# 14

# Formal Models in Budgeting and Incentive Contracts

## ISSUES AND TERMS IN FORMAL INCENTIVE MODELS

### Wealth, Leisure, and Risk Attitudes

In Chapter 13, we explored the types of incentive contracts used by organizations. Building on this institutional base, contemporary research in organizational economics, finance, and accounting has developed theoretical insights about how contracts can be constructed to motivate managers to act in the best interests of the company's owners. The research consists of formal economic and mathematical models of the behavior of individuals. The research models the relationship between the owners, or principals, and their managers, or agents. Both principals and agents are assumed to be rational economic-maximizing individuals. They pursue their specified individual objectives within the organizational setting and the terms of the contractual relationship. Specifically, owners are interested solely in the expected monetary return that will be generated from their investments in the firm, and managers value both their **wealth** and their **leisure**.

The analysis assumes that managers prefer more wealth to less but that the marginal utility, or satisfaction, of wealth decreases as more wealth is accumulated. Therefore, managers display **risk aversion**, which leads them to value the outcomes from a risky investment as less than its expected, or actuarial, value. Owners, however, are assumed to be **risk-neutral**: They value investments at their expected value.

For example, consider a large company, with shares widely dispersed among individual shareholders, who are also well diversified through investments in many other companies. We would expect that the individual shareholder would evaluate investments on an expected-value (i.e., risk-neutral) basis. Individual managers, however, responsible for making large risky investments, would be concerned about how negative outcomes would affect their compensation or opportunities for advancement. Because managers cannot diversify away from the consequences of bad outcomes, they are risk-averse and

may turn down risky projects that have positive expected values. The difference in risk attitude between managers and owners creates one source of conflict between the two groups.

Managers are also assumed to value their leisure. *Leisure* is defined as the opposite of the effort that managers put into the firm. That is, managers who work hard sacrifice leisure in return for increasing the value of the firm. Leisure is a generic concept that also includes the manager's consumption of perquisites or benefits. Examples of perquisites are company cars, lavish offices, first-class travel, and other nonmonetary benefits. Such perquisites divert the owners' capital away from productive investments in the firm and into the managers' consumption. Leisure could also represent time spent by senior managers on prestigious or personally remunerative external activities, such as boards of directors and trusteeships, that provide them with visibility and status but little in direct return to their companies.

Thus, owners hire managers (buy the managers' time) and also supply capital to the firm. Managers split their time between leisure and productive time and deploy the owners' capital between productive investments and personal perquisites. The agency literature attempts to design incentives for managers to mitigate excess consumption of leisure and perquisites.

Note that we are not speaking of illegal theft as monitored by law-enforcement agents or auditors. We are concerned with a more subtle theft, of time (the manager does not work when or as hard as he is supposed to) and capital (the manager spends more money than necessary to accomplish assigned managerial tasks).

## Individual Honesty and the Role of Contract Monitoring

Many readers of this agency paradigm comment, "The agency literature involves fraud and theft. I believe that most people are honest. Therefore, the agency literature is cynical and irrelevant." But extensive evidence exists of efforts in the world around us to monitor behavior and provide disincentives for engaging in effort diversion and time theft.

A second common observation is: "Even if I grant that some people will shirk their assigned duties or will spend more money than they should on their personal consumption, I can always observe and discipline this behavior." **Monitoring** involves observing people to determine whether they have lived up to the provisions of a contract. If the job is well defined, monitoring is fairly easy. We can simply measure outputs. Like Frederick Taylor, we can assess the performance of a manual task by measuring the amount of work done or the amount of output created. However, if the job is more complicated, measuring output may not be realistic because of the possibility of many intervening variables between input and output.

For example, suppose we decided to assess the performance of a neurosurgeon by observing the patient six months after the operation. Consider the problems with a rule that assesses the neurosurgeon as having done a bad job if the patient dies or has suffered a disability as the result of the operation. For example, the outcome—patient disabled—could have occurred because the patient's condition was very poor before the surgeon's intervention and it was only the surgeon's great skill that prevented death, or the unhappy outcome could have occurred because of a patient condition that was not serious, coupled with an incompetent surgeon. The intervening variable—the unobserved state of the envi-

ronment (the patient's condition)—makes it difficult to infer inputs (the neurosurgeon's skill, effort, and care put into the procedure) from outputs (the patient's condition after the operation). Therefore, we have an outcome that is jointly determined by the manager (the surgeon) and the environment (the patient's condition at the time of the operation). Any given outcome can result from different combinations of the environment and the manager's skill and effort.

In general, inputs are related to the amount of effort and the quality of effort or skill. The agency literature has focused on the first aspect, namely, checking up on the withholding of effort. This withholding is called **shirking**. Measurement, or monitoring, of inputs is introduced to verify that the conditions of the contract have been met: The manager has delivered the required amount of time and has not shirked.

It seems reasonable to conclude that the lack of time clocks for managers implies that shirking, at least overt shirking related to staying away from work, cannot be the crucial issue in manager-owner conflicts. The shirking, however, may be more subtle. Recall from the discussion in Chapter 7 that we create decentralized organizations to allow managers the opportunity to specialize in terms of both action (the skill component) and information. Developing the market and technological information to accomplish these tasks successfully may require managers to leave their comfortable offices (and homes) to travel to diverse operating sites and to spend considerable amounts of their time in settings where they can accumulate relevant market, technological, and competitive information. In this case, shirking would involve not investing sufficient time and energy to develop the information required to be successful in the job and being prepared with an alibi if bad outcomes occur: "I did my best. This bad outcome resulted from events beyond my control."

## Choosing the Right Manager and the Role of Information

Owners must be concerned with managers' skills. The difficulty of selecting managers with the appropriate skills for a required task is called the **adverse selection** problem. When a managerial contract is offered, it will appeal only to managers who have opportunities that are equal to or lower than the skill levels and compensation level envisioned in the contract of employment. Therefore, unless carefully designed, the contract will encourage people who are not qualified for the position to apply for the job. Moreover, once selected and installed in jobs, incumbent managers may not invest enough to keep their skills up to the level required for satisfactory job performance.

Because of the differences in information and skills between the owners and the manager, the owners can never be certain about how managerial effort and skill contributed to actual outcomes. This information difference, or **information asymmetry**, brought about by differences in skills, specialization, and the limited ability of owners to monitor the amount and quality of the manager's inputs, creates problems in contracting between owners and managers. The information asymmetry prevents the imposition of the obvious contract: namely, to pay the manager a salary and to verify that the manager's inputs were as specified in the contract of employment. The principal paying a salary under conditions in which the agent's input cannot be verified creates a situation, called **moral hazard**, wherein the manager is motivated to renege on the contractual terms. *Moral hazard* is a general term that was first used in the medical insurance literature to describe a situation in which the provisions of a contract may motivate someone to act in a way that is prejudicial or unintended by the contract.[1]

Information asymmetry presents additional problems because the best information available for planning and control is in the hands of the controlled (the managers) and not in the hands of the controller (the owners). Moreover, managers are not motivated to disclose their private information for fear that it might be used against them. Managers' reluctance to disclose their specialized local information is called **information impactedness** and has led to interest in designing innovative schemes to encourage managers to reveal what they actually believe or know.

When inputs (managerial effort and ability) cannot be measured, the only variable available for constructing an incentive contract is the output: the consequences of managers' decisions, efforts, and skills. But a contract that provides rewards based on outputs imposes undesirable risk on the manager. Managers invest effort (for which they have disutility, relative to leisure, by assumption) to improve the firm's return. The managers' efforts combine with factors outside the managers' control to determine the actual outcome. One can think of the manager's effort affecting the mean of the distribution that will generate the actual result, but not the actual realization from this distribution. A manager may think, "Wait a minute here. I might work hard (by sacrificing leisure) and then have all my hard work wiped out by something beyond my control like a general downturn in the economy or industry."

Therefore, managers face a gamble, or risk, when deciding whether to invest some of their leisure for a chance at increased outcomes (or, for that matter, by sacrificing perquisites for income-generating investments). In making this tradeoff, managers will prefer a different allocation of effort or perquisite consumption than risk-neutral owners would select. The owners, because of their risk neutrality, should absorb all the risk in the firm. But by rewarding managers on the basis of actual outcomes, owners end up imposing risk on risk-averse managers because the owners do not have the same information available to them as the managers. The contract is inefficient, because owners, willing to bear risk without cost, must provide additional compensation to managers to bear risk because of the owners' inability to observe the managers' information, actions, and abilities.

## Balancing Incentive and Return Considerations

In designing an optimal incentive contract for the manager, we must make compromises between the desirability of having the owner bear all the risk in the firm and the necessity of imposing risk on the manager to minimize shirking and overconsumption of perquisites. For this reason, contracts requiring managers to bear risk are called **second-best** solutions to the incentive contracting, or motivation, problem. These contracts are second best because an economic loss is created by the owners' inability to monitor inputs; therefore owners cannot verify that managers have lived up to the terms of the employment contract and pay them with a fixed (nonrisky) wage.

Any output (such as profit or product quality or customer satisfaction) that we can observe and that is correlated *in any way* with managerial effort can provide a useful basis for structuring incentives. Moreover, the more closely the outcome measure reflects (that is, is correlated with) the input of the manager, the more valuable the measure is in an incentive contract.[2] This, of course, is the reason for tying executive compensation to stock options or for providing rewards based on reported profit.

Many variations have been created from this basic theme in the agency literature. First, to control for the adverse selection problem in hiring, we try to structure contracts

that weed out people who are not qualified. As one example, research suggests offering salespeople contracts that provide high rewards for high sales achievement and low or no rewards for selling nothing. Such a contract would attract people who know (or believe) that they have strong selling skills and would help to eliminate unqualified applicants for a selling job. But by tying compensation solely to sales results achieved, we impose risk, created by factors beyond selling effort and ability, on the salesperson. Therefore, we have to offer a higher expected-cost contract to compensate the salesperson for absorbing this risk. Thus, we overcome the adverse selection problem but at the expense of having to offer additional expected compensation.

To avoid the imposition of risk on the manager, we might determine whether the outcome provides any indication of the manager's input. If the manager's input can be inferred exactly from the output, then a simple wage/penalty scheme can be used. For example, suppose that when a purchasing manager does not perform effectively one time in 100 poor-quality materials will be purchased. Moreover, the poor-quality materials can be purchased only when the purchasing manager is not doing the contracted job. The employment contract in this case is simple: The wage is paid unless poor-quality materials are purchased. If poor-quality materials are purchased, the manager is penalized, perhaps fired. If the penalty is large enough and can be enforced, shirking can be eliminated entirely.

These are the broad insights that have emerged from the agency literature. The theory attempts to explain or predict contracts observed in practice, but we must be cautious in interpreting the results literally. The conclusions have been derived from models with restrictive and perhaps unrealistic assumptions. The literature's main contribution has been to provide us with a framework for thinking about incentive contracts and to point out relevant issues on risk sharing and observability that we might be less sensitive to without the formal analysis.

## PROBLEMS OF OBTAINING INFORMATION FOR STANDARDS AND BUDGETS

Standards and budgets occupy a prominent place in the literature of cost accounting, management control, and organization theory. Standard-setting and budgeting activities are so pervasive in management teaching and practice that we tend to accept them without considering the fundamental forces that make these activities desirable. In an ideal world of certainty, costless information, and observability, and unbounded computational capacity, a central decision maker can make globally optimal decisions and can direct subordinates (local managers) to implement centrally determined plans. In this setting, there would seem to be little role for budgets.

In the real world, however, local managers are given considerable decision-making authority. Profit-sharing incentive contracts may be instituted to motivate the managers to make decisions that are in the firm's best interests, as described above and in Chapter 13. But, as we have seen, simple profit-sharing contracts introduce uncertainty into the managers' compensation functions, and managers may take actions (such as lowering output levels) to compensate for this uncertainty. Such risk-avoiding behavior is not generally desirable for the firm as a whole or for its shareholders. We must attempt to design the most efficient contracts to balance the conflicts between managers and owners.

## Using Information for Rewards and Control—The Moral Hazard Problem

Conflicts can arise in even simple situations. Consider a salesperson who is asked by the sales manager to provide an estimate of expected sales in the upcoming period. The sales manager will use the estimate to plan production and marketing efforts and as the basis for the compensation plan. More specifically, the salesperson is paid a base salary and a commission on sales in excess of a target amount. The sales manager will use the estimate of sales potential to set the target level of sales that the salesperson must attain before commissions are paid. In this situation, almost all salespersons tend to understate the assessed sales potential. The problem is not limited to sales. A production manager may understate the potential output from an assembly line so that, if something goes wrong, she will still have a good chance of attaining the production quota.

The misrepresentation of private information occurs because of two critical conditions: (1) The subordinate has information, by virtue of specialization, that the superior requires for planning purposes; and (2) the information is used both for planning and for control purposes. These problems are another example of the moral hazard problem; in this case, the manager (or subordinate) is motivated by the structure of the control or evaluation system to misrepresent private information.[3] The condition for this moral hazard situation arises whenever the manager's information or actions are not directly observable by the manager's superiors.

Moral hazard is not necessarily the consequence of a poorly designed control system. In fact, because of the specialization sought by decentralization, and the need for specialist information in control, moral hazard is almost guaranteed in a decentralized firm that attempts to assess individual contributions to the firm.

## Moral Hazard and Information Impactedness

The existence of moral hazard creates the information impactedness situation, described earlier, whenever available, valuable information does not flow as required in the firm. As another example of information impactedness, consider a situation in which a manager knows that she has made a bad decision but refuses to correct the situation because doing so would make the bad decision obvious to all. On the other hand, leaving the existing decision unchanged may cause damage to the firm but not harm the manager's reputation (or compensation), because no one else will recognize that a bad decision has been made.

Information impactedness arises when local managers possess valuable, perhaps unique, information about their local environment but do not convey it truthfully. We are not suggesting that managers are evil or indifferent to the overall performance of the firm. We are suggesting that when managers are evaluated and promoted on the basis of comparisons of their performance with a standard, we should not expect managers to act contrary to their own self-interest when asked to provide information on the appropriate level of the standard. Their self-interest may cause them to strategically manipulate their information and intentions. Because of inherent uncertainty and the costliness of observation, owners will rarely be able to detect whether an unexpected outcome was due to prior misrepresentation of information or an unusually good or bad outcome.

Information impactedness problems can be mitigated by basing rewards on companywide rather than individual performance. In this way, managers have more motivation to share information and cooperate. But, when managerial rewards are based on overall

rather than individual performance, managers will not capture the full gains from their individual efforts, information acquisition, and decision making. As a consequence, they will reduce their efforts along those dimensions—the practice of free-riding described in Chapter 13. Many firms base rewards on individual performance. Apparently, the motivational benefits provided by measuring and rewarding individual behavior outweigh the potential costs of information impactedness and risk-avoiding behavior.

## THE AGENCY MODEL

To bring this discussion into focus consider the following example that illustrates the problem of choosing an incentive compensation plan that the owner (or principal) will find superior to a pure wage contract.

### The Setting

Suppose that the principal, who is risk-neutral, is dealing with an agent who is risk-averse and whose utility for wealth can be modeled by the negative exponential utility function with risk aversion parameter $r = -0.0001$. That is, this manager's utility[4] for wealth ($w$) can be written

$$U[w] = -\exp^{rw}$$

Both the principal and the agent agree that the prospects facing the firm depend jointly on the actions taken by the agent (the act which can be high or low) and an event (the state of nature, which can be favorable or unfavorable) that is outside the agent's control.

When the agent's effort is high (which we will denote as $H$) he devotes considerable time and effort to develop information and skills and refrains from excess consumption of perquisites that would reduce the organization's asset base and its earnings power. Effort level low (which we will denote as $L$) occurs when the agent puts less work into the firm while consuming more perquisites.[5]

The agent can earn a wage of $10,000 working outside the firm. We will call this wage $m$, the market wage. Moreover, the agent experiences a personal cost, which is expressed in dollar terms as $15,000, for providing a high level of effort (which we will denote as $ch$) and $5,000 for providing a low level of effort (which we will denote as $cl$).[6] The manager suffers no psychic cost from contracting with the principal to provide one level of effort and then providing another (i.e. lying).

An unfavorable state means that the general conditions facing the firm are adverse; in the unfavorable state, a given action by the agent produces a lower financial return to the organization than in the favorable state.

There are two possible results from the agent's actions and the random state of nature: a return of $50,000 (called the high outcome) or a return of $20,000 (called the low outcome). The following are the probabilities of the high and low outcomes given the underlying agent effort level.

| LEVEL OF EFFORT | HIGH OUTCOME | LOW OUTCOME |
|---|---|---|
| High | 0.9 | 0.1 |
| Low | 0.2 | 0.8 |

The agent's activities and the state of nature are such that they are unobservable, or observable only at a prohibitive cost, to the principal. Therefore, faced with any outcome, high or low, the principal is unable to know which effort level the agent provided.

## The Motivational Problem: Why a Flat Wage Will Not Do

In terms of the discussion preceding this section we have the conditions that create the problem of moral hazard. The principal has no way of enforcing a flat wage contract of $25,000 ($10,000 for the opportunity cost and $15,000 for the high level of effort), for a high level of effort that will be paid whatever outcome occurs. The agent will sign this contract and then renege by providing a low level of effort. The agent's reward or utility from this contract will be

$$\text{Utility} = -\exp^{-0.0001*(25000-5000)} = -0.135$$

which is higher than the utility of $-0.368$ corresponding to the market wage of $10,000. This is the gain from shirking. The principal's expected return from this contract will be

$$\text{Expected return} = (0.2 * 50{,}000) + (0.8 * 20{,}000) - 25{,}000 = 1{,}000$$

## The Principal's Problem: How to Tie Reward to Performance

The principal wants to see if she can increase her expected reward by tying the agent's reward to the outcome. The principal's problem is to find the lowest-cost pay for performance scheme that motivates the agent to provide the level of effort that the principal thinks best benefits the firm.[7]

The compensation package the principal offers the agent must reflect two constraints. First, compensation package must provide a return that is no less than what the agent can earn outside the firm. This is called the **individual rationality** (IR) condition or constraint. Second, the compensation package must provide the agent with a return from providing the desired level of effort that is no less than the expected return from a lower level of effort. This is called the **incentive compatibility** (IC) condition or constraint.

If it is in the principal's best interests to contract for the lowest level of effort, the problem is trivial. In that case, the principal will pay the agent a flat wage of $15,000, and the agent will supply low level of effort. The agent is not motivated to provide more than what is contracted. The more interesting problem is when the principal's best interests require contracting for the high level of agent effort.[8]

In this case, the principal wants to minimize the expected compensation paid to the agent subject to giving the agent a compensation package that at least matches the outside opportunities (*IR*) and that motivates the agent to deliver the high rather than the low level of effort (*IC*).

If we write *rh* as the compensation paid to the agent if the outcome is high, and *rl* as the compensation paid to the agent if the outcome is low, we can write the principal's problem as follows:

$$\begin{aligned} &\text{Minimize } (0.90 * rh) + (0.10 * rl) \\ &\text{Subject to: } \text{EU[w|H]} \geq \text{EU[w|L]} \qquad IC \\ &\qquad\qquad \text{EU}[w|H] \geq \text{EU}[m] \qquad IR \end{aligned}$$

where

1. EU[$w|H$] is the agent's expected utility under the compensation package of providing the high level of effort. In this case EU[$w|H$] equals (0.9 * [ $-\exp^{r(rh-ch)}$]) + (0.1 * [$-\exp^{r(rl-ch)}$])
2. EU[$w|L$] is the agent's expected utility under the compensation package of providing the low level of effort. In this case EU[$w|L$] equals (0.2* [$-\exp^{(rh-cl)}$]) + (0.8 * [$-\exp^{r(rl-cl)}$])
3. EU[$m$] is the agent's expected utility of the market wage. In this case, EU[$w$] equals $-\exp^{rw}$

Recall that we are designing a compensation package that guarantees that the agent will supply a high level of effort, so we use the outcome probabilities associated with the effort level's being high.

We can solve[9] this problem to find that the optimal solution is $rh$ = \$27,816.59 and $rl$ = \$13,339.76. Note that the principal's expected return is

$$\text{Expected return} = [0.9 * (50{,}000 - 27{,}816.59)] + [0.1 * (20{,}000 - 13{,}339.76)] = \$20{,}631$$

That is considerably higher than the \$1,000 return expected under the flat wage contract. Moreover, we can verify that the expected utility provided by this compensation package exactly equals the utility of the market wage and is such that the agent's utility of providing the high level of effort equals that of providing the low level of effort, and we invoke the assumption that the agent, when indifferent, will choose not to shirk.[10]

Note that the expected compensation given this solution is \$26,368.91 ([0.9 * 27,816.59] + [0.1 * \$13,339.76]). The difference of \$1,368.91 between \$25,000 and \$26,368.91 is the risk premium that the principal must pay the agent to bear the risk imposed on the agent to provide for incentive compatibility. The risk premium plus the \$15,000 the principal must pay the agent to provide the high level of effort is the total agency cost.

As the agent's risk aversion falls (that is, goes to zero), the risk premium falls as the agent's expected compensation converges on \$25,000, as shown in Exhibit 14-1.

The expected return from the organization before the agent's compensation is \$47,000 ([0.9 * 50,000] + [0.1 * 20000]). If the agent were risk-neutral, the optimal solution would be for the agent to rent the organization from the principal for \$22,000 and bear all the organization's risk.

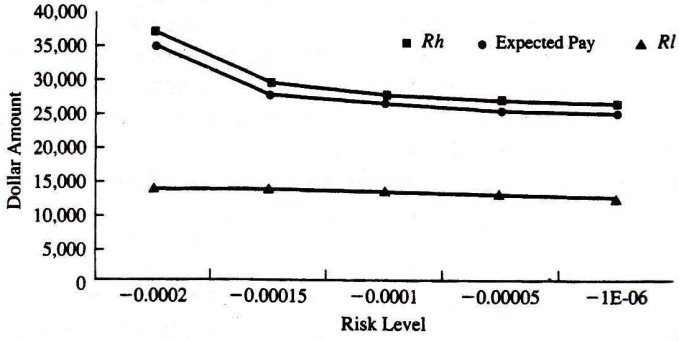


**EXHIBIT 14-1 The Effect of Risk**

## ELICITING HONEST REVELATION OF PRIVATELY HELD BELIEFS

Organizations decentralize to allow managers to develop specialist information. When planners want information to develop companywide plans, they face the problem of eliciting this information since it is often used for both planning and control purposes. That is, the information is often simultaneously used in planning and also to evaluate the manager's subsequent performance.

The central planners of the Soviet Union devised and apparently implemented a system of bonuses that rewarded both accurate forecasts and outstanding performance.[11] Independently and outside the Soviet Union, an essentially identical scheme was advocated for eliciting accurate forecasts in a sales organization and for a budget-forecasting system.[12] The scheme provided penalties for managers who set output targets so low that the budget was easily achieved. Also, it provided an incentive for managers, after achieving the budgeted performance, to put out even more effort to exceed the budget. The scheme motivated people to disclose their information truthfully in the process of target setting and then, once the target was set, to work to achieve or better the target.

With the forecast incentive scheme, the top management establishes a basic bonus pool, $B_0$, and specifies three positive parameters: $\alpha$, $\beta$, and $\gamma$. The manager first declares a targeted or budgeted output level $y_h$, which increases the bonus pool by the amount of $\beta y_h$. This factor provides the manager with an incentive to declare a higher, rather than a lower, budgeted output level. If the actual output level, $y$, exceeds the budgeted level, $y_h$, an additional bonus of $\alpha(y - y_h)$ is paid. This bonus component motivates the manager to exceed budgeted performance after the budgeted target has been established. But $\alpha$ is set less than $\beta$, so that if output is going to be high, it is better to declare this fact in the budget than to realize it by exceeding the budget. If the actual output level, $y$, is less than budget, a penalty of $\gamma(y_h - y)$ is subtracted from the bonus. In this case, $\gamma$ is set larger than $\beta$, so that the manager receives no benefit from inflating the budget, only to be disappointed later. In summary, the incentive properties of this mechanism require that $0 < \alpha < \beta < \gamma$.

Formally, if $B$ is the actual bonus paid to the manager, the plan can be described by

$$B = \begin{cases} B_0 + \beta y_h + \alpha(y - y_h) \text{ if } y \geq y_h \\ B_0 + \beta y_h - \gamma(y_h - y) \text{ if } y < y_h \end{cases} \qquad [1]$$

with $0 < \alpha < \beta < \gamma$. As an example of how this incentive scheme operates, Exhibit 14-2 displays the bonus, $B$, as a function of $y_h$ and $y$ when $B_0 = 100$, $\alpha = 0.2$, $\beta = 0.4$, and $\gamma = 0.6$.

For any given value of actual output, $y$, in Exhibit 14-2 (reading along a row), the highest bonus is achieved when the forecast $y_h$, equals $y$. That is, the largest bonuses appear along the main diagonal. If the manager knows for certain what the actual output will be, she can maximize her bonus by issuing a forecast equal to this actual amount. Any other forecast will decrease the bonus below the maximum achievable level. Looking down a column reveals that once a forecast $y_h$ is issued, the manager will always prefer more output to less output. Thus, there is an incentive for the manager to produce the maximum output regardless of the forecast. Also, the parameters have been established so

**EXHIBIT 14-2** Truth-Inducing Budget-Based Contract

$$B = \begin{cases} 100 + 0.4\,y_h + 0.2(y - y_h) & \text{if } y \geq y_h \\ 100 + 0.4\,y_h - 0.6(y_h - y) & \text{if } y < y_h \end{cases}$$

| ACTUAL OUTPUT, $Y$ | 50 | 60 | 70 | 80 | 90 | 100 | 110 | 120 |
|---|---|---|---|---|---|---|---|---|
| 50 | 120 | 118 | 116 | 114 | 112 | 110 | 108 | 106 |
| 60 | 122 | 124 | 122 | 120 | 118 | 116 | 114 | 112 |
| 70 | 124 | 126 | 128 | 126 | 124 | 122 | 120 | 118 |
| 80 | 126 | 128 | 130 | 132 | 130 | 128 | 126 | 124 |
| 90 | 128 | 130 | 132 | 134 | 136 | 134 | 132 | 130 |
| 100 | 130 | 132 | 134 | 136 | 138 | 140 | 138 | 136 |
| 110 | 132 | 134 | 136 | 138 | 140 | 142 | 144 | 142 |
| 120 | 134 | 136 | 138 | 140 | 142 | 144 | 146 | 148 |

that not achieving the forecasted output is penalized more heavily than output in excess of the forecast is rewarded. Note also that, for any budgeted output, rewards are increasing in the actual output.

The key to obtaining all these desirable properties in the incentive scheme is to ensure that $0 < \alpha < \beta < \gamma$. Planners using this incentive device developed a rule of thumb that $\beta$ should be at least 30% larger than $\alpha$ and that $\gamma$ should be at least 30% larger than $\beta$.

## The Role of Uncertainty in Belief Elicitation Models

When we speak of exceeding the budget in this model, we introduce the prospect of uncertainty, which we have not formally developed. Uncertainty is important, because it introduces two dimensions that are not apparent in the certainty model: (1) the possibility of managerial risk aversion, which we will ignore for the moment, and (2) the need to further restrict the relationship among the model parameters. Note that this model really makes little sense without some form of uncertainty. If the controller knew that the manager knew, with certainty, what the result would be, the incentive scheme would simply be to penalize the manager heavily for not disclosing during the planning stage what turned out to have actually happened. Therefore, the certainty case is both trivial and unrealistic. Assume, therefore, that the manager does not know for sure what the outcome will be but does have beliefs about what will happen.

Using equation [1], and assuming that the manager can express her uncertainty about the outcome $y$ in terms of a cumulative probability distribution, $F(y)$, we can construct the manager's expected return problem as choosing the communicated target $y_h$ when the realized value of $y$ is not known for sure. We can show that the manager's expected return is maximized under this scheme when the target communicated has the following property:

$$F(y_h) = \frac{\beta - \alpha}{\gamma - \alpha} \qquad [2]$$

where the function F represents the cumulative distribution of the manager's assessed distribution for the outcome, $y$. Equation [2] states that the manager's target output is a function of the values of the parameters of the incentive model as well as her beliefs about the probabilistic nature of the outcome. If we want the mean of the manager's distribution of $y$ communicated as $y_h$, then the parameters of the model will be chosen so that

$$0.5 = \frac{\beta - \alpha}{\gamma - \alpha}$$

or

$$\gamma = 2\beta - \alpha \qquad [3]$$

This result imposes an additional constraint on the values of the model parameters.

To illustrate, return to the example in Exhibit 14-2 and assume that the manager believes that actual output can assume any value on the interval 50 to 120, with all outcomes equally likely. In this case, the manager believes that the mean of the distribution of outcome is 85. With $\alpha = 0.2$, $\beta = 0.4$, and $\gamma = 0.6$, as in the previous example, the budgeted output, or target $y_h$, that will be communicated by the manager should satisfy:

$$F(y_h) = \frac{\beta - \alpha}{\gamma - \alpha} = \frac{0.4 - 0.2}{0.6 - 0.2} = \frac{1}{2}$$

That is, the manager chooses a budget target $y_h$ with the property that the probability is one-half that the actual outcome will be less than, or equal to, the budget. In our numerical example, she will choose 85 as the budget [85 = 50 + 1/2 * (120 − 50)].

Suppose we use the Soviet rule of setting $\beta$ 30% larger than $\alpha$. Therefore, $\beta = 1.3\alpha$. Now using the $\gamma = 2\beta - \alpha$ rule, we have

$$\gamma = 2(1.3\alpha) - \alpha = 1.6\alpha$$

So, if we set $\alpha = 0.2$, we have $\beta = 1.3 * 0.2 = 0.26$ and $\gamma = 1.6 * 0.2 = 0.32$. Now,

$$F(y_h) = \frac{\beta - \alpha}{\gamma - \alpha} = \frac{0.26 - 0.20}{0.32 - 0.20} = \frac{1}{2}$$

and the value of $y_h$ that would be chosen is 85 [since 85 = 50 + 0.5 * (120 − 50)]. Note that the same incentive to communicate the mean has been achieved but with parameters that are much closer together.

In summary, the bonus forecasting incentive system given by equation [1] and illustrated in Exhibit 14-2 produces the desirable incentives of rewarding accurate forecasts and encouraging greater rather than lesser output. The parameters $\alpha$, $\beta$, and $\gamma$ can be set on the basis of the relative values of accurate forecasts, the benefits of output in excess of the forecast, and the costs of not achieving the forecasted output level.

## Limitations of the Truth-Inducing Budget Scheme

The forecasting incentive scheme provides an attractive but imperfect mechanism for eliciting realistic forecasts. It is a costly mechanism, since real resources (cash payments to

managers) are being transferred based on a forecast, $y_h$, rather than on the basis of actual output, but it does serve to reward managers for both information skill or knowledge (the forecast) and for performance (the outcome). The cost of operating this scheme seems necessary and even desirable if resource allocation and coordination decisions are to be based on budgeted output levels.

We mentioned briefly the rule of thumb that Soviet planners have used to define the relative values of $\alpha$, $\beta$, and $\gamma$, but this discussion raises the issue of how planners should choose the absolute levels of $B_0$, $\alpha$, $\beta$, and $\gamma$, the components of the incentive scheme. Compensation experts appear to agree that a person's basic market wage should not be at risk. Therefore the fixed or certain part of the compensation should reflect the individual's market wage. The fixed part of the compensation equals the $B_0$ component and the portion of the $\beta y_h$ component. To illustrate, suppose that the planner or controller sets a target, $y_t$, based on past experience and revises the bonus scheme as follows.

$$B = \begin{Bmatrix} B_0 + \beta(y_h - y_t) + \alpha(y - y_h) \text{ if } y \geq y_h \\ B_0 + \beta(y_h - y_t) - \gamma(y_h - y) \text{ if } y < y_h \end{Bmatrix} .$$

The motivational properties of this revised scheme are the same as those of the original. Therefore, specifying a target $y_t$ has the same effect as adjusting the fixed wage. That effect is to determine whether the overall compensation package is acceptable to the individual. However, it has no effect on the output or prediction levels.

The advantage of the revised scheme is that it sets a target, often called a *bogey*, that taxes away the portion of the bonus that reflects an average level of performance and bases the bonus on an above-average level of performance. Therefore, it would be desirable to set $\alpha$ at a level thought to encourage the additional level of effort that would cause performance to rise above the target or average level of performance. The values of $\beta$ and $\gamma$ would then follow using the 30% rule discussed earlier. Presumably this rule reflects the experience of the planners in determining the sharing rules that provide the appropriate motivation to work harder without giving away too much to the employee. The problem with this adjustment is that the planner, strictly speaking, must guess at the target level used to tax away the easy returns.

The scheme does have some other major limitations. First, multiperiod gaming effects exist that are not captured in the simple one-period incentive scheme. For example, the manager may believe that the fixed portion of compensation, or equivalently the target level of output, in the subsequent period will be a function of the budgeted and actual output levels in the current period. This ratchet effect is a well-known budgeting procedure, particularly in governmental organizations.[13] If the ratchet effect is a plausible assumption, the manager, when determining what the current forecast and actual output should be, will try to solve a multiperiod optimization problem based on expectations of how current forecasts and actual output will affect future bonus pools. If this occurs, the one-period properties described above (for example, optimal forecast equals expected output) will not be valid. To avoid these complications, the manager must be convinced that any current communication will not affect the setting of future standards or bonus pools or that the adjustments will occur so far into the future that when they are discounted they will effectively be ignored.

A second problem arises from risk aversion on the part of the manager in the presence of uncertainty, conditions not formally treated with our simple formulation. The piecewise linear-sharing rules, given by the compensation scheme in equation [1], will not yield the equation [2] result that we derived under conditions of risk neutrality. With risk aversion, the budget chosen by the manager will reflect, in addition to the parameters already discussed, the manager's attitude toward risk. In general, however, we would expect that if equation [3] were used to set the parameters of the incentive scheme, the risk-averse manager would set a target such that the probability exceeds 0.50 and that the target would be achieved.

More important is the third limitation: If real resources are to be transferred among divisions (or among firms in the economy) on the basis of the forecasts, an incentive still exists to misrepresent forecasts. When headquarters allocates resources to divisions on the basis of forecasts, divisions may be motivated to conceal certain production or profit opportunities.[14]

## Truth-Inducing Schemes for Resource Allocation Decisions

Some research has been carried out to devise truth-inducing incentive mechanisms when two or more divisions are competing for the firm's common scarce resources (such as capital and computing facilities). In this situation, a central planner acquires a resource centrally (the motivation may be economies of scale in management and operation of the resource or a desire to tightly control the resource) and then allocates the capacity to the individual managers each period. To undertake the resource allocation, the central planner relies on forecasts, provided by the division managers, of the return that they can earn from using the centrally supplied resource. In a system in which managers are rewarded based on divisional profitability and divisional profitability does not reflect the cost of the centrally held resources that they use, the managers are motivated to overstate the return that the resource can provide in order to obtain as much of the centrally controlled resource as possible. Therefore, the objective in designing an incentive plan is to find an alternative performance measure that will not provide an incentive to overstate the return from divisional use of the resource.

The Groves mechanism[15] to obtain truthful forecasts computes a performance measure for Division $i$ based on the actual realized profits in Division $i$ plus the forecasted profits of the other divisions at their actual allocated resource levels. We will not work through the proof, but it can be shown that if divisions attempt to maximize their Groves measures, then:

1. Each division will attempt to maximize its actual profits, since the Groves measure is strictly increasing in the division's profits.
2. Each division is best off sending an accurate forecast independent of what any other division sends or how it believes any other division is computing its forecast.
3. Each division's performance measure will be independent of the realized (actual) profits or operating efficiency of the other divisions.

Thus, this measure seems to have the desirable properties we would prefer to see in a performance measure. The Groves mechanism achieves its desirable properties by using

a combination of realized division profits and a profit-sharing scheme based on expected corporate profits. The form of the incentive scheme is

$$\text{Reward} = a + k\,(Q + R)$$

where $a$ is any constant, which can be construed as a wage; $k$ is any constant (lying between 0 and 1), which can be construed as a profit share; $Q$ is the *expected* profit of all the other divisions in the firm (given the final allocation of the centrally held resource); and $R$ is the *realized* profit of the manager's division. Note that $Q + R$ equals the expected total corporate profits of all the divisions plus the variance of the manager's divisional profit. Therefore, we can write this reward function as

$$\text{Manager's reward} = \text{wage} + k\,(\text{firm's total expected profits} + \text{variance in manager's division})$$

If the division reward were based solely on realized division profits ($R$), each division manager would be motivated to distort the communicated information about the value of allocating the common resources to himself. The manager treats the allocated resource as a free good and wants to have as much of its capacity as he can. Eliminating this tendency is the portion ($Q$) of the reward function relating to corporate profitability. This term forces the manager to consider all uses of the centrally held resource and, in effect, charges the manager with the opportunity cost of the resource (reflecting its use in other divisions) when the resource is allocated to the manager's division. This term ($Q$) represents the sum of the profit expectations of all the other divisions conditioned on an optimal centrally determined resource-allocation decision and the prior information of the central agent. Because the reward function for each division represents overall corporate profits, the incentive for divisional honesty in communicating its opportunity set dominates the incentive for false reporting, and all divisions report truthfully. Finally, no division need be concerned, ex post, about efficiency or forecasting variances in other divisions, since such variances are allocated solely to the responsible division.

An element of noncontrollability still remains, because the evaluation of a division depends on forecasts produced by other divisions. But this interdependency seems inevitable because of the divisional competition for the common resource. The noncontrollable aspect may even be desirable in this setting, since it highlights the interdependence among the operating divisions and, therefore, the need for the divisions to work together for their overall benefit.

Unfortunately, the Groves scheme is cumbersome to implement in practice because the parameters $a$ and $b$ of the Groves model must be specified before any type of communication takes place. Therefore, the resulting managerial compensation could be very large, insignificant, or even negative.[16]

A second shortcoming of the Groves scheme is the assumption that all managers are risk-neutral. If any of the managers is risk-averse or prefers leisure to working, the properties of the scheme are lost. For example, suppose a risk-neutral manager believes that another manager is highly risk-averse. Because of the nature of the manager's risk aversion, that manager will request lower amounts of the centrally held resource than if he had

been risk-neutral. The risk-neutral manager in the second division, sensing this effect, will understate his opportunities to cause more of the centrally held resource to be allocated to the first division in order to correct for that manager's risk aversion. When this type of manipulation starts to happen, the desirable properties of the Groves mechanism vanish as each manager second-guesses the decisions and actions of all the other managers.

## THE ROLE OF INSURANCE

We have seen that uncertainty, in the form of noncontrollable random outcomes, makes it difficult to develop local performance measures for the managers of decentralized units. Uncertainty leads managers to engage in risk-avoiding behavior that may not be optimal for the overall firm. It also hinders contractual arrangements between units that interact with each other and leads to a demand for subjective information to develop budgets for performance appraisal.

A thoughtful reader may wonder whether some form of insurance contract might be developed to reduce the adverse effects of uncertainty. After all, on a personal level, we purchase insurance to limit the negative financial consequences from uncertain events such as death, illness, or accidents. Why cannot such arrangements be developed for commercial transactions within a firm? If local managers could purchase insurance to protect themselves (or their divisions) from the adverse consequences of uncertainty, deleterious risk-avoiding behavior could be eliminated.

Unfortunately, good reasons can be provided for why insurance against uncertain events is not readily available for local managers. Two factors introduced earlier in the chapter, moral hazard and adverse selection, make it difficult to offer reasonably priced insurance in this situation. Moral hazard creates the problem of distinguishing between genuine risks (such as adverse outcomes caused by exogenous random events) and failures to take the best action to avoid the event being insured against. Once the insured manager is protected from the negative consequences of events such as sales declines, delivery delays, or uncertain product quality, the manager's incentive to exert a maximum effort to overcome normal commercial difficulties is greatly reduced. We do not want the managers, because they are insured against these events, to accept such commercial difficulties passively. We want them to do whatever they can to reach their sales targets, expedite deliveries, or improve the quality of their products.

Moral hazard arises in personal insurance when people with automobile insurance drive less carefully or when people with full medical insurance coverage forego health-building activities or demand excessive amounts of medical care. Because of moral hazard, the insurer must insure not only against random factors causing losses but also against the expected reduction in effort to avoid the insured event by the insured.

Adverse selection problems also limit the role for insurance to reduce the consequences of uncertainty within the firm. In general, the insured knows its own risks better than the insurer. The insurer may set rates on an overall fair actuarial basis after observing many similar events. High-risk units will find it profitable to purchase this insurance, but low-risk units will find the insurance too expensive. The actual experience for the insurer will therefore have a higher incidence of claims than had been expected when rates were initially set. When rates are raised to reflect the higher-than-expected losses, more lower-

risk units will withdraw from the insurance contract. Thus, because of the inequality of information between the insured and the insurer, many units will have risks that are inadequately covered. Both moral hazard and adverse selection are caused by limited observability (or as we have called it earlier, private or asymmetric information).

Limited observability will be characteristic of most activities within a firm, so insurance arrangements are unlikely to be developed to eliminate the unfavorable consequences of uncertainty. Devices such as flexible budgets and annual budgeted performance can be viewed as limited forms of insurance to shield managers from some uncontrollable factors, but a significant degree of uncertainty in evaluating managerial performance is unavoidable if incentives for excellent performance are to be part of the managers' compensation arrangement.

## SUMMARY

Many solutions have been proposed to determine optimal contracts between managers and their superiors in the presence of private (asymmetric) information and diverse risk attitudes. Agency theory attempts to design efficient and effective incentive schemes to motivate decentralized managers to act in the best interests of the owners. The optimal contracts under these conditions require that managers bear more risk, by sharing in the outcomes from their actions, than what would otherwise be required or desirable. Because risk-averse managers have to be compensated for the risk bearing that has been imposed on them for motivational purposes, the owners of the firm suffer economic losses. Moreover, because managers are put in situations in which they must bear risk, the managers may make decisions that reflect risk attitudes different from those of the owners and may be motivated to misrepresent the information they have about local markets, technologies, and opportunities.

Researchers have studied a number of incentive systems that have been developed in practice. The most interesting of these is the incentive system used in the former Soviet centrally controlled economy. The Groves mechanism represents an alternative approach to incentive contracting in a situation in which the decision makers control both the level of effort and the level of investment in their respective divisions.

In general, these incentive contracting devices focus on situations in which the manager, by virtue of skill and specialized knowledge, is best able to determine the appropriate course of action in the firm. The problem is that a manager may pursue a personal agenda when making decisions that clashes with the owners' objectives. This dichotomy is possible because the owners are unable to determine, because of the difficulty of auditing managerial actions and the impossibility of auditing managerial beliefs, whether the manager's decisions are in their best interests. The objective in incentive contracting is to choose an incentive contract that aligns the interests of the owner and managers.

## ENDNOTES

1. For example, in the medical insurance literature, researchers were concerned whether medical insurance would cause the insured to act more recklessly since risks of injury would now be covered.

2. Note that, in the limit, if the measure is perfectly correlated with the manager's input, we are back to imposing no risk on the manager because we can always infer the manager's input from the output.
3. In general, this literature assumes that people suffer no personal costs from guile or lying. Even if people do suffer personal costs from lying, the substantive results of this literature remain unchanged.
4. Those unfamiliar with the notion of utility can think of utility as an index of the desirability of a particular level of wealth. Exponential utility models an individual with constant aversion to risk where aversion to risk is the willingness to sell the rights to a gamble for less than its expected value. The difference between the monetary value of a gamble to the risk-averse person and the expected value is called the risk premium and is a function of the individual's aversion to risk. For negative exponential utility, the parameter $r$ captures all that is relevant about the person's risk attitude than is constant for all levels of wealth. Risk aversion falls as the value of $r$, the risk parameter, approaches zero.
5. A more realistic analysis would treat agent effort as a continuous variable. However, we have simplified the agent's action choices for the insight the resulting simplification provides without changing the basic nature of the results that follow.
6. That is to say, the agent values the loss of personal time, the mental stress of providing effort, and the value of perquisites foregone as $15,000 for providing the high level of effort relative to the outside employment opportunity.
7. Note that the principal may prefer the high level of effort, the low level of effort, or may prefer not to contract with the agent at all (that is, to liquidate the firm).
8. The reader can verify that for this problem the principal's best interests are served by contracting for the high level of agent effort, which is the contract we will discuss.
9. You can solve this problem using a nonlinear program. Alternatively, your instructor can provide you with an Excel worksheet (**amach14.xls**) provided by the authors that solves this problem using Excel's solver algorithm. This compensation package results in a net (after paying the agent) expected return to the principal of $20,631. Using the same approach, you can show that the principal's net expected return from contracting with the agent to supply a low level of effort is $14,627.
10. If you find this latter assumption disagreeable, add one cent to the agent's compensation in either outcome and the agent will strictly prefer to provide a high level of effort.
11. This system is described in M. L. Weitzman, "The New Soviet Incentive Model," *Bell Journal of Economics* (Spring 1976), pp. 251–57. Extensions to the basic model have been provided by V. Snowberger, "The New Soviet Incentive Model: Comment," *Bell Journal of Economics* (Autumn 1977), pp. 591–600; and M. L. Weitzman, "The 'Ratchet Principle' and Performance Incentives," *Bell Journal of Economics* (Spring 1980), pp. 302–08. Criticisms of the Soviet incentive system are presented in M. Loeb and W. A. Magat, "Soviet Success Indicators and the Evaluation of Divisional Management," *Journal of Accounting Research* (Spring 1978), pp. 1–28.
12. See J. Gonik, "Tie Salesmen's Bonuses to Their Forecasts," *Harvard Business Review* (May–June 1978); and Y. Ijiri, J. C. Kinary, and F. B. Putney, "An Integrated Evaluation System for Budget Forecasting and Operating Performance with a Classified Budgeting Bibliography," *Journal of Accounting Research* (Spring 1968), pp. 1–28.
13. See Weitzman, 'Ratchet Principle' and Performance Incentives."
14. See Loeb and Magat, "Soviet Success Indicators" and L. P. Jennergren, "On the Design of Incentives in Soviet Firms—A Survey of Some Research," *Management Science* (February 1980), pp. 193–97.
15. This class of performance measures was first formally described in T. Groves, "Incentives in Teams," *Econometrica* (July 1973), pp. 617–31. It is also featured in Loeb and Magat, "Soviet Success Indicators" and Groves and M. Loeb, "Incentives in a Divisionalized Firm," *Management Science* (March 1979), pp. 221–30.

16. The motivational properties of the Groves mechanism do not change if a constant is added to the basic model or if the basic equation is multiplied by a constant.

## ■ PROBLEMS

### 14-1 *Effect of the Profit-Sharing Parameter on the Selection of a Risky Project*

Many incentive contracts reward people with bonuses if performance exceeds a target level or bogey but do not penalize performance that falls below the target. That is, the incentive scheme is

$$\begin{cases} \text{Wage} + a^*(\text{performance} - \text{target}) & \text{if performance} > \text{target} \\ \text{Wage} & \text{if performance} \leq \text{target} \end{cases}$$

where $a$ is number between 0 and 1.

***Required***

(1) What are the likely behavioral consequences of this type of reward system?
(2) What modifications would you make to this type of reward system, and why? Alternatively, why would you leave it as it is?

### 14-2 *Design of the Optimal Incentive Contract When Employee Is Work-Averse*

Helmut Paris, the owner of a small farming operation is pondering the current employment contract between himself and his sole employee, Gary Drumbo.

Gary operates a small farm owned by Helmut. The farm is located some distance from Helmut, who, therefore, has no opportunity to observe Gary's activities. The farm's total output, $X$, is a function of Gary's level of effort, $a$, and a combination of outside, uncertain events, $\theta$, such as sun, rain, and pests, over which Gary has no control.

Helmut and Gary have studied the production function and found that it has the form:

$$X = a + \theta$$

where $\theta$ is thought to take on values lying between zero and $b$.

Helmut makes decisions using the expected value decision-making criterion, whereas Gary is both risk- and effort-averse. That is, Gary suffers a personal cost when exerting effort.

This admission has prompted Helmut to offer Gary a share in output "to motivate Gary to provide higher effort." After some haggling, Gary has agreed to provide 100 units of effort in exchange for a salary of $1,000 and 10% of the farm's output, which will be accurately measured by a third party at the end of the growing season.

Although the matter has not been discussed, if Gary is caught supplying fewer than

100 units of $a$ he will face immediate dismissal. Dismissal will result in irreparable damage to his reputation, thereby impairing future employment opportunities, so Gary will avoid putting himself in danger of dismissal at any cost.

***Required***

(1) Do you think that this contract will achieve its intention of motivating "more effort" from Gary?
(2) Suppose that Gary and Helmut agree on a contract that pays $1,000 plus 10% of any output that is in excess of a target that is set equal to the average yield in surrounding farm properties. Would that condition change Gary's behavior?
(3) Ignore the variation in Requirement 2. What will happen if Gary is risk-neutral and effort-averse? Can you think of a better contract than the existing one?
(4) Ignore the variation in Requirement 2. How does the situation in the original contract change if $X$ is of the form $X = a\theta$?

## 14-3 *Effect of Observability on the Form of an Employment Contract*

Fred Principal of Swissvale Investments is considering an investment in a farming venture in the country of Markovia.

The plan is to grow and harvest Gronk, a revolutionary natural food highly prized by distance runners for its sustenance attributes. The climatic conditions and soil of southwestern Markovia are unique and are the only known conditions under which Gronk can be produced.

Gronk-growing technology is well understood. Gronk production depends on weather conditions and the effort of the farmer in the growing season and hence is subject to uncertainty.

Markovia is a new and remote country that is virtually inaccessible to outsiders. Although Markovia has a well-established legal system, commercial development is backward.

Moral Hazard, a Markovian farmer and promoter, has invited Fred and other investors to invest in Gronk farming. Moral would farm the Gronk, sell the product, and distribute the proceeds to investors.

Fred, and all other potential investors, are risk-neutral. Moral is risk-averse.

***Required***

(1) If no other information is available, what is Fred's best course of action regarding this opportunity?
(2) Suppose Fred discovers that Markovia has a well-established and reputable public accounting profession. How, if at all, would this information affect your response to Requirement 1?
(3) What further information, if any, might Fred seek beyond the information that a public accountant might supply?

## 14-4 *Incentives for Distorting Information*

HS Construction specializes in renovations and new home construction. For incentive purposes, the company is organized on a profit-center basis with two profit centers: the renovation division and the new home division.

The critical resource of the firm is its skilled carpenters. Because there is a shortage of carpenters, HS Construction has a policy of hiring all carpenters at the corporate level and then assigning carpenters to one of the two profit centers. The union rate for carpenters is $26.00 per hour, and, at this price, the managers of the two profit centers have a joint demand for carpenters that is far in excess of the available supply.

Given this situation, the company is faced with the problem of how to ration the available supply of carpenters. The operation of each of the profit centers is subject to some uncertainty, so ex ante managerial claims regarding carpenter productivity are difficult to evaluate ex post. Consequently, the controller is reluctant to base allocations on a priori assertions by the divisional managers.

In the renovation division, the return ($\pi_1$) received per carpenter hour ($q_1$) is

$$\pi_1 = 600 - 0.18q_1$$

In the new home construction division, the return is

$$\pi_2 = 300 - 0.07q_2$$

Suppose the controller successively announces prices the divisions will pay per carpenter hour and the division managers respond with demand at that price. The controller seeks to equate demand and the supply of carpenter hours which is 2,000. Divisions will be assessed a charge against profits equal to the amount bid for the labor used. All managers are risk-neutral.

***Required***

(1) Suppose both divisions respond honestly to the controller's price bids:
   (a) How many carpenter hours will be allocated to each division?
   (b) What price will clear this market?
   (c) What will be the profit reported by each division?
(2) Suppose the manager of the renovation division intends to respond honestly to the controller's bids. The manager of the new construction division knows this and also knows the renovation division's return function. Show that there is an incentive for the manager of the new construction division to be dishonest. (Hint: How would a manager behave to produce a transfer price of $0?)
(3) Can you suggest a method for solving the problem raised in Requirement 2?
(4) Under what circumstances will the solution proposed in Requirement 3 not have the desired motivational consequences?

## 14-5 *Groves Mechanism: Applications and Limitations*

For Susan Martin, President of Elmira Nursery, the crucial weekly operating decision is allocating the firm's 10 gardeners to the firm's two operating divisions, Commercial and Nursery. No other gardeners can be hired.

The Commercial division solicits contracts for landscaping and garden maintenance. It is widely known that its return is fixed and contracts reflect market conditions. Shawn Dempsey, the manager of this division, knows that this division can keep all 10 of the firm's ten gardeners fully occupied at a net profit to the firm of $50 per gardener hour.

The Nursery division consists of a greenhouse operation that grows plants and shrubs for the commercial market. Its return is uncertain and depends on volatile market conditions. Karen Barton, the manager of this division, believes that, in the current market, the distribution of net profit per gardener hour is uniform over the interval \$40 to \$55. This belief is held privately by Karen and is not known to the other members of the senior management team at Elmira Nursery.

***Required***
***Consider each question separately.***

(1) Suppose Karen's compensation is a function of the reported weekly profits of the Nursery division. Suppose further that Susan allocates gardeners to divisions based on the expected returns estimated by the division managers. If Karen is an expected-value decision maker, show that this organization structure will motivate Karen to lie about her division's expected return per gardener hour.

(2) Suppose now that Karen's compensation is a function of the reported weekly profits of Elmira Nursery. If Karen is an expected-value decision maker, is there any motivation for Karen to lie about her division's expected return per gardener hour? Explain the dysfunctional consequences of this reward mechanism if the divisional return can be influenced by managerial competence.

(3) Suppose Susan has decided to use the Groves mechanism to allocate the gardeners to the two divisions in her business. For Elmira Nursery, the Groves measure for the Nursery division would have the form

$$G_N = \pi_N^A(X_N) + \pi_C^F(X_c) - K_N$$

where $\pi_N^A(X_N)$ = actual weekly profits for the Nursery division, with $X_N$ gardeners allocated to this division

$\pi_C^F(X_C)$ = forecasted weekly profits for the Commercial division, with $X_C$ gardeners allocated to this division

$K_N$ = a constant independent of the Nursery division's forecasted or actual profits

How would use of the Groves measure improve the information elicited from Karen and Shawn?

(4) Suppose further that Susan wishes to make $G_N$ relevant to Karen by incorporating it into Karen's compensation function. Karen's compensation will be

$$y_E = W_E + kG_N$$

where $y_E$ = Karen's total compensation

$W_E$ = Karen's fixed wage

$K$ = a fixed positive constant

$G_N$ = the Groves measure for the Nursery division

Note that $EG_N$ represents, apart from the scalar $K_N$, *expected* corporate profits so that Karen's expected return is a wage plus a share of expected corporate profits. Assume that Karen could earn \$550 per week in a comparable job outside the firm. Show that a compensation policy based on $y_E$ is unlikely to be optimal. Is $G_N$ a reasonable basis to use for compensating divisional managers?

(5) Return to the original data of this problem but assume now that the net profit per gardener in the Commercial division is only \$47 per hour. Karen has the same beliefs as before but is risk-averse. Karen's utility for wealth, and therefore her compensation ($y_E$) is given by

$$U(y_E) = -\exp\left[\frac{-y_E}{500}\right]$$

where $y_E = \$500 + 0.1G_N$.

$K_N$ is set equal to the profit of the firm if the Nursery division received no gardeners; that is, $K_N$ = (\$47/hour)(10 gardeners)(40 hours/week) = 18,800.
Suppose Susan is risk-neutral. What is the optimal allocation of gardeners from Susan's point of view? Show that Karen will lie about her beliefs in this case so that all gardeners will be allocated to the Commercial division. What are the implications of this result?

(6) Assume the same data as in Requirement 5 with the following exception. Karen's utility function is

$$U(y_E, X_N) = E(y_E) - 0.1X_N$$

where $X_N$ is the number of gardeners assigned to the Nursery division. In other words, Karen is risk-neutral but suffers a loss of well-being (or utility) when she is assigned workers to supervise.

Show that, in this case, Karen will lie about her prospects and all gardeners will be assigned to the Commercial division. What are the implications of this result?

## 14-6 *The Effect of a Skill Parameter in Formulating an Incentive Plan*

Outport Fishery Products is a large integrated fish-products company. The company operates its own fleet of fishing trawlers, whose catches are processed in one of the company's 11 processing plants. The final products are sold internationally under the company's brand name Bye-the-Sea.

Because of the demand for sea products and the limitations on the amount of fish that can be caught and processed, the company can sell as much fish as it can produce.

Many of the processing plants are located in depressed areas, and employment in the plants is highly valued. One of the most prestigious and skilled plant jobs is filleting, the process that separates the flesh of the fish from the bones. In filleting, the two fillets (one from each side) must be removed from the spine of the fish in whole pieces, because whole fillets command a large premium over broken pieces. Also, the cut separating the flesh from the bone should be deep enough that a minimal amount of flesh is left on the bone, yet shallow enough so that no bones remain in the fillet. Leaving flesh on the bone results in a loss of salable product. Leaving bones in the fillet requires indirect labor to remove the bones from the fillet. For this reason, the skill exercised in the filleting operation is a significant determinant of the value of the final product that is derived from a given catch (the others are the size of each fish and the species of fish). Skilled filleters are highly paid.

***Required***

How would you evaluate the performance of the filleters, and how would you pay them?

## 14-7 *Setting the Parameters of the Soviet Incentive System*

In the former Soviet Union a central planning authority controlled production in the manufacturing enterprises. In order to plan and coordinate aggregate production in the economy, the central planning authority requires forecasts from the enterprise managers about the production possibilities during the upcoming planning period. At first, managers were rewarded based on their ability to live up to production quotas that were, for the most part, based on the production forecasts of the managers themselves.

In response to evidence that enterprise managers built slack into forecasts of production possibilities, a new Soviet Incentive Plan was implemented. This plan provided a means of eliminating slack from forecasts by changing the basis of the rewards received by the enterprise managers.

The details of this plan were discussed in the chapter.

***Required***

(1) Explain why the ranking of the order of the three parameters of the Soviet Incentive model is important.

(2) What relationship must exist among the three parameters of the incentive equation of the Soviet Incentive model in order to motivate the manager to set a planned target that equals the manager's expectation of the mean value of production?

(3) In applying the scheme, the central planners committed to changing the parameters of the incentive plan only every five years. Why is this characteristic important, and how would the properties of the incentive scheme be changed if the parameters of the incentive scheme were changed annually? What implications does this observation have for target setting in participative budgeting schemes in general?

(4) Explain how the properties of the Soviet Incentive model would change if managers were risk-averse. (This question requires the use of differential calculus and a basic knowledge of the properties of utility theory.)

## 14-8 *Incentive Considerations in Allocating a Scarce Resource*

The Brantford Corporation has 500 units of capacity available for production during the upcoming period. This capacity is to be distributed between the two major divisions in the company: the Commercial Controls Division and the Computer Division. Each division uses one unit of capacity to make one unit of output.

The managers of each division view the demand for the products of the two divisions. Only the division's manager knows the demand facing that division.

The contribution margin provided by each Commercial Controls Division product is $250,000, and the division manager believes that the total demand for the Commercial Controls Division products will be somewhere between 500 and 800 units, with each value on this interval equally likely.

The contribution margin provided by each Computer Division product is $320,000, and the division manager believes that the total demand for the Computer Division products will be somewhere between 0 and 500 units, with each value on this interval equally likely.

Because of production line setups and tooling, once the capacity is assigned to one division at the start of the production period, it cannot be transferred for the other division to use if the demand on the facility turns out to be less than the amount allocated. The managers of the two divisions have been asked to submit their requirements for use of the capacity during the upcoming period.

***Required***

(1) What level of capacity will each manager request if each manager's bonus is based solely on the manager's ability to meet the production plan for the allocated capacity? What is the expected contribution margin associated with this assignment of capacity?
(2) What level of capacity will each manager request if each manager's bonus is based on the contribution margin generated by the capacity allocated to that manager's division and the managers are not assigned a charge for the capacity allocated to their respective divisions? What is the expected contribution margin associated with this assignment of capacity?
(3) What level of capacity will each manager request if each manager's bonus is based on the contribution margin associated with the capacity that is earned by the company? What is the expected contribution margin associated with this assignment of capacity?
(4) What do the results to Requirements 1, 2, and 3 imply about the design of incentive schemes in decentralized organizations? Why might these results be misleading?

## 14-9 *The Revelation Principle in Budget Setting*

Kentville Orchards grows and sells a wide variety of fruits. Norm Wilson, the vice president-controller of Kentville Orchards, is responsible for all aspects of budgeting and forecasting in the firm. Norm has become both disillusioned and dissatisfied with the traditional approach that Kentville Orchards has taken to budgeting. Norm summarized his concerns as follows:

> The traditional approach, where we set budget objectives and then evaluate performance relative to those objectives, is not working well. First, the budget is focusing attention on the wrong things. The managers are interested in making short-run profit as large as possible and are not doing things to improve long-run profitability. Second, I do not think that the model of evaluating performance based on profits has the scope to evaluate the jobs that the managers are doing. Their jobs are much more complicated than a simple profit measure implies, and we need a more accurate picture of how well they are doing. Finally, the existing system is motivating the managers to build slack into both their standards and performance targets so that they can make budget and earn bonuses. As a result, our forecasting system is unable to predict either sales levels or input usage accurately.

Norm went on to indicate that he was considering recommending to the senior management committee at Kentville Orchards that the current budgeting system be replaced with a new system using participative budgeting techniques. Specifically, the new system would require that the objectives for each management job in the organization be defined relative to the organization's strategic goals by negotiations between the job's incumbent and the incumbent's supervisor. From these general objectives, specific performance objectives would be set for each job each year through negotiations between the incumbent and the incumbent's supervisor. The objectives would be multidimen-

sional and would include performance objectives for all attributes of the job that are considered important.

The annual evaluation would reflect two dimensions of performance appraisal. First, the incumbent would be evaluated for innovation in developing ways of carrying out assigned responsibilities. Second, the incumbent's performance would be evaluated relative to the targets that were negotiated with the supervisor. Norm summarized his feelings as follows:

> The only thing that is holding me back is that I do not think that the proposed changes go far enough. The proposed system deals with the problem of inadequate performance measurement but still provides managers with incentives to understate their potential, since their performance will be evaluated relative to the targets that each manager negotiates with his supervisor. Moreover, the planned system, like the old system, still has the aspect of checking up on people rather than relying on them to do their jobs. Perhaps we should go even further and implement the proposed system but evaluate managers only on their ability to be innovative in undertaking the tasks that they have been assigned. If they are not evaluated relative to the targets that they set jointly with their supervisors, they will be motivated not to understate their potential. The bottom line is that I think that we should get rid of the concept of standards altogether, irrespective of who sets the standards. As a result of eliminating the concept of standards, the budget will serve to communicate and coordinate rather than be a threat and a means of checking up on the managers.

***Required***

Evaluate the initial proposal for the revision of the budgeting system as well as the proposal that would eliminate the use of standards.

## *14-10 Individual Rewards versus Group Rewards*

Lake Erie Steel Products Limited is a large integrated steel-products firm producing a full line of steel products that are sold internationally.

The company is organized on a profit center basis, with the major primary profit centers being the coal-mining operations, the iron ore-mining operations, and the scrap steel operations. The major manufacturing profit centers are hot-rolled products, cold-rolled products, and shaped products. The major finishing profit centers are fastener products, tube products, and specialty products.

The company has implemented a market-based transfer pricing system for every product that has a well-organized external market. This segment accounts for about 75% of the transfers that take place between the profit centers. The balance of transferred products are priced using a transfer price that consists of fixed fee plus standard variable cost.

The transfer pricing system is used to evaluate profit center performance along two dimensions. First, the profit center's controllable margin is used as an assessment of the performance of the manager. Second, the profit center's profit is used to evaluate the ongoing decision to continue the operations of the profit center or to abandon the profit center.

All the employees in the organization except the chairman, president, and vice presidents participate in the corporate profit-sharing plan. (The excepted individuals participate in a stock option plan and a bonus system that focuses on accomplishing strategic

performance objectives.) The pool available for bonuses is based on corporate earnings and equals 10% of all corporate earnings in excess of the target level of earnings that is established for any particular year.

The senior management committee evaluates the performance of each profit center relative to its financial *and* operating goals. The overall performance of the profit center is rated as poor, acceptable, or outstanding. Performance values of 0, 0.25, and 1 are assigned to each of these qualitative ratings, respectively. Therefore, an overall profit center performance that is rated as acceptable is assigned a performance value of 0.25.

Next, the employee's supervisor rates the individual performance of each employee. (In the case of the profit center manager, the evaluation is done by the vice president to whom the manager reports.) The employee's performance is evaluated relative to the objectives that the employee and his supervisor established for each job. There are, by design, exactly four attributes of each employee's job that are measured and evaluated. None of the four attributes is a financial measurement. The overall performance of the employee is rated as poor, acceptable, or outstanding and is assigned the corresponding performance value of 0, 0.25, or 1, respectively.

The following sequence of calculations is then undertaken:

1. Sum the employee's profit center performance rating and the individual's personal performance rating to determine the employee's aggregate performance measure.
2. Multiply each employee's aggregate performance measure by the employee's wages to determine the employee's weighted wages.
3. Sum the weighted wages of all the employees who are participants in the profit-sharing plan to compute a sum of weighted wages.
4. Divide the bonus pool available by the sum of weighted wages to determine the bonus per dollar of weighted wage.
5. Determine each employee's bonus by multiplying the employee's weighted wage by the bonus per dollar of weighted wage.

This calculation had resulted, on average, of bonuses of 18% of wages to be paid during the last five years.

***Required***

Evaluate this incentive scheme, discussing your impressions of its positive and negative aspects.

## *14-11 Agency Theory Considerations in Choosing a Wage*

Conestogo Farms produces ginseng. The farm is owned by an absentee landlord who hires a manager to grow and harvest the crop. The market wage for hired help is $40,000 per season.

The ginseng output is determined by two factors: the weather, which is a random factor that cannot be controlled, and the manager's care level, which can be high or low. The manager suffers a personal cost of $10,000 for putting in a low level of care and $25,000 for putting in a high level of care. The landlord can observe neither the weather conditions nor the manager's care level. Only the crop outcome can be observed.

There are two possible crop outcomes: good or bad. The following table shows the probability of good and bad outcomes, for high and low care levels.

| | CARE LEVEL HIGH | CARE LEVEL LOW |
|---|---|---|
| Probability of good crop outcome | 0.85 | 0.25 |
| Probability of bad crop outcome | 0.15 | 0.75 |

The landlord has decided that she would like to motivate the manager to provide a high level of care. The manager has a utility for wealth that can be modeled as negative exponential with a risk parameter equal to $-0.0001$.

***Required***

How should the landlord pay the manager to ensure that the manager provides a high level of care?

## 14-12 *Designing an Incentive Scheme to Attract the Target Manager*

Scharl Construction does house framing. The owner, Holly Scharl, wants to hire a carpenter. The work is unsupervised, so Holly wants to make sure that she hires the right kind of person.

There are two grades of carpenters: qualified and unqualified. The difference between the two grades is reflected in the amount of work they do during a shift, which results in a high or low level of output. Output is also affected by the quality of the raw materials and whether there are delays caused by weather or late deliveries of supplies, neither of which Holly can observe because she is not on site. The result is that it is impossible to infer, from the output level, whether the carpenter was qualified or unqualified.

The following table indicates the probability of a high or low level of output for the two types of workers.

| | OUTPUT IS HIGH | OUTPUT IS LOW |
|---|---|---|
| Carpenter is qualified | 0.9 | 0.1 |
| Carpenter is unqualified | 0.2 | 0.8 |

Holly wants to hire a qualified carpenter. However, although the carpenter knows whether he is qualified or unqualified, he has no way of proving it to Holly. Qualified carpenters require a market wage of $15,000 for the time period that Herman is considering; unqualified carpenters command a market wage of $8,000. Holly knows that the wealth

preferences of all carpenters can be modeled by a negative exponential utility function. The risk-aversion parameter for qualified carpenters is $-0.0001$ and for unqualified carpenters is $-0.00005$.

***Required***

(1) Given these circumstances, devise an incentive plan for Holly that will ensure that she hires a qualified carpenter.

(2) Suppose that the market wage for an unqualified carpenter is \$5,000 instead of \$8,000. How would this difference change the incentive plan that you devised in Requirement 1? Explain the change.

(3) Suppose that Kathy Investigations can do a background check on any prospective carpenter and verify that carpenter's qualification with 100% accuracy. What is the maximum that Kathy should be willing to pay Kathy Investigations to supply a qualified carpenter? You can assume that Kathy Investigations will act honestly in its dealings with Kathy.