial r} \leq 0, \qquad \frac{\partial b^*}{\partial w_a} \leq 0.$$

Figure I shows that the optimal subjective bonus varies with the firm's discount rate. At sufficiently low discount rates (for example, $r = 5$ percent), the present value of the ongoing relationship is high so the first-best contract $b^* = 1$ is feasible. For intermediate values (such as $r = 7$ percent), $b = 1$ is not feasible, but other values of b satisfy the reneging constraint, so b^* is the largest of these feasible values (about 0.89, as shown in the figure). For such intermediate values of r, the optimal bonus falls as r increases. Finally, for sufficiently high discount rates (such as $r = 10$ percent), no values of b satisfy the reneging constraint, so no implicit contract is feasible.

Figure II shows that the optimal subjective bonus depends on the worker's alternative wage. As the alternative wage increases (from $w_a = 0.02$ to $w_a = 0.03$ in the figure), the present value of the ongoing relationship falls, so the largest feasible (and hence optimal) bonus declines. As illustrated in the figure, for sufficiently high alternative wages, no values of b satisfy the reneging constraint so no implicit contract is feasible.

III. The Optimal Interplay between Implicit and Explicit Contracts

We can now begin the novel part of the analysis: combining an explicit contract based on an objective performance measure with an implicit contract based on a subjective performance assessment.[7] We assume in subsection III.A that the subjective performance assessment is noncontractible but otherwise perfect, and in subsection III.B we extend the analysis to imperfect subjective performance assessments. Both analyses proceed much as in subsection II.C. The two main results are (1) that the presence of imperfect explicit contracts can make (otherwise perfect) implicit contracts infeasible, and (2) that the presence of an explicit contract can affect the present value of the ongoing relationship, and hence affect the design and performance of the optimal implicit contract. We also derive several comparative-statics results.

III.A. Perfect Subjective Performance Assessments

At the end of each period the firm and worker observe the realization of the objective performance measure, p, and the realization of the worker's contribution, y. If $p = 1$, the firm pays the bonus β dictated by the explicit contract, and if $y = 1$, the firm chooses whether to pay the worker the bonus b specified in the implicit contract. In subsection II.C the firm's expected profit was $V(b)$ per period if it honored the implicit contract, but zero in all future periods if it reneged on the bonus, since we assumed that the worker would refuse to work for the firm if it reneged. When both objective measures and subjective assessments are available, however, there are new consequences of honoring or reneging on the implicit portion of the contract. First, the expected profit per period from honoring the implicit contract is not $V(b)$ from (11) but rather $V(b,\beta)$ from (5). Second, when explicit contracts are available, they are available both before and after the firm reneges. We assume that if the firm were to renege, then the worker would refuse to participate in any future implicit contracts but would be willing to consider explicit contracts and would accept an explicit contract if it were sufficiently attractive.

In the absence of implicit contracts, the expected profit per period from the optimal explicit contract is $V(\beta^*)$ as defined in (9),

7. Pearce and Stacchetti's [1988] analysis is similar in spirit, but focuses on the risk-bearing costs of explicit contracts rather than the distorted incentives we emphasize. They do not examine the effect of variations in the quality of the objective performance measure, as we do in our two main results.

which can be positive or negative depending on the worker's alternative wage w_a, and the level of distortion in the objective performance measure, var(μ). As long as $V(\beta^*) > 0$, implying that the optimal explicit contract can both attract the worker and make money for the firm, the relevant fallback position for a firm reneging on an implicit contract is $V(\beta^*)$. When this best feasible explicit contract yields negative expected profit, $V(\beta^*) < 0$, it is optimal for the firm to shut down rather than enter into this contract, so the relevant fallback position is zero profit. The sign of $V(\beta^*)$ has important implications for the optimal interplay between implicit and explicit contracts, so we consider the two cases separately.

Case 1: $V(\beta^*) > 0$. We first examine the case where the firm's fallback position is a profitable explicit contract, $V(\beta^*) > 0$. Given the payoffs from paying and from not paying the bonus b, the firm should honor the implicit contract by paying the bonus if and only if the present value of the difference in expected profit beginning next period exceeds the size of the bonus:

$$\text{(14)} \qquad \frac{V(b,\beta) - V(\beta^*)}{r} \geq b, \qquad \text{or } V(b,\beta) - V(\beta^*) \geq rb.$$

Assuming that the reneging constraint (14) is satisfied, the worker's effort decision $a^*(\mu, b, \beta)$ is given by (2).

The optimal contract sets b and β to maximize expected profit $V(b,\beta)$, subject to the reneging constraint (14). Defining λ as the Lagrange multiplier for (14), and using (2), (5), and (9), the first-order conditions for the optimal contract involving both subjective assessments and objective measures (i.e., when $b > 0$ and $\beta > 0$) are

$$\text{(15a)} \qquad (1 + \lambda) \cdot (1 - b - \beta) = 2\lambda\gamma r,$$

$$\text{(15b)} \qquad (1 + \lambda) \cdot (1 - b - \beta \cdot E_\mu\{\mu^2\}) = 0.$$

We denote the optimal bonuses as b^{**} and β^{**}, to distinguish them from (and compare them with) the optimal implicit contract b^* in subsection II.C and the optimal explicit contract β^* in subsection II.B.

Equation (15b) yields the optimal β given an arbitrary value of b, which we denote $\beta^{**}(b)$:

$$\text{(16)} \qquad \beta^{**}(b) = (1 - b) \cdot \frac{1}{1 + \text{var}(\mu)} = (1 - b) \cdot \beta^*.$$

That is, the optimal β when explicit and implicit contracts are combined is the optimal β for an explicit contract alone in the incentive problem of size $(1 - b)$ that remains once an implicit contract with bonus b is in effect. One intuitive implication of (16) is that if b^{**} is near one then β^{**} is near zero: if an implicit contract alone nearly achieves the first-best, then there is not much need for an explicit contract based on an imperfect performance measure.

