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CONFLICT RESOLUTION WITHIN ECONOMIC ORGANIZATIONS

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Alternatives for reducing goal conflict within an organization are analyzed via a mathematical model. To bring the goals of managers into line with organizational goals, compensation via salary and profit sharing are examined as well as schemes for imposing profit constraints and using transfer pricing. Conclusions of the analysis can be summarized in four propositions. (*a*) A salary compensation plan will not motivate managers in a decentralized organization to maximize company profits. (*b*) Profit sharing can be used to increase both division profit and the satisfaction of the manager relative to a simple salary compensation plan. (*c*) However, a bonus compensation plan cannot yield maximum company profits. (*d*) The combination of transfer pricing and a profit sharing compensation plan can provide maximization of company profits under decentralization.

Much of the literature of organization theory testifies to the importance of conflict and its resolution within the organization (see Cooper, Leavitt, and Shelly, 1964; Cyert and March, 1963; March and Simon, 1958). The emergence of conflict requires, at a minimum, a reallocation of resources to resolve the problem; more specifically, conflict might impede the attainment of organizational goals or destroy the organization itself. Among the factors creating and contributing to conflict within organizations are: (*a*) the differentiation between participant and organizational goals; (*b*) incompatibility within organizational policy and procedures; (*c*) the quality of internal motivation systems and their affect on goal formation by sub-units; (*d*) role identification by participants and the impact of the subgroup influence process; (*e*) limitations on communication within information systems. In this paper we focus on goal conflicts between the individual and the organization and investigate the effectiveness of several mechanisms for resolving this conflict.[1]

GOAL CONFLICT

By voting, moral suasion, participative management, or the will of an individual, organizations develop a goal or set of goals. While the process of developing organizational goals is of importance, particularly since it can interact with conflict (through participative management as opposed to dictatorial pronouncements), we will not consider this aspect further. Rather, we will

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[1] Conventional economic theory ignores the problem of goal conflict. In assuming that firms maximize profit, the theory admits of no aberrations as a result of managers seeking their own self-interest.

> "The variability of individual motivation has been assumed away by focusing on the employment contract. Granting that individual motivations differ, participants in an organization are induced to conform to organizational goals by payments (most commonly thought of as money payments) by means of which their individual goals are satisfied." (March and Simon, p. 124).

Economic theory implicitly assumes that individuals are motivated by money and not by other goals, that compensation can be arranged so as to equate the individual's goals with those of the organization. As noted by critics, "Money is a very effective generalized means to a wide variety of specific goals, but it does not suffice for some." (March and Simon, p. 125).

In the course of bargaining within the organization, side payments often take the form of policy commitments rather than money (see Cyert and March, Pp. 29–36). However, money can be considered as a surrogate for nonmonetary resource transfers. For example, a commitment by a chief executive to improve the logistics support for marketing could be characterized within a model as an increase in the budget allocation to marketing. Consequently, we don't regard the focus on monetary side payments as a serious limitation of the analysis.

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focus on cases of goal conflict where individuals have goals which are not always synonymous with those of the organization. Following the formalization of Marschak (1954), a group of individuals might be classified as a coalition, foundation, or team depending upon whether (*a*) no well-defined organizational goal exists; (*b*) the goal exists but there is group conflict; or (*c*) there is a goal and no conflict. The definition of a team requires complete "solidarity" of its members' interests. Needless to say, few economic organizations satisfy this critical assumption.

One interpretation of a team is that its members place the highest priority on the efficiency and goals of the organization, even at the expense of their individual payoff. No conflict between members continues beyond the process of formulating the organizational goal. A foundation is distinguished from a team in that members retain their individual preferences in spite of the existence of a "foundation goal." Since this goal conflict is expensive, it is worth exploring how an organizational structure can be changed (through behavioral constraints or incentives) to cause a foundation to act as a team.

