MANAGERIAL AND DECISION ECONOMICS, VOL. 10, 81–84 (1989)

# Responsibility Accounting and Asymmetry of Information

JEFFREY L. CALLEN and JOSHUA LIVNAT

Jerusalem School of Business Administration, The Hebrew University, Israel

**This paper uses the principal-agent model to show that a manager's optimal compensation should generally include non-controllable factors of production such as the firm's investment in capital. This implies that the managerial accounting distinction between profit and investment centres is artificial. Examples are shown in which the ROI or RI criteria could be optimal for compensating managers implying that the optimal compensation criterion is very much specific to the firm's production and risk parameters. Thus, the debate about which criterion is more appropriate is vacuous.**

## INTRODUCTION

One of the earliest accepted tenets in managerial accounting is the evaluation of performance that is based on controllable factors. Indeed, the American Accounting Association Committee on cost accounting concepts and standards has incorporated the following statement regarding costs as a device for motivation:

> Some guides in deciding the appropriate costs to be charged to a person (responsibility center) are as follows:
> (a) If the person has authority over both the acquisition and the use of services, he should be charged with the cost of such services.
> (b) If the person can significantly influence the amount of cost through his own action, he may be charged with such costs.
> (c) Even if the person cannot significantly influence the amount of cost through his own direct action, he may be charged with those elements with which the management desires him to be concerned so that he will help to influence those who are responsible (AAA, 1956, p. 189).

This notion of responsibility accounting is incorporated into many textbooks. For example, Anthony and Dearden (1976) discuss the appraisal of performance and state that:

> The greater the degree of control that a divisional manager can exercise over the critical performance variables, the easier it is to develop an effective budgetary control system.
>
> The difficulty in measuring the performance of a divisional manager is directly related to the number and type of noncontrollable and semicontrollable performance variables that exist p. (547).

Some objections to performance measurements that are based only on controllable factors have been made in the literature. For example, Rick (1971) criticizes responsibility accounting because, frequently, decisions are made by a group of managers rather than an individual manager. Also, data collection and measurement problems make the application of accurate responsibility accounting impractical.

On more theoretical grounds, work by Wilson (1968), Ross (1973) and Demski (1976) has shown that once uncertainty is introduced, optimal contracts will seek to share the risk among the owner and the manager, so that the manager will be evaluated on non-controllable as well as controllable factors. This result is correct even if the manager is assumed to select the optimal level of effort from the owner's perspective. However, as Kaplan (1982) has pointed out, such risk-sharing models assume that the only useful role that the manager plays is to share part of the owner's risks. Therefore, 'unless one believes that an important function for managers of firms is to share the risks of the owners or the central management group, then the reason for including noncontrollable random outcomes in the manager's incentive function disappears' (Kaplan, 1982, p. 612). In a subsequent paper, Demski and Feltham (1978) assert that, where the information about the manager's effort is costly, it may be optimal to write a contract that is based on non-controllable factors, because otherwise the owner will incur the information costs and will have less funds for compensating the manager.

In a more recent paper, Baiman and Demski (1980) discuss the shortcomings of responsibility accounting when the manager's level of effort is unobservable and output is produced as a result of decisions made by two managers. They provide conditions under which the compensation contracts will be based only on factors controllable by the individual manager, and when the optimal contract should also include the

0143–6570/89/010081–04$05.00

joint output of the two managers. Their analysis, however, assumes that output is determined solely by the efforts of the agents and the state of nature.[1]

One purpose of this note is to show the shortcomings of responsibility accounting even when the problem is reduced to a single manager–single owner setting. Unlike Baiman and Demski, we assume that output is not only the result of the manager's efforts and the state of nature but also the level of productive resources (assumed to be capital assets) supplied to the manager by the owner. Using the principal–agent paradigm (Holmstrom, 1979), we will show by example that the optimal compensation contract may well be a function of the productive resources provided by the owner in spite of the fact that the manager has no control over them.

Having shown that compensation contracts may include non-controllable capital resources raises another equally important issue in managerial accounting. In the literature on investment centres much intellectual effort has been expended on the question as to whether managers should be evaluated on the basis of a ratio such as Return on Investment (ROI) or in terms of an absolute profit measure such as Residual Income (RI).[2] However, despite such effort, the appropriateness of the ROI and RI evaluation criteria for investment (or profit) centres has yet to be ascertained in terms of an optimal compensation framework such as the principal–agent paradigm. In fact, we will show by example that the optimality of the ROI or RI criteria is very much dependent upon the parameters of the underlying principal–agent optimization process. In particular, depending upon the parameters of the density function for revenues, either the ROI or RI (or neither) criterion may be optimal.

The paper is organized as follows. The next section provides an example for which the manager's optimal compensation package includes non-controllable capital resources provided by the firm's owner. The third section shows that the optimal compensation contract may be written in terms of an ROI or RI criterion depending upon the specific parameters of the firm's revenue density function. The final section briefly concludes the paper.

## NON-CONTROLLABLE FACTORS IN THE MANAGER'S OPTIMAL COMPENSATION PACKAGE

Consider a firm composed of an owner and a manager. The owner provides the manager with productive capital resources that will affect future revenues. It is assumed that the level of productive capital resources, $K$, is determined solely by the owner, and is observable by both the manager and the owner at the beginning of the period, before the manager undertakes any effort.[3] Since these productive resources are given by the owner to the manager, they represent factors beyond the manager's control.

The owner also supplies the manager with a compensation package, denoted $R[.]$, whose purpose is to induce the manager to operate in the owner's interest. The question we wish to address is whether the optimal $R[.]$ includes the non-controllable factor $K$ or whether $R[.]$ is simply a function of $P$ and $e$, where $P$ denotes the revenues generated by the firm gross of the costs of the productive resources $K$ and $e$ is the manager's effort. $P$ is assumed to be a random variable with density function $g(P;\, K,\, e)$. The latter means that the firm's revenues are in general a stochastic function (presumably increasing) of the investment in productive assets $K$ and the level of effort $e$ (also measured in dollars) expended by the manager.

We assume that the optimal level of productive assets $K$ is chosen by the owner in a rational expectations framework. Specifically, the owner is assumed to solve for the optimal $R[.]$ via a standard principal–agent model where the solution is viewed as a function of $K$. The owner then maximizes this solution with respect to $K$. More formally, the owner is assumed to maximize $Z(K)$ with respect to $K$, where $Z(K) =$ Maximum with respect to $R[.]$ and $e$ of:

$$\int V(P-K-R[.])\,g\,\mathrm{d}g \tag{1}$$

subject to:

$$\int (U(R[.])-T(e))\,g\,\mathrm{d}g \geqslant H \tag{2}$$

and

$$\int U(R[.])\,g_e\,\mathrm{d}g = T'(e) \tag{3}$$

Here $V$ is the owner's utility function, $U$ is the manager's utility over his reward and $T$ his utility over effort expended. It is assumed that $V''<0$, $U''<0$, and $T'>0$, where primes denote derivatives.[4] $H$ is the minimum expected utility acceptable to the manager given his reservation wage in the labour market.

We will now show for a specific example that the manager's optimal compensation package includes non-controllable (from the manager's point of view) factor $K$. We assume that the owner is risk neutral and the manager is risk averse, with utility function given by

$$2(R[.])^{1/2}-e^2 \tag{4}$$

The density function $g(P;\, K,\, e)$ is assumed to be exponentially distributed with parameters $K+e$, that is,

$$P \sim (1/(K+e))\exp-(P/(K+e)) \tag{5}$$

Thus, expected revenues are assumed to be an increasing function of investment in productive assets and of the effort expended by the manager.[5]

In the Appendix we derive the optimal compensation package for the program described by Eqns (1)–(5). This contract has the form

$$R[.] = ((H-e^2)/2+e(P-K))^2 \tag{6}$$

The most important characteristic of this contract for our purposes is that it explicitly includes the non-controllable factor $K$.[6] In particular, the manager's compensation in this example is an inverse function of the resources provided by the owner. Of almost equal importance is the manner in which $P$ and $K$ enter the compensation function, that is, in the form $(P-K)$. The latter is, in fact, simply a Residual Income concept, with profits less the cost of the productive assets provided by the owner.

The reason that non-controllable factors enter the manager's compensation function is that the optimal $K$ is a function ultimately of the manager's efforts. That is, *ex ante*, the owner chooses $K$ in an optimizing rational-expectations fashion by anticipating the manager's future effort response to different levels of $K$ and $R[.]$. The owner is then able to choose the optimal *ex ante* value for $K$. Therefore, as long as there is some interaction between $e$ and $K$ in generating revenues—in our example the interaction comes in the density function $g$—the compensation function $R[.]$ will likely be a function of $K$.

It is worth noting that, inevitably, in every one of the examples analysed by us, $K$ optimally entered the manager's compensation function. This suggests that *in general* it is optimal for non-controllable factors to enter the manager's compensation function, as long as $K$ is a parameter in the revenue density function.[7]

## ROI OR RI COMPENSATION STRUCTURES: SOME EXAMPLES

The literature on responsibility accounting differentiates between profit and investment centres.[8] Profit centres are supposed to be appropriate for those divisions in which plant and equipment are not subject to control by divisional managers. On the other hand, it is argued that investment centres are appropriate for divisions in which local management has responsibility for the investment in fixed assets as well. Given the result of the previous section, that even non-controllable factors enter the manager's compensation package optimally, it is obvious that the distinction between profit and investment centres is artificial and that, in effect, decentralized responsibilities are all of the investment centre type. Given this conclusion, we are then led to an important issue which arises generally when dealing with investment centres. If division managers are to be evaluated on the investment in plant—which in our case is beyond their control—should the evaluation (i.e. compensation) be in terms of a ratio such as ROI or of an absolute profit measure such as RI?

In the example in the previous section we saw that the manager's compensation scheme was optimally of the RI type. We will now show that, by slightly modifying the example, we can obtain a compensation function for which the evaluation criterion is of the ROI type. Specifically, we assume that the density function $g$ is:

$$P \sim (1/Ke)\exp-(P/Ke) \tag{7}$$

Otherwise, the conditions of the previous example remain unchanged. As seen from the appendix, the optimal compensation function for this latter example is:

$$R[.]=((H-e^2)/2+e(P/K))^2 \tag{8}$$

Again, the optimal compensation of the manager is inversely related to $K$. However, in contradistinction to the previous example in which the parameters were additive, when the parameters enter the density function in a multiplicative fashion, the manager's compensation is optimally a function of the ratio $(P/K)$, a ROI formulation.

These examples should not be misconstrued to mean that the optimal compensation scheme is always of the ROI or RI type. On the contrary, it is quite easy to concoct examples where the optimal compensation scheme cannot be interpreted to be of either type. Rather, the point of the exercise is to demonstrate that the form of the optimal compensation is very much a function of the underlying parameters and no simple criterion such as ROI or RI is generally optimal. Even worse, as these examples suggest, it may be impossible to say which criterion corresponds to which situation. After all, firms are unlikely to know the risk structure of their revenue functions, and even minor changes in the parameters of this structure, as we have seen, yield markedly different evaluation criteria.

## CONCLUSION

We utilized the principal–agent framework to analyse two basic issues in responsibility accounting. The firm's owner was assumed to supply productive capital resources to the manager, whose efforts could not be monitored directly. It was shown by example that the manager's optimal compensation package was a function of the owner's investment in capital, despite the fact that this investment was beyond the manager's control. The reason for this is that when determining his optimal investment in capital, the owner takes into account the manager's future effort response to different levels of initial investment in capital. Therefore, in a rational-expectations world, the dictum that managers should be evaluated only on the basis of controllable factors is simply not correct in general.

Since managers may be evaluated optimally on the basis of non-controllable factors, this means that the distinction between profit and investment centres is artificial. This raises the issue as to the potential optimality of the ROI and RI criteria for compensating divisional managers. We provided two examples, one a slight modification of the other, such that the RI criterion was optimal for one and the ROI optimal for the other. If these examples sustain generalization, they have two important implications for responsibility accounting. First, the optimal criterion for evaluating divisional managers is very much specific to the underlying parameters of the firm and the functional form they take. Second, the firm is unlikely to be sufficiently knowledgeable about these parameters (for example, the parameters of the revenue density function) or their functional forms (for example, additive or multiplicative) to be able to determine the optimal compensation criterion.

## APPENDIX

Let $\lambda$ and $\mu$ be the Lagrangian multipliers associated with constraints (2) and (3), respectively. Pointwise optimization with respect to $R[.]$ yields

$$-g+\lambda(R[.])^{-1/2}g+\mu(R[.])^{-1/2}g_e=0 \tag{A1}$$

so that

$$R[.]=\left[\lambda+\mu\frac{g_e}{g}\right]^2 \tag{A2}$$

solving for $g_e/g$ results in

$$R[.]=\left[\lambda+\mu\frac{(P-K-e)}{(K+e)^2}\right]^2 \tag{A3}$$

Substituting Eqn (A3) into Eqn (2) gives

$$\lambda=\frac{H+e^2}{2} \tag{A4}$$

Similarly, $\mu$ can be solved for by substituting Eqn (A3) into Eqn (3), yielding

$$\mu=e(K+e)^2 \tag{A5}$$

Further substituting Eqns (A4) and (A5) into Eqn (A3) yields

$$R[.]=\left[\frac{H-e^2}{2}+e(P-K)\right]^2 \tag{A6}$$

The second example assumes that revenues are distributed as

$$P\sim\frac{1}{Ke}\exp\left(\frac{-P}{Ke}\right) \tag{A7}$$

Substituting the appropriate terms in Eqn (A2), we get

$$R[.]=\left[\lambda+\mu\frac{P-Ke}{Ke^2}\right]^2 \tag{A8}$$

Substituting Eqn (A8) into Eqns (2) and (3) gives

$$\lambda=\frac{H+e^2}{2} \tag{A9}$$

$$\mu=e^3 \tag{A10}$$

Thus, Eqn (A8) becomes

$$R[.]=\left[\frac{H+e^2}{2}+\frac{(P-Ke)}{K}\right]^2 \tag{A11}$$

$$=\left[\frac{H-e^2}{2}+\frac{eP}{K}\right]^2$$

## NOTES

1. Baiman and Demski are concerned with the interaction of the agents' joint efforts on their compensation functions. We, on the other hand, are concerned with interaction of the principal and agent on the agent's compensation function.
2. See, for example, Kaplan (1982, Ch. 15).
3. Thus, $K$ is very different from Holmstrom's signal $y$. $y$ is a stochastic variable whose value is observed only *ex post*, whereas $K$ is observed by all parties *ex ante*. Also, $K$ is not stochastic.
4. This means that the owner is either risk averse or risk neutral, whereas the manager is risk averse in reward and averse to effort.
5. Specifically, $E(P)=K+e$.
6. Of course, the distribution of $R[.]$ induced by $P$ is also a function of $K$. Specifically, since $R[.]$ is monotonically increasing in $P$, it can be shown that $R[.]$ is distributed:
$$\frac{R^{-1/2}}{2e(e+K)}\exp-((R^{1/2}-b+eK)/e(e+K))$$
where $b=(H-e^2)/2$. Thus, the manager's expected compensation
$$2e^2(e+K)^2\exp+((b-eK)/e(e+K))$$
is also a function of $K$.
7. We are unable to provide general conditions for which the compensation function is independent of non-controllable factors. What such conditions might be (or if they exist at all) we leave as an open conjecture.
8. See Horngren (1982, Chs 19 and 20) and Kaplan (1982, Chs 14 and 15).

## REFERENCES

American Accounting Association Committee on Cost Accounting Concepts and Standards (1956). Tentative statement of cost concepts underlying reports for management purposes. *The Accounting Review* July, 182–93.

R. J. Anthony and J. Dearden (1976). *Management Control Systems*, Homewood, Ill.: Irwin.

S. Baiman and J. S. Demski (1980). Economically optimal performance evaluation and control systems. *Journal of Accounting Research* **18**, (Suppl.), 184–220.

J. S. Demski (1976). Uncertainty and evaluation based on controllable performance. *Journal of Accounting Research* **14**, Autumn, 230–45.

J. S. Demski and G. A. Feltham (1978) Economic incentives in budgeting control systems. *The Accounting Review* **53**, April, 336–59.

B. Holmstrom (1979). Moral hazard and observability. *The Bell Journal of Economics* **10**, Spring, 74–91.

C. T. Horngren (1982). *Cost Accounting: A Managerial Emphasis*, 5th edn, Englewood Cliffs, NJ: Prentice-Hall.

R. A. Kaplan (1982). *Advanced Management Accounting*, Englewood Cliffs, NJ: Prentice-Hall.

J. Rick (1971). Is responsibility accounting irresponsible? *The New York Certified Public Accountant* July 487–94.

S. Ross (1973). The economic theory of agency: the principal's problem. *American Economic Review* **63**, March 134–9.

R. Wilson (1968). The theory of syndicates. *Econometrica* **36**, January, 119–32.