For parameter values such that the first-best implicit contract $b^{**} = 1$ is not feasible, the optimal b^{**} is determined by substituting $\beta^{**}(b)$ into the reneging constraint (14). Using equations (2), (5), and (9), the reneging constraint reduces to

$$(17) \qquad V[b,\beta^{**}(b)] - V(\beta^*) = \frac{b(2-b)}{4\gamma} \cdot \frac{\mathrm{var}(\mu)}{1 + \mathrm{var}(\mu)} \geq rb.$$

The optimal implicit-contract bonus b^{**} is then the largest value of b solving (17). Thus,

$$(18) \quad b^{**} = \begin{cases} 1 & \text{for} \quad \mathrm{var}(\mu) > \dfrac{1-4\gamma r}{4\gamma r}, \\[2ex] 2 - 4\gamma r \dfrac{1+\mathrm{var}(\mu)}{\mathrm{var}(\mu)} & \text{for} \quad \dfrac{1-4\gamma r}{4\gamma r} \geq \mathrm{var}(\mu) \geq \dfrac{1-2\gamma r}{2\gamma r}, \\[2ex] 0 & \text{for} \quad \mathrm{var}(\mu) < \dfrac{1-2\gamma r}{2\gamma r}. \end{cases}$$

Equation (18) implies that implicit contracts cannot be used ($b^{**} = 0$) when the discount rate is sufficiently high or the level of distortion in the objective performance measure is sufficiently low. The intuition behind the former result is clear from subsection II.C. The intuition behind the latter is more interesting, and is our first main result. If objective performance measures are sufficiently close to perfect, then the firm's fallback position after reneging on an implicit contract is too attractive—the firm will renege on any implicit contract. That is, even when explicit contracts are not perfect, they can be sufficiently effective that they hinder (in fact, destroy) attempts to use implicit contracts either in addition to or instead of explicit contracts. In the extreme, an appropriate implicit contract alone could yield the first-best ($b^* = 1$), but the possibility of a slightly imperfect explicit contract as a fallback position could make this implicit contract infeasible.

Similarly, the first-best ($b^{**} = 1$) can be achieved at sufficiently low discount rates, but the highest discount rate at which the first-best can be achieved declines as var(μ) falls. Even for a very low discount rate, the first-best cannot be achieved when the objective performance measure is nearly perfect, and so the fallback contract itself is nearly first-best.

For intermediate values of the optimal implicit-contract bonus ($0 < b^{**} < 1$), the optimal implicit-contract bonus increases as the objective performance measure becomes more distortionary (var(μ) increases), and (16) then implies that the optimal explicit-contract bonus β^{**} decreases as var(μ) increases. Likewise, as r falls b^{**} rises, so β^{**} falls. These results confirm the intuition that implicit and explicit contracts can be substitutes.

One important difference between b^{**} and b^* (the optimal implicit contract in the absence of explicit contracts analyzed in subsection II.C) is that b^* depends on (and declines with) the alternative wage w_a, while b^{**} in (18) is independent of w_a. This difference reflects the difference in fallback positions from reneging on the implicit contract. In subsection II.C, in the absence of explicit contracts, the employment relationship ended if the firm reneged on an implicit contract, so the firm had to meet the worker's alternative wage after honoring an implicit contract but not after reneging. When $V(\beta^*) > 0$, however, the firm must meet the worker's alternative wage both after honoring the implicit contract and after reneging on it, so the net cost of reneging in (14) is independent of the alternative wage.

To summarize, (18) and (16) yield the following six comparative static results: when $V(\beta^*) > 0$ (and for parameters such that $0 < b^{**} < 1$),

$$\begin{gathered} \frac{\partial b^{**}}{\partial r} < 0, \qquad \frac{\partial b^{**}}{\partial w_a} = 0, \qquad \frac{\partial b^{**}}{\partial \mathrm{var}(\mu)} > 0, \\ \frac{\partial \beta^{**}}{\partial r} > 0, \qquad \frac{\partial \beta^{**}}{\partial w_a} = 0, \qquad \frac{\partial \beta^{**}}{\partial \mathrm{var}(\mu)} < 0. \end{gathered} \tag{19}$$

Case 2: $V(\beta^*) < 0$. We now examine the alternative case, in which the firm's fallback position after reneging on an implicit contract is to shut down and earn zero profit thereafter. This case arises when the expected profit from the optimal explicit contract in the absence of implicit contracts is negative, $V(\beta^*) < 0$, which occurs in our model when the incentive distortions caused by the objective performance measure are sufficiently high. In a richer model, however, there could be additional circumstances in which the firm's fallback position after reneging on an implicit contract is to shut down. Imagine, for example, that reneging on an implicit contract precludes the firm not only from entering into implicit contracts but also from entering into effective explicit contracts, perhaps along the following lines.

Although such issues are beyond the scope of our model, in practice, multiperiod explicit contracts are ineffective in the absence of implicit understandings not to "ratchet" the piece-rate or performance target over time [Roy 1952; Gibbons 1987]. To avoid this notorious ratchet effect, Lincoln Electric promises to change piece prices only after important technological innovations [Fast and Berg 1975]; this promise is part of an implicit contract enforced through Lincoln's reputation. Reneging on one implicit contract (say, an implicit contract based on a subjective performance assessment) may affect other implicit contracts (say, the implicit contract not to ratchet piece-rates in a sequence of explicit contracts), and hence affect the effectiveness of some explicit contracts. Thus, it may be impossible for the firm to fall back to $V(\beta^*)$; instead, the relevant alternative may be to shut down. The results we derive below apply whenever the relevant fallback is to shut down, whether because the available objective measures are excessively distortionary or because employer-employee trust is essential if explicit contracts are to be effective.

When $V(\beta^*) < 0$, the reneging constraint is not $V(b,\beta) - V(\beta^*) \geq rb$ as in (14) but rather $V(b,\beta) \geq rb$. Solving for the optimal contract proceeds as above; the only difference is in the reneging constraint. As shown in the Appendix, the first-order conditions (15a) and (15b) continue to hold for this new problem, as does the expression for $\beta^{**}(b)$ in equation (16). The reneging constraint can therefore be written as $V[b,\beta^{**}(b)] \geq rb$, from which it is straightforward to derive the first five of the following six comparative static results: when $V(\beta^*) < 0$ (and for parameters such that $0 < b^{**} < 1$),

$$\text{(20)} \qquad \begin{array}{lll} \dfrac{\partial b^{**}}{\partial r} < 0, & \dfrac{\partial b^{**}}{\partial w_a} < 0, & \dfrac{\partial b^{**}}{\partial \mathrm{var}(\mu)} < 0, \\[2ex] \dfrac{\partial \beta^{**}}{\partial r} > 0, & \dfrac{\partial \beta^{**}}{\partial w_a} > 0, & \dfrac{\partial \beta^{**}}{\partial \mathrm{var}(\mu)} \gtreqless 0. \end{array}$$

Recall that when $V(\beta^*) > 0$, an increase in the discount rate reduces the largest feasible implicit-contract bonus, and (16) then implies that the optimal explicit-contract bonus increases. These two results reappear when the relevant fallback position is to shut down. Similarly, recall from subsection II.C (i.e., in the absence of explicit contracts) that an increase in the alternative wage w_a reduces the present value of the ongoing employment relationship, so the implicit-contract bonus falls. This result also reappears when the relevant fallback position is to shut down, and (16) again implies that the explicit-contract bonus increases.

The most interesting comparative static results in (20) involve changes in var(μ), the level of distortion of the objective performance measure. Recall that when $V(\beta^*) > 0$, decreasing the distortion in the objective performance measure increases the explicit bonus and decreases the implicit bonus: implicit and explicit contracts are substitutes. When $V(\beta^*) < 0$, however, the implicit bonus b^{**} *increases* as the objective performance measure becomes less distortionary, while the effect on the explicit bonus β^{**} is ambiguous. The intuition behind these results is as follows.

Suppose that the worker and firm are currently engaged in the optimal implicit contract in the absence of explicit contracts—b^*, as derived in subsection II.C—earning expected profit $V(b^*) > 0$. Suppose further that the discount rate is sufficiently high that this implicit contract is second best ($b^* < 1$), so that the reneging constraint (12) is binding: $V(b^*) = rb^*$. Now consider the introduction of an imperfect objective performance measure, but suppose that p is sufficiently distortionary that it could not support a profitable explicit contract in the absence of implicit contracts; that is, $V(\beta^*) < 0$. Even though p is not profitable on its own, setting a low piece-rate β can improve expected profit, holding b constant: $V(b^*,\beta) > V(b^*)$ for small values of β. This increase in the present value of the ongoing employment relationship implies that the reneging constraint is no longer binding, $V(b^*,\beta) > rb^*$, which in turn implies that the implicit bonus b^{**} can be larger than the largest feasible value in the absence of explicit contracts, $b^{**} > b^*$. Thus, the objective performance measure enhances the effectiveness of subjective performance assessment by increasing the value of the ongoing relationship between the firm and the worker, thereby decreasing the firm's incentive to renege on an implicit contract and so increasing the reliance on the subjective assessment.

The result that *introducing* an objective performance measure increases the value of the ongoing relationship, thereby allowing the increased use of implicit contracts, also holds for *improvements* in existing objective measures. As long as $V(\beta^*)$ remains negative, decreases in var(μ) improve the value of the relationship and so cause the optimal bonus b^{**} to increase. As for explicit contracts, equation (16) suggests why the effect of changes in var(μ) on β^{**} is ambiguous: both b^{**} and $1/(1 + \mathrm{var}(\mu))$ increase when var(μ) declines, so the net implication for β^{**} is unclear. It is not difficult to construct examples in which β^{**} is nonmonotone in var(μ).

Figure III illustrates how implicit and explicit contracts vary with the level of distortion in the objective performance measure. The figure assumes a discount rate $r = 0.08$, an alternative wage $w_a = 0.02$, and an effort-disutility parameter $\gamma = 3$. The top panel

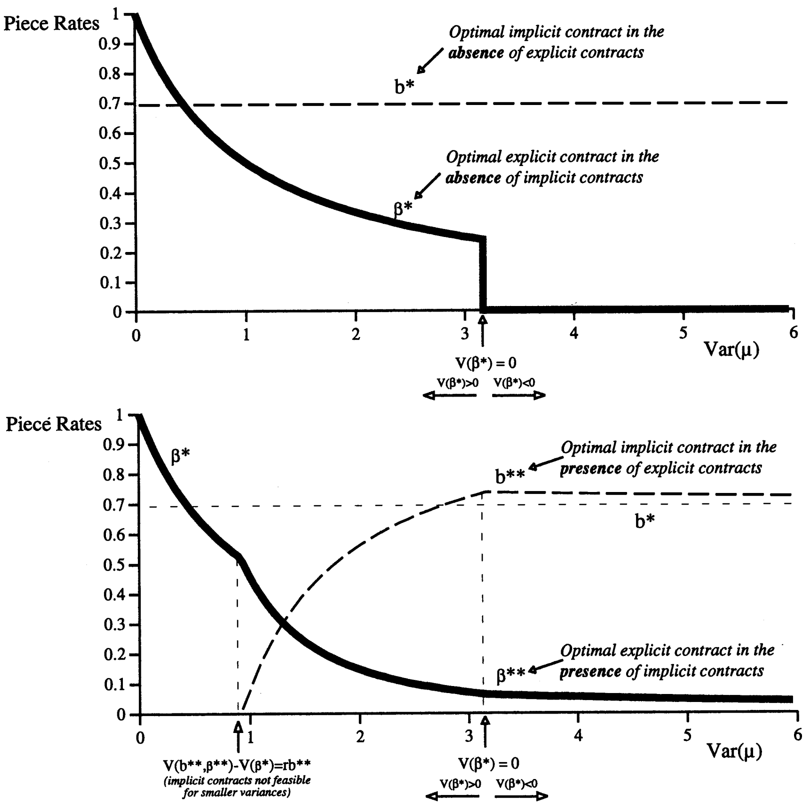

FIGURE III

Figure III shows the interaction between implicit and explicit incentives in optimal incentive contracts. The top panel shows b^*, the bonus for an implicit contract in the absence of any explicit contract, and β^*, the bonus for an explicit contract if no implicit contract is used. The bottom panel shows b^{**} and β^{**}, the implicit and explicit bonuses when the two contracts are used in combination. The figure assumes that $w_a = 0.02$, $r = 8$ percent, and $\gamma = 3$.

of the figure shows the optimal explicit contract in the absence of implicit contracts (β^* from subsection II.B) and the optimal implicit contract in the absence of explicit contracts (b^* from subsection II.C). Naturally, variations in var(μ) have no effect on the optimal implicit contract b^*. As var(μ) approaches zero, β^* approaches one, since then p is identical to y and the optimal explicit contract can achieve the first-best. At sufficiently high distortions (i.e., var(μ) $> 19/6$, given the other parameter assumptions), the best explicit contract in the absence of implicit contracts is unprofitable, $V(\beta^*) < 0$.

The bottom panel of Figure III considers optimal implicit and explicit contracts when the two are used together (b^{**} and β^{**}). For sufficiently small var(μ), no implicit contract is feasible because the firm's fallback position is too attractive, so the optimal contract is simply the explicit contract β^*. The optimal implicit-contract bonus b^{**} becomes positive once the distortion in the objective performance measure makes the firm's fallback position sufficiently unattractive: $V[b,\beta^{**}(b)] - V(\beta^*) > rb$ for small values of b. Equation (18) shows that $b^{**} > 0$ when var(μ) $> 2\gamma r/(1 - 2\gamma r)$ (or var(μ) $> 12/13$, given the assumed parameters). This critical value of var(μ) is denoted by $V(b^{**},\beta^{**}) - V(\beta^*) = rb^{**}$ in the figure. Increases in the distortion of p past this critical value result in increases in b^{**} and further decreases in β^{**}, both because higher implicit bonuses can be supported as the fallback position becomes less attractive, and because p becomes less useful as a performance measure.

A second critical value of var(μ) is denoted by $V(\beta^*) = 0$ (or var(μ) $= 19/6$, as defined in the top panel). For all values of var(μ) above (and for some values below) this second critical value, the optimal implicit bonus b^{**} exceeds the bonus b^* from the optimal implicit contract in the absence of explicit contracts, because the use of $\beta^{**} > 0$ enhances the value of the ongoing relationship and so allows increased reliance on the subjective performance assessment.

Figure IV provides a more striking illustration of the extent to which implicit and explicit contracts can reinforce each other. As Figure I illustrated, for sufficiently high values of r or w_a, no implicit contract is feasible on its own: no value of b would generate enough future profit to stop the firm from reneging. Likewise, if the variance of μ is sufficiently large, then no explicit contract is feasible on its own: $V(\beta^*) < 0$. If the variance of μ is not too large,

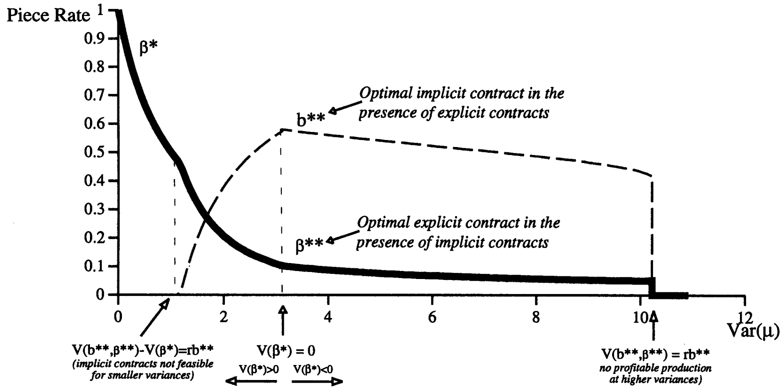

FIGURE IV

Figure IV depicts the case where implicit incentives are not feasible without explicit incentives. The figure assumes that $w_a = 0.02$, $r = 9$ percent, and $\gamma = 3$. No implicit contract is feasible on its own, so b^* (the bonus for an implicit contract in the absence of any explicit contract) is not defined. If $\text{var}(\mu) > 10.3$, implicit contracts are infeasible even in combination with the optimal explicit contract, so b^{**} (the bonus for an implicit contract in the presence of an explicit contract) is undefined.

however, then it may be that implicit and explicit contracts can operate in combination even though neither is feasible alone.

The parameters underlying Figure IV are the same as assumed in Figure III, except that the discount rate has been increased to $r = 0.09$—sufficiently high that no implicit contract is feasible on its own. (Note that the scale of the figure differs from Figure III.) As before, $w_a = 0.02$, and $\gamma = 3$, so no explicit contract is feasible on its own when $\text{var}(\mu) \geq 19/6$. Nonetheless, for a substantial range of values of $\text{var}(\mu)$ above $19/6$, implicit and explicit contracts are feasible if (but only if) used in combination.

III.B. Imperfect Subjective Performance Assessments

In subsections II.C and III.A we assumed that the firm and the worker both observed the worker's contribution to firm value (y), so that y could be the basis of an implicit contract, if not an explicit one. In this subsection we relax this assumption. We assume that one or both of the parties cannot observe y, so implicit contracts like those in subsections II.C and III.A are not possible. We also assume, however, that both parties can observe a new *subjective* performance measure, q, which is an imperfect proxy for y in the same way that p is (as explained below). In this subsection we sketch our model and describe the primary results and intuition behind our analysis. The formal derivations of these results are available upon request.

We interpret q as representing performance evaluation by immediate supervisors. The imperfections in q as a proxy for y could reflect the supervisor's inability or bias in assessing local aspects of the subordinate's performance. Alternatively, local performance could be assessed perfectly, but firmwide performance imperfectly. The worker may be able to exploit suspected biases in the supervisor's evaluation technology, by focusing on actions that are perceived favorably by the supervisor regardless of their effects on the value of the organization. This possibility suggests the value of performance evaluation by multiple supervisors, which we discuss in Section V.

Formally, we assume that q equals either zero or one, and that $q = 1$ with probability $\varepsilon \cdot a$ (where $\varepsilon > 0$, and the support of ε and the value of γ are such that $\varepsilon \cdot a < 1$). We also assume that ε and μ are independent; given ε, μ, and a, the events that $q = 1, p = 1$, and $y = 1$ are independent; and $E\{\varepsilon\} = 1$. A worker paid on the basis of the subjective and objective performance measures q and p observes ε and μ (neither of which is observed by the firm) and then chooses an action. Thus, the only qualitative difference between q and p is that the former is subjective and so cannot be the basis of an explicit contract.

The two main results from subsection III.A continue to hold for imperfect subjective performance measures: (1) the presence of imperfect explicit contracts can make (now imperfect) implicit contracts infeasible, and (2) the presence of an explicit contract can affect the present value of the ongoing relationship, and hence affect the design and performance of the optimal implicit contract. In addition to reinvestigating the results derived in subsection III.A, we also analyzed the effects of increasing the distortion associated with the subjective assessment (modeled as increases in the variance of ε). Not surprisingly, as the subjective measure becomes increasingly distortionary, the optimal size of the implicit-contract bonus decreases and the optimal size of the explicit-contract bonus (β^{**}) increases. To emphasize that the subjective performance measure is q rather than y, we will write B rather than b for the bonus paid in the implicit contract. In this notation, the above result can be stated as

$$\frac{dB^{**}}{d\mathrm{var}(\epsilon)} \leq 0, \qquad \frac{d\beta^{**}}{d\mathrm{var}(\epsilon)} \geq 0.$$

Simply put, as the accuracy of the implicit performance measure goes down, less use will be made of implicit contracts, and more use will be made of explicit ones.

IV. Subjective Weights on Objective Performance Measures

It is common for employers to specify the factors used in the performance appraisal process without specifying explicitly how each factor will be weighed in rewarding performance. In evaluating junior faculty performance at research universities, for example, the quantity of published research is typically an important consideration, but there is seldom an explicit weight or piece-rate attached to the number of publications. Similarly, at Lincoln Electric the objective piece-rate rewards an employee for output produced, but so does the subjective bonus ("output" is one of the handful of determinants listed in the description of the bonus).

In this section we consider a second model of subjective performance assessment, in order to address the use of such subjective weights on objective performance measures. We argue that such contracts allow the employer to "back out" unintended dysfunctional behavior induced by piece-rate incentives. The employer can use subjective observations of the conditions actually faced by the employees to adjust the total incentives provided for quantity (or any other objective measure).

To make this point formally, recall that the explicit contracts analyzed in subsection II.B and Section III induced the worker's effort supply to be an increasing function of μ, but the first-best action ($a^* = 1/(2\gamma)$ is independent of μ. If the worker signs the optimal explicit contract in the absence of implicit contracts, $\beta^* = 1/(1 + \mathrm{var}(\mu))$ from (8), for example, the worker will work harder than socially optimal when $\mu > (1 + \mathrm{var}(\mu))$, and will work less hard than socially optimal when $\mu < (1 + \mathrm{var}(\mu))$. The worker "games" the compensation system by taking actions that achieve high bonuses (or economize on disutility), even when these actions do not maximize the value of the firm.

In this section we assume that the employer or a supervisor can subjectively assess the incentive distortions caused by the imperfect objective performance measure. In particular, we assume not only that the worker observes μ before choosing an action (as before) but now also that the firm observes μ after p is realized. If the employer's observation of μ were contractible, then the first-best could be achieved by setting a μ-contingent piece-rate of $\beta(\mu) = 1/\mu$. This explicit contract would equate the expected marginal products of the worker's action on y and p for all values of μ, thus eliminating all incentive distortions. We assume, however, that μ is noncontractible (or "subjective," in the sense in which we applied the term to the performance assessments y and q).

When the employer's observation of μ is noncontractible, it can be used only as part of an implicit contract enforced through the firm's reputation concerns. In our analysis of such subjective weights on objective performance measures (or "subjective piece-rates," for short), we assume as before that the worker receives a base salary s and a bonus for achieving $p = 1$. The total bonus is $\beta + b(\mu)$, including both a nonnegative objective component, $\beta \geq 0$, and a nonnegative subjective component, $b(\mu) \geq 0$. Since μ is noncontractible, β cannot be contingent on μ, but the implicit-contract bonus $b(\mu)$ can vary with μ.

In order to focus on subjective weights on objective measures, in this section we ignore subjective weights on subjective measures; that is, we ignore implicit contracts based on y or q, as were analyzed earlier. If the worker believes that the firm will honor the implicit contract $b(\mu)$, the worker's problem (after observing μ) is

$$\max_a s + \mu \cdot a \cdot [\beta + b(\mu)] - c(a), \tag{21}$$

so the worker's optimal action is

$$a^*[\mu,\beta,b(\mu)] = \frac{\mu[\beta + b(\mu)]}{2\gamma}. \tag{22}$$

As in our earlier analyses of implicit contracts based on y, the first-best can be achieved here if the discount rate is sufficiently low. To achieve the first-best, the firm must pay a total bonus of

$$\beta + b(\mu) = 1/\mu \tag{23}$$

for each possible value of μ. If the firm honors this implicit contract (by paying the subjective piece-rate $b(\mu)$ on the objective performance measure p), it will thereafter receive the first-best profit; namely, $V_{fb} = 1/(4\gamma) - w_a$. If the firm reneges, however, it will thereafter receive the profit from the optimal explicit contract; namely, $V(\beta^*) = 1/4\gamma(1 + \text{var}(\mu)) - w_a$ from (9). The firm thus will honor the first-best contract defined by (23) if and only if the present value of the difference in expected profit beginning next period exceeds the size of the bonus:

$$b(\mu) \leq \frac{V_{fb} - V(\beta^*)}{r} \qquad \text{for all } \mu, \tag{24}$$

or, equivalently,

$$\frac{1}{\mu} - \beta \leq \frac{1}{r4\gamma}\left(\frac{\text{var}(\mu)}{1 + \text{var}(\mu)}\right) \qquad \text{for all } \mu. \tag{25}$$

As (25) shows, the firm is most tempted to renege after observing low realizations of μ, since these realizations require high subjectively determined bonuses. A sufficient condition for achieving the first-best is for (25) to hold at $\beta = 0$ for the lowest possible value of μ, which we denote by $\mu_L > 0$. If this sufficient condition fails, the firm may still be able to achieve the first-best by combining implicit and explicit contracts, as follows.

Denoting the highest value of μ by μ_H, the highest possible β consistent with the first-best is $\beta = 1/\mu_H$, since any higher objective piece-rate would require a negative subjective piece-rate over some range of μ (which in turn might induce workers to renege on the implicit contract, as discussed in footnote 6). We will call $\beta_{fb} = 1/\mu_H$ the first-best objective piece-rate. To achieve the first-best, the subjective piece-rate $b(\mu)$ must be $b_{fb}(\mu) = 1/\mu - \beta_{fb}$, so that total incentives are $\beta_{fb} + b_{fb}(\mu) = 1/\mu$ for each μ, as in (23): the subjective piece-rate completely eliminates or "backs out" the distortions that would be inherent in any objective piece-rate contract. This combination of implicit and explicit contracts—$b_{fb}(\mu)$ and β_{fb}—is illustrated by the bold curve in Figure V.

Although this first-best contract is feasible at sufficiently low discount rates, it is not feasible when discount rates are too high, because the firm finds it worthwhile to renege on the largest subjectively determined bonuses (which are associated with the smallest values of μ). If we (temporarily) fix the objective piece-rate at its first-best level, $\beta_{fb} = 1/\mu_H$, then we can define $\mu_L^* > \mu_L$ as the lowest value of μ that satisfies (25). That is, μ_L^* solves

$$\frac{1}{\mu_L^*} \equiv \frac{1}{r4\gamma}\left(\frac{\text{var}(\mu)}{1 + \text{var}(\mu)}\right) + \beta_{fb}. \tag{26}$$

One feasible contract is to set the objective piece-rate at β_{fb} and the subjective piece-rate at $b(\mu) = 1/\mu - \beta_{fb}$ for $\mu \geq \mu_L^*$ and $b(\mu) = 1/\mu_L^* - \beta_{fb}$ for $\mu < \mu_L^*$. (This contract is depicted in Figure V as the bold dashed line along the first-best contract for $\mu \geq \mu_L^*$ and

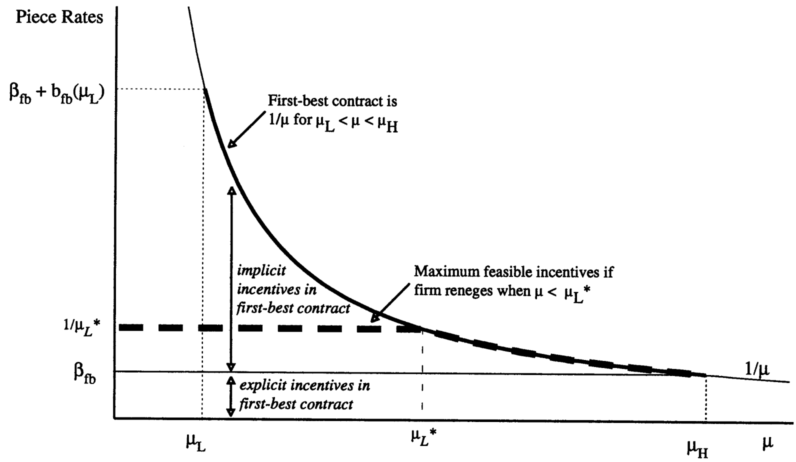

FIGURE V

Figure V shows the first-best combination of explicit and implicit weights on the objective performance measure (bold curve), as well as the maximum feasible total incentives associated with first-best explicit incentives (bold dashed line). See text for definition of variables.

the bold dashed line at $1/\mu_L^*$ for $\mu < \mu_L^*$.) This feasible contract will provide first-best incentives for $\mu \geq \mu_L^*$, but will not induce optimal effort for low realizations of μ.

The envelope theorem implies that this feasible contract can be improved by setting the objective piece-rate β above its first-best value. Consider the effects of a small increase in the explicit piece-rate to some $\beta > \beta_{fb}$. First, total incentives for the highest levels of μ will be too high, leading to departures from first-best actions. Since β_{fb} provided first-best incentives for these highest values of μ, however, this change is second-order. The second effect of increasing β is to increase total incentives for all values of μ less than μ_L^* (so far holding $b(\mu)$ fixed as specified above). Since total incentives were below the first-best level for all $\mu < \mu_L^*$, this increase in total incentives is a first-order effect. Indeed, this first-order gain will increase expected profits and so allow the firm to increase b for low values of μ, further increasing the total incentives in this region.

By the preceding argument, the second-best contract (illustrated in Figure VI) sets $\beta_{sb} > \beta_{fb}$, providing too much incentive for high realizations of μ, and too little incentive for low values of μ. The second-best contract will involve two critical values of μ,

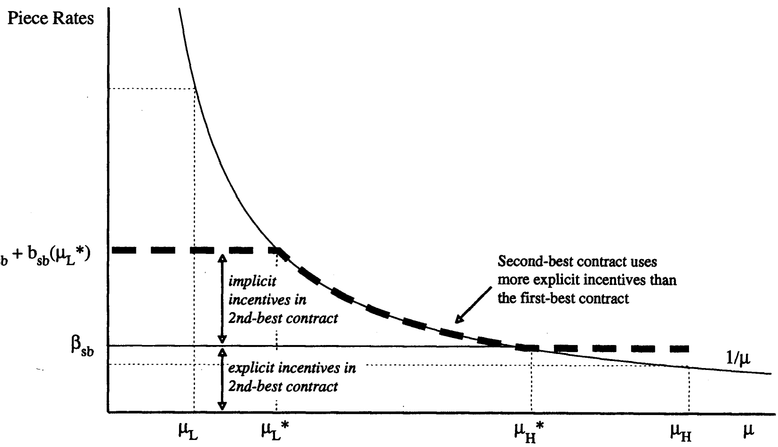

FIGURE VI

Figure VI shows the second-best combination of explicit and implicit weights on the objective performance measure (bold dashed line). See the text for the definition of variables.

denoted by $\mu_L{}^{sb}$ and $\mu_H{}^{sb}$, where $\mu_L < \mu_L{}^{sb} \leq \mu_H{}^{sb} < \mu_H$. For values of $\mu < \mu_L{}^{sb}$, the firm will suffer inadequate incentives but will not renege on its implicit contract; for values of $\mu > \mu_H{}^{sb}$, the firm will suffer excessive incentives, because $\beta_{sb} = 1/\mu_H{}^{sb} > 1/\mu$. The subjective weight on the performance measure in this second-best contract is given by

$$b_{sb}(\mu) = \begin{cases} 0 & \text{for } \mu \geq \mu_H{}^{sb}, \\ 1/\mu_L - \beta_{sb} & \text{for } \mu_L{}^{sb} < \mu < \mu_H{}^{sb}, \\ 1/\mu_L{}^{sb} - \beta_{sb} & \text{for } \mu \leq \mu_L{}^{sb}. \end{cases} \tag{27}$$

In this analysis of subjective weights on objective performance measures, subjective weights allow the employer to mitigate distortions in the performance measurement process. To do so, the contract between the worker and the firm is deliberately left vague: although there is an explicit understanding of how performance is measured, there is only an implicit understanding regarding how that performance measure is rewarded. There is an important role for objective weights in this contract, because increasing the objective piece-rate reduces the firm's temptation to renege on the subjective bonus. Objective weights that do not distort incentives will always be preferred to subjective weights, so the explicit contract should set β at least as high as β_{fb}. When the first-best cannot be attained, however, the envelope theorem implies that the firm will accept some degree of distorted incentives ($\beta_{sb} > \beta_{fb}$) for an increased ability to enter into implicit contracts.

V. Future Work

The effectiveness of incentive contracting in organizations depends on a large set of social, psychological, and economic factors. This paper brings formal analysis to questions about incentive contracts that have been only informally treated in the past. Specifically, we model trust in subjective compensation contracts, using the requirement that such contracts be self-enforcing. We feel that, like Kreps's [1990] game-theoretic analysis of corporate culture, the paper shows promise for the use of formal techniques in the analysis of topics previously considered "too soft" for such work.

There are many aspects of the problem we have not addressed. Some may be permanently beyond the reach of formal analysis, but others would be natural extensions of the first steps we have presented here. In subsection III.B, for example, we suggested that the worker's private information ε that affects the imperfect subjective performance assessment q could be used to model supervisor bias. It would be natural to extend the model to explore the use of multiple evaluators in subjective performance assessment systems. Suppose that the ith supervisor's subjective evaluation involves a distortion ε_i, and that workers "game" the performance-appraisal process by taking actions that are perceived favorably by a particular supervisor. If the distortions are independently distributed across supervisors, the gaming can be mitigated by combining the subjective performance evaluations of several supervisors.[8]

The supervisorial biases discussed so far reflect ways in which supervisors misinterpret performance data, but do not reflect explicit favoritism on the part of the evaluator. One way to begin to model such favoritism would be to allow the supervisor to observe q privately (rather than publicly with the worker, as in subsection III.B), and then to analyze the supervisor's incentive to report q truthfully. This potential exercise of managerial discretion over truthfully reporting the performance measure suggests another role for trust in the performance-evaluation process: workers do not trust subjective performance evaluation when they feel that supervisors indulge in favoritism.

8. Prendergast and Topel [1992] make a similar suggestion.

Finally, in Section IV we considered subjective weights on objective performance measures and argued that such subjective piece-rates allow firms to correct dysfunctional behavior that would be induced by an explicit contract alone. In our simple model, dysfunctional behavior arises only because the objective performance measure is too easy for the worker to manipulate ($\mu \gg 1$) or too hard (μ near 0). A more interesting model would also allow for noncontractible variations in the effect of the worker's effort on the worker's contribution to firm value, as in Baker [1992]; that is, the probability that $y = 1$ might be θa, where θ is a random variable akin to μ. Now the firm might value subjective piece-rates for their ability to induce great effort when it is valuable ($\theta \gg 1$) and little effort when it is valueless (θ near 0).

Although this paper has focused on implicit and explicit *compensation* contracts, it is easy to imagine parallel analyses of the interplay between other explicit and implicit contracts. Promotion decisions, for example, are typically based on a combination of objective and subjective criteria. Also, while most employment is subject to an implicit contract in which employees can quit and employers can discharge for any (subjective) reason (the "at-will doctrine"), many employees (including an increasing number of top executives) enter into explicit contracts specifying employment security with severance provisions. Models developed to examine implicit and explicit elements of promotions, job security, and other aspects of the employment relationship will of course differ from the model developed here to examine compensation and incentives. But many of the issues studied in this paper—including the distortionary costs of explicit contracts, the enforcement costs of implicit contracts, and the optimal combination of explicit and implicit contracts—will also be relevant in these parallel analyses.

APPENDIX: COMPARATIVE STATICS FOR CASE 2: $V(\beta^*) < 0$

This Appendix solves for the optimal b^{**} and β^{**} for the case when the explicit contract in the absence of implicit performance measures is unprofitable, $V(\beta^*) < 0$, and derives the comparative static results reported in equation (20). When $V(\beta^*) < 0$, the reneging constraint is not $V(b,\beta) - V(\beta^*) \geq rb$ as in (14) but rather $V(b,\beta) \geq rb$, where (using (2) and (5))

$$\text{(A1)}\quad \begin{aligned} V(b,\beta) &\equiv E_\mu\{a^*(\mu,b,\beta) - \gamma a^*(\mu,b,\beta)^2 - w_a)\}, \\ &= (1/4\gamma)\,(2(b + \beta - b\beta) - b^2 - \beta^2(1 + \text{var}[\mu])) - w_a. \end{aligned}$$

The optimal contract sets b and β to maximize expected profit $V(b,\beta)$, subject to the reneging constraint $V(b,\beta) \geq rb$. Defining λ as the Lagrange multiplier for this constraint, the first-order conditions for the optimal contract involving both subjective assessments and objective measures (i.e., when $b > 0$ and $\beta > 0$) are

(A2a) $$(1 + \lambda) \cdot (1 - b - \beta) = 2\lambda\gamma r,$$

(A2b) $$(1 + \lambda) \cdot (1 - b - \beta \cdot (1 + \mathrm{var}[\mu])) = 0.$$

The first-order conditions (A2a) and (A2b) are identical to (15a) and (15b) for the case $V(\beta^*) > 0$. Equation (A2b) yields $\beta^{**}(b)$, the optimal β given an arbitrary value of b:

(A3) $$\beta^{**}(b) = (1 - b)/(1 + \mathrm{var}(\mu)).$$

For parameter values such that the first-best implicit contract $b^{**} = 1$ is not feasible, the optimal implicit-contract bonus b^{**} is the largest value of b solving

(A4) $$V[b,\beta^{**}(b)] = (1/4\gamma)(-b^2k + 2bk + 1 - k) - w_a \geq rb,$$

where $k = \mathrm{var}(\mu)/[1 + \mathrm{var}(\mu)] < 1$. When the constraint (A4) binds, it produces a quadratic of the form $-kb^2 + Cb + D = 0$, where $C = 2k - 4\gamma r$, and $D = 1 - k - 4\gamma w_a$. If $C^2 + 4kD > 0$, then there exists an interval of values of b satisfying (A4). The solution is the largest value of b in [0,1] that satisfies (A4):

(A5) $$b^{**} = \frac{C + \sqrt{C^2 + 4kD}}{2k}.$$

Since C decreases with r, the fact that $\partial b^{**}/\partial C > 0$ implies that b^{**} decreases with r. Similarly, b^{**} increases with D and thus decreases with w_a. Finally, as $\mathrm{var}(\mu)$ increases, k increases (approaching unity), so b^{**} decreases. To summarize,

$$\frac{\partial b^{**}}{\partial r} < 0, \qquad \frac{\partial b^{**}}{\partial w_a} < 0, \qquad \frac{\partial b^{**}}{\partial \mathrm{var}(\mu)} < 0.$$

The comparative statics for the explicit-contract bonus β^{**} follow from (A3):

$$\frac{\partial \beta^{**}}{\partial r} > 0, \qquad \frac{\partial \beta^{**}}{\partial w_a} > 0.$$

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