In the following sections we investigate ways in which conflict between participant and organizational goals can be resolved by considering management compensation plans and transfer pricing schemes as mechanisms for bringing a manager's goals into line with the organization's and show that at least one such operational scheme will induce a foundation to behave as a team. To facilitate understanding, the analysis is illustrated by a highly simplified, two-division firm. The example is developed in the next section after the problem has been defined in general terms. Throughout the analysis, we shall assume that the organizational goal of the firm is profit maximization, while that of the individual manager is maximization of his utility function.[2]

A MODEL OF THE MULTI-DIVISION FIRM

At the outset it is useful to establish some basic definitions which will be employed throughout. Consider an organization consisting of $i = 1, 2, \cdots, n$ divisions which make products $X_1, X_2, \cdots, X_n$, respectively. Let $\pi_i(x_1, x_2, \cdots, x_i, \cdots, x_n)$ be the profit function for division i and let $g_i(x_1, x_2, \cdots, x_i, \cdots, x_n)$ be the corresponding divisional cost function where x_i is the output decision for division i and $i = 1, 2, \cdots, n$. In the tradition of classical economics, we assume the $\pi_i(\cdot)$ are strictly concave functions and the $g_i(\cdot)$ are strictly convex functions, implying decreasing marginal profitability (above the maximum π) and decreasing marginal productivity in the x_i, respectively. Suppose also there is a shortage of working capital available to the organization such that beyond a minimal level, say W, the firm must borrow funds and pay increasingly higher interest rates as the size of the loan increases.

Now consider the Decision Problem; find values of the x_1 to x_n variables which

$$(1) \quad \text{maximize } \pi = \textstyle\sum_{i=1}^{n} \pi_i(x_1, x_2, \cdots, x_n)$$

subject to the conditions that

$$(2) \quad g = \textstyle\sum_{i=1}^{n} g_i(x_1, x_2, \cdots, x_n) \leqq W$$

[2] While our model is simple, we believe it preserves the crucial aspects of the problem. Adding more structure would have the effect of making the reward structure and actions more complicated; it would not reverse the direction of the effects we investigate.

We have assumed that firm attempts to maximize profit rather than satisfice (see March and Simon); the simplicity of our example makes profit maximization more realistic. For the more general analysis, satisficing can be substituted for profit maximization with little change. Although the model contains areas of ignorance on the part of individuals, we further assume there is no uncertainty. Elaborating the model to encompass uncertainty and search would require considerably more structure.

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and

(3) $x_i \geq 0$ for $i = 1, 2, \cdots, n$

where the above interpretations of the variables and functions apply.

Definition 1: A *firm* is an organization of n divisions which are economically related by Decision Problem (1).

Definition 2: A *centralized organization* is a firm in which Decision Problem (1) is solved by one central authority (say, "company headquarters") on the basis of complete information on the problem elements, π, g, and W.

Definition 3: A *decentralized organization* is a firm in which the solution to Decision Problem (1) is obtained from the individual decisions of n managers, where each manager has less than complete knowledge of the problem elements π, g, and W.

Definition 4: A *transfer pricing system* is a procedure for control of resources in a decentralized organization in which input (factor) and output (product) prices for divisions are established by a central corporate authority (say, "company headquarters").

Decision Problem (1) might be solved by nonlinear programming for a centralized organization. In particular, if company headquarters has perfect information on π, g, and W, we have:

Theorem I[3]

The optimal solution to Decision Problem (1) is given by $x^* = (x_1^*, x_2^*, \cdots, x_n^*)$ and λ^* if and only if the following $(3n + 3)$ conditions are satisfied:

$$\left.\begin{array}{ll}\text{(I-1) If } x_i^* > 0, \text{ then } \dfrac{\partial \pi}{\partial x_i} - \lambda^* \dfrac{\partial g}{\partial x_i} = 0 \\ \text{(I-2) If } x_i^* = 0, \text{ then } \dfrac{\partial \pi}{\partial x_i} - \lambda^* \dfrac{\partial g}{\partial x_i} \leq 0\end{array}\right\}$$

for $i = 1, 2, \cdots, n$

(I-3) If $\lambda^* > 0$, then

$$\textstyle\sum_{i=1}^{n} g_i(x_1, \cdots, x_n) - W = 0$$

(I-4) If $\lambda^* = 0$, then

$$\textstyle\sum_{i=1}^{n} g_i(x_1, \cdots, x_n) - W \leq 0$$

(I-5) $\lambda^* \geq 0$, and $x_i^* \geq 0$

for $i = 1, 2, \cdots, n$.

For example, suppose $n = 2$ and the output demand curve for each division is the linear function $p_i = a_i - b_i x_i$ where p_i is the unit price of good X_i. Suppose also that the average variable cost (equal to marginal cost) of division i is a constant c_i and there is a company fixed cost, say F, which is "joint" to both divisions (for example, see Pfouts, 1961). Then, in this case

(4) $\pi = \sum_{i=1}^{2} [(a_i - b_i x_i)x_i - c_i x_i] - F$

and

(5) $g = c_1 x_1 + c_2 x_2 + F \leq W.$

Note, if the a_i, b_i and c_i are all positive ($i = 1, 2$), then π_i is concave for all nonnegative x_1 and x_2, since

$$\frac{\partial^2 \pi}{\partial x_i^2} = -2b_i < 0 \quad \text{and}$$

$$\frac{\partial^2 \pi}{\partial x_1^2}\frac{\partial^2 \pi}{\partial x_2^2} - \left(\frac{\partial^2 \pi}{\partial x_1 \partial x_2}\right)^2 = 4b_1 b_2 \geq 0;$$

the linear function g is convex trivially.

Consider the following numerical example. Each of the two divisions faces the linear demand curve $p_i = 112 - x_i$; the marginal and average variable cost of production is 10 for each division; there is a company fixed cost of \$2000, and there is a limit of \$3000 on working capital. This problem satis-

[3] This theorem is the well-known Kuhn-Tucker lemma; the proof of the lemma is given in Kuhn and Tucker (1951).

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fies the conditions of Theorem I and the solution is characterized by Equations (I-1) to (I-5). Solving these equations leads to the solution: $\lambda^* = 0.2$, $x_1^* = x_2^* = 50$, $p_1^* = p_2^* = 62$, and total profit is \$3200. The first equality carries the interpretation that the constraint on working capital is holding down profit; if the firm were offered an opportunity to borrow funds to increase its working capital, it should do so as long as the interest rate on this capital is less than 20 percent. For example, given an interest rate of 10 percent, company headquarters should solve Equations (I-1) to (I-5) for $\lambda = 0.1$; the solution is $x_1^* = x_2^* = 50.5$, $p_1^* = p_2^* = 61.5$, and total profit is \$3200.50. Being able to borrow funds to increase working capital results in expanded production, greater revenue (\$6211.50), greater production costs (\$3010), and increased profit.

The solution to Decision Problem (1) given by Theorem I requires some centralized source, such as company headquarters, to have perfect information on π, g, and W. Insofar as this information is available, it is known at the division level and it is expensive to transfer to company headquarters. Consequently, firms decentralize their management structure and decision-making authority to permit specialization of action and information. For our analysis thus far, we can state the following corollary to Theorem I (which follows directly from elementary arguments).

Corollary

The optimal solution to Decision Problem (1) can be obtained from Equations (I-1) to (I-5) for the individual x_i^* values under a decentralized organization provided

$$\frac{\partial^2 \pi}{\partial x_i \partial x_j} = \frac{\partial^2 g}{\partial x_i \partial x_j} = 0 \tag{6}$$

$$\text{for } i \neq j \quad \text{and} \quad i, j = 1, 2, \cdots, n$$

and λ^* is known to each division manager.

The condition given in Equation (6) is equivalent to the statement that the output decision cross elasticities are zero, that is, neither demand nor production cost depends on the decisions of other division managers. Knowledge of λ (or λ^*, specifically) gives a division manager knowledge of the firm's "cost of capital," a transfer price on corporate working capital requirements which depends on the output decisions as shown in Equation (2).

The corollary states that optimality can be attained under decentralization; it does not guarantee that optimality will be obtained. While each division manager will know what to do to maximize profit, there is no guarantee that he will choose to do it. In terms of the earlier discussion, division managers must behave as a team in order to maximize profit. If they behave as a foundation and seek goals contradictory to the firm goal of maximizing profit, decentralization will increasingly depart from optimality.

It is unrealistic to assume that division managers will seek to maximize division profit. While the manager can be assumed to seek a goal which is related to division profit, the correspondence might be quite imperfect. We assume that the manager maximizes his utility within the decision framework provided by technical constraints and the policies of the firm. The following definition formalizes these notions:

Definition 5: The utility of a (division) manager is a continuous, differentiable, and strictly monotone increasing function of his income, I, and his power, P:

$$U(I, P). \tag{7}$$

The "income" argument of a manager's utility is a surrogate for all of the manager's monetary goals. The "power" argument of the manager's utility is taken as a surrogate for all non-monetary (non-income) goals of the individual. We assume that power is directly related to the scale of division operations (the amount of output); for example, the larger the scale of operations, the more

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people will be under the manager's supervision, the greater will be his prestige relative to his peers, and the greater will be the "personal satisfaction" of the manager. We can suppose that a division manager seeks decisions which maximize his utility for "income and power," subject to operating constraints imposed by the corporation ("company headquarters").

Utility maximizing behavior by division managers raises the problem of potential goal conflict within a decentralized organization. If a division manager behaves (decides) so that corporate profits are maximized, decentralization represents considerable savings in the amount of information transferral. If division managers make other decisions, corporate profit could fall substantially under decentralization. Under what conditions will utility maximization by division managers conflict with maximization of division profit? How might corporate headquarters arrive at a system of constraints, rewards, penalties, transfer prices or the like, which lead to maximum profit for a decentralized firm? In particular, which of the alternatives currently employed by organizations most closely guarantees profit maximizing behavior in a foundation?

COMPENSATION PROGRAMS AND BEHAVIOR COERCION

Salary compensation plans

To explore the issue of behavior coercion under decentralization, we first consider the "income" argument of a manager's utility function. A popular compensation plan in business practice today is the "salary" reward system under which managers are paid in direct proportion to their administrative responsibilities, the number of employees they supervise, or the size of their division.

Definition 6: A salary compensation plan is a reward system where a manager's income, I, is a direct function of output, x_i; $\partial I/\partial x_i > 0$.

Theorem II

Let I and P be differentiable, strictly monotone increasing functions of output, x_i. Then the maximization of utility (U) requires that output (x_i) be indefinitely large.

Proof

The maximization of U requires

$$\text{(8)} \qquad \frac{\partial U}{\partial I}\frac{dI}{dx} + \frac{\partial U}{\partial P}\frac{dP}{dx} = 0.$$

From Definitions 5 and 6, and the statement of the theorem, $\partial U/\partial I$, $\partial U/\partial P$, dI/dx, dP/dx are strictly positive. Therefore, $(\partial U/\partial I)(dI/dx) = (\partial U/\partial P)(dP/dx) = 0$ for a maximum, which is impossible except for x indefinitely large.

The consequence of Theorem II on the division manager's behavior is that he is motivated rationally to expand divisional output perpetually. We can expect, therefore, that as output continues to rise, profits will fall, and corporate performance will increasingly depart from the goal of profit maximization.

In a practical sense, suppose in addition to a salary compensation plan, the corporation imposes a behavioral constraint on each division manager to meet a profit target or "be fired." Three profit targets seem relevant: total corporate profits must be positive, division profits must be positive, or division profits must exceed a predetermined figure (such as, the prorated corporate fixed cost). Let $\delta_i = \delta_i' + s_i$, represent the perceived profit target for division i, where δ_i' corresponds to the lower bound on profits established by corporate headquarters and s_i corresponds to the "slack" at the division for meeting this requirement. Then each division's output decision can be viewed as the solution to a constrained utility maximization problem by forming the Lagrangian in $U_i(\cdot, \cdot)$ and $\pi_i(\cdot)$ given δ_i; that is,

$$\text{(9)} \quad L_i = U_i(I_i, P_i) - \mu_i(\pi_i(x_i) - \delta_i).$$

Since at the optimal values $x_i > 0$ and $\mu_i > 0$, necessary conditions for the maxi-

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mization of (9) with respect to the x_i give

$$(10) \qquad \frac{dL_i}{dx_i} = 0 \quad \text{and} \quad \frac{dL_i}{d\mu_i} = 0.$$

For the example in (4) the conditions in (10) reduce to

$$(11) \quad \mu_i^* = k_i[(a_i - c_i)^2 - 4b_i\delta_i]^{-1/2}$$

and

$$(12) \quad x_i^* = \frac{1}{2b_i}[a_i - c_i - (k_i/\mu_i^*)],$$

where $k_i = (\partial U_i/\partial I_i)(dI_i/dx_i) + (\partial U_i/\partial P_i) \cdot (dP_i/dx_i)$. When $a_1 = a_2 = 112$. $b_1 = b_2 = 1$, and $c_1 = c_2 = 10$, as above, the condition in (12) becomes $x_i^* = 51 \mp (2601 - \delta_i)^{1/2}$.

Is it conceivable that a division manager could be coerced to maximize corporate profit by placing a profit constraint on his division? The answer is trivially yes: if each manager faced a profit constraint (δ_i') of \$2601, corporate profit would be \$3202 (and $s_i = 0$). The result is trivial because company headquarters must know the maximum possible division profit in order to know the constraint which would lead to maximum profit. In order to know the proper profit constraint, company headquarters would have to possess divisional information in sufficient detail so as to obviate decentralization.

Now suppose that, in spite of these conclusions, corporate management was compelled to use a salary compensation plan. Then, short of centralizing all information, their basic problem in control is learning the optimal constraint value to impose on each division. Setting a constraint which is impossible to achieve (that is, anything over \$2601 in our example) would lead to a demoralized division and the firing of managers. Whatever constraint was set (such as last year's profit), each division manager would be motivated to argue that the constraint was impossible to achieve.[4] Indeed, a determined manager might go to the limit of his bargaining power, such as losing money for a short time. The "solution" to this situation is indeterminant and is unlikely to be stable. We conclude that, while profit constraints might conceivably be used to attain maximum profit, it is unlikely that these constraints could be implemented effectively in practice.

This analysis is summarized in:

Proposition 1: A salary compensation plan will not motivate managers in a decentralized organization to maximize corporate profit.

Under a salary compensation plan, the division manager is motivated to expand his output indefinitely. Unless constraints are placed on the divisions, the company will incur substantial losses. A profit constraint on the division is one way to provide control. However, the only way to achieve maximum corporate profit is to know the most profit each division can earn and use this figure as the constraint. The complete centralization of this information is incompatible with decentralization.

Compensation with profit sharing

In the past several years corporations have introduced what is called a "profit sharing" compensation plan for managers. In one form or another, the manager's income is determined by a bonus tied to division or corporate profit (π) in addition to a "base" salary. Often the size of the bonus and the "base" salary are determined by the amount of "power" resident with the manager (for example, the number of workers or the amount of expenditures supervised).

Definition 7: A profit sharing compensation plan is a reward system where a manager's income is a differentiable, strictly monotone increasing function of divisional output and profit: $I_i = f_i(x, \pi)$.

[4] See Winston (1964), particularly pages 414–416, for examples of business practice and apparent inconsistencies in establishing operating controls.

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A profit sharing compensation plan is superior to salary compensation as demonstrated by the next three theorems. In Theorem III we show that a manager prefers profit sharing to salary. In Theorem IV we show that a firm's profit will rise when profit sharing is introduced. Finally, in Theorem V we show that even profit sharing falls short of inducing managers to maximize company profit under a decentralized decision structure.

Theorem III

Define $h_i(x_i) = f_i(x_i, 0)$ to be a manager's income function under a salary compensation plan. Let $x_i^{(1)}$ represent the value of x_i which maximizes $U_i(h_i(x_i), P_i)$ and let $x_i^{(0)} < x_i^{(1)}$ be a value of x_i such that $\pi_i(x_i^{(0)}) > 0$. Then

$$(13) \quad U_i(f_i(x_i^{(0)}, \pi_i), P_i) > U_i(h_i(x_i^{(0)}), P_i)$$

for all $x_i^{(0)}$, given $U_i(\cdot, \cdot)$ and $P_i(\cdot)$.

Proof

For all $x_i^{(0)}$ such that $\pi_i(x_i^{(0)}) > 0$, $f_i(x_i^{(0)}, \pi_i) > h_i(x_i^{(0)})$. Since $U_i(\cdot, \cdot)$ is a strictly monotone increasing function of P_i and f_i or h_i, (13) follows immediately.

Theorem IV

Let $x_i^{(2)}$ represent the value of x_i which maximizes $U_i(f_i(x_i, \pi), P_i)$. Then

$$(14) \quad \pi_i(x_i^{(1)}) \leq \pi_i(x_i^{(2)})$$

for the same $U_i(\cdot, \cdot)$. (Equation (14) is a strict inequality for finite $x_i^{(2)}$.)

Proof

Under a profit sharing plan, a manager should seek an output $x_i^{(2)}$ which is a solution to:

$$(15) \quad \frac{\partial U_i}{\partial f_i} \frac{df_i}{dx_i}\bigg|_{x_i^{(2)}} + \frac{\partial U_i}{\partial P_i} \frac{dP_i}{dx_i}\bigg|_{x_i^{(2)}} = -\frac{\partial U_i}{\partial f_i} \frac{\partial f_i}{\partial \pi_i} \frac{d\pi_i}{dx_i}\bigg|_{x_i^{(2)}}.$$

All derivatives in Equation (15) are positive except $d\pi_i/dx_i$. Thus $d\pi_i/dx_i$ must be negative at $x_i^{(2)}$ and the right hand side of Equation (15) must be positive. Now U_i is a strictly monotone increasing function of f_i and P_i, which are strictly monotonic increasing functions of x_i, so that $x_i^{(1)} \geq x_i^{(2)}$. If the solution to Equation (15) occurs at a finite $x_i^{(2)}$, $x_i^{(1)} > x_i^{(2)}$, since, by Theorem II, $x_i^{(1)}$ is arbitrarily large. The maximization of $\pi_i(x_i)$ requires that $d\pi_i/dx_i = 0$, and profit is a concave function of output for x_i greater than the profit maximizing x_i; therefore, $\pi_i(x_i^{(1)}) \leq \pi_i(x_i^{(2)})$ and there is a strict inequality if $x_i^{(1)} > x_i^{(2)}$.

Theorem V

Let $x_i^{(3)}$ be that value of x_i which maximizes $\pi(x_i)$. Then

$$(16) \quad x_i^{(2)} > x_i^{(3)} \quad \text{and} \quad \pi(x_i^{(3)}) > \pi(x_i^{(2)}).$$

Proof

At $x_i = x_i^{(3)}$ (the maximum profit output) the right hand side of (15) vanishes, since $(d\pi_i/dx_i)|_{x_i^{(3)}} = 0$; and utility is not maximized at $x_i^{(3)}$, since (15) is strictly positive. Thus from Theorem IV, $x_i^{(3)} < x_i^{(2)} \leq x_i^{(1)}$ and the theorem is proved.

To illustrate Theorem V and the preceding arguments we again return to the numerical example in (4). Recall from the analysis leading to (12) that the profit maximizing output was $x_i^* = x_i^{(3)} = 51$. Profit falls as output is increased beyond this amount. Now suppose the marginal utility of income $(\partial U_i/\partial f_i)$ for Manager 1 is 10, that the manager receives 10 percent of division profits as a bonus incentive, that his base compensation rises \$1 for every unit of output he produces, and that his marginal utility for "power" is 2. Substituting for these values into Equation (15), we obtain[5]

[5] In these computations our assumed numbers for the partial derivatives in (15) give a value for the ratio of the marginal utility of money to the marginal utility of power equal to 5. Below are given decision values (x); as a function of several

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$10\,(0.1)(102 - 2x) + 10\,(1) + 2 = 0$, or $x_1 = 57$. So that $p_1 = 55$; $\pi_1 = \$2565$; $f_1(\pi_1, x_1) = \$313.50$; and net profit $\hat{\pi}_1 = \$2251.50$.

These calculations illustrate the consequences of Theorems III and IV; namely, a bonus compensation plan raises both the profits of the corporation and the utility of the manager and therefore represents an improvement over the simple salaried plan considered earlier. However, the present system does not give rise to *maximum* profits for the company as proven in Theorem V. In fact, the bonus compensation plan cannot yield maximum profits for the company unless the manager *is paid* "an infinite amount" of money. This conclusion follows from the fact that only $d\pi/dx_i$ is non-positive in (15). Thus, utility cannot be maximized in our example unless $x > 51$. The stronger the relationship between the manager's income and division profits $(\partial f/\partial \pi_i)$, the closer the manager will get to the profit maximizing output decision. However, even if the manager were paid all of the profit (that is, his bonus incentive were 100 percent and he owned the business), he would not choose output $x_j = 51$. Note that as the manager's compensation from division (output) size increases, he selects output decisions which increasingly diverge from the profit-maximizing output. If it were possible to *lower* his compensation as division size (and responsibilities) increased, corporate headquarters could coerce him into selecting $x_i = 51$, but such an alternative based on compensation seems totally unrealistic. Table 1 and Figure 1 illustrate the relation between the output decision (x_i), the manager's compensation (I_i), divisional profits (π_i), and net divisional profits (Net $\hat{\pi}_i$) as the bonus percentage of profits paid to the manager $(\partial f_i/\partial \pi_i)$ is varied, where the other parameters are the same as given above.[6]

values of this ratio, where $U_f \equiv \partial U_i/\partial f_i$ and $U_p \equiv \partial U_i/\partial x_i$.

(U_f/U_p):	100	10	5	1	0.1
x_i:	56.05	56.5	57	61	106

TABLE 1

PARAMETRIC VARIATIONS OF BONUS COMPENSATION, PRODUCTION OUTPUT AND DIVISION PROFITS

$(\partial f/\partial \pi_i)$	x for U_i max	I_i	π_i	Net $\hat{\pi}_i$
1%	111	\$101.10	\$−999.00	\$−1100.10
10%	57	\$313.50	\$2565.00	\$2251.50
50%	52.2	\$1351.98	\$2599.56	\$1769.58
100%	51.6	\$2652.24	\$2600.64	\$−52.24
200%	51.3	\$5253.12	\$2600.91	\$−2652.21
∞	51	∞	\$2601.00	$-\infty$

We summarize this analysis in:

Proposition 2: Profit sharing can be used to increase both division profit and the satisfaction of the manager relative to a simple salary compensation plan.

Proposition 3: A bonus compensation plan cannot yield maximim corporate profits under decentralization.

CONTROL THROUGH COMPENSATION AND TRANSFER PRICING

Earlier it was shown that the use of transfer prices (on the cost of capital) could lead to optimal decentralized decision making.[7] One use of transfer pricing that has not been discussed elsewhere is as a mechanism for resolving goal conflict. In our analysis thus far, we have shown that a division manager is motivated to enlarge his division beyond the profit maximizing size due to his satisfaction from "power;" the company is penalized by this uneconomic expansion through a loss in profit. If decentralized

[6] In analyzing the salaried compensation plan, we saw that profit constraints could be used to raise divisional profit. With both a profit sharing plan and a profit constraint, there is bound to be one superflous constraint. A zero division profit constraint is redundant (will have no effect on the manager's decision behavior) if the manager is paid a bonus of 10 percent of the profit or more. The profit sharing plan is redundant if the manager is paid 1 percent of profit or less. The constraint can be effective only if the profit sharing plan is redundant, and vice versa.

[7] Recall the corollary to Theorem I.

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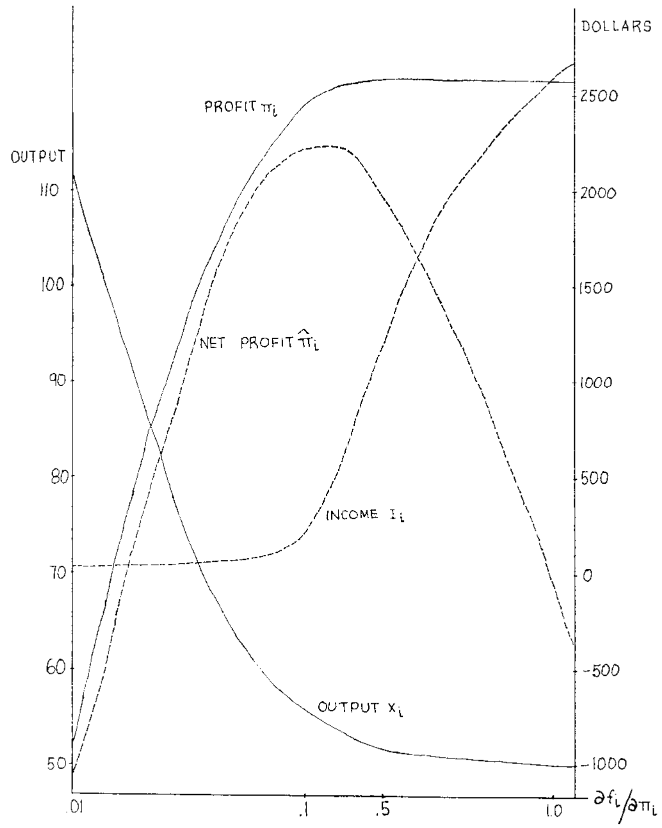

FIG. 1. Parametric Variations of Bonus Compensation, Production Output and Division Profits

control is to be retained, a way must be found of transferring this company loss to the manager, by penalizing him for too large a division.

One transfer price that is essential to efficient operation of a decentralized company is the cost of capital. For reasons such as the inability to borrow unlimited funds, the company rate of return might be substantially higher than a market rate of interest. Many companies calculate an internal cost of capital and use it as a standard for the allocation of investments within the company. Even in the unlikely case where a decentralized company had unlimited funds, it could realize greater profit for Decision Problem (1) by establishing a high cost of capital as a transfer price. This contention is made explicit by:

Theorem VI

Let h be the salary compensation plan of Definition 6, δ be a division profit constraint, and λ_0 and λ_1, transfer prices such that $\lambda_1 > \lambda_0$. If δ can be attained under both λ_0 and λ_1, then this increase in transfer price will cause division output to be reduced and company profit to increase.

Proof

Company profit, π, is a function of the level of output (and demand) and the prices of input factors, such as λ, the cost of working capital. Profit may be written as the function $\pi_i(x_i, \lambda)$. Then, $\partial\pi/\partial\lambda < 0$, since for any x_i, raising the price of an input factor increases cost and thus lowers profit. By Theorem II and Equations (9)–(12), under a salary compensation plan $h_i(x_i)$ the manager will choose the largest value of x_i which

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satisfies the profit constraint. Raising the transfer price λ on an input factor lowers profits, which means the established constraint can no longer be satisfied at the output solution for x_i prior to the price increase, such as in (12). The constraint can be reestablished, therefore, only by lowering the value of x_i. (Provided it is possible to satisfy the constraint with the new transfer price.) Company profits, which are computed net of the transfer price, rise as output falls from $x_i^{(1)}$.

Theorem VII

Under a profit sharing compensation plan (Definition 7), raising the transfer price of an input factor causes division output to be reduced and company profits to rise (provided division profit is non-negative after the increase in the transfer price).

Proof

From Theorem IV recall that $x_i^{(2)}$ yielded the solution to Equation (15). For λ defined as above, the only expression in Equation (15) directly affected by an increase in the transfer price is $d\pi_i/dx_i$; $d\pi_i/dx_i$ is the difference between marginal revenue and marginal cost. From Theorem V, $x_i^{(2)} > x_i^{(3)}$, the maximum profit output. At $x_i^{(3)}$, marginal revenue equals marginal cost; at $x_i^{(2)}$, marginal cost exceeds marginal revenue. An increase in λ given x_i increases divisional marginal cost, so that for any stationary $U_i(\cdot, \cdot)$, (15) becomes an inequality at $x_i^{(2)}$. The equation is restored only by reducing the output value of x_i, diminishing the impact of $d\pi_i/dx_i$ in (15). Finally, since $\pi_i(\cdot)$ is concave, a reduction in x_i increases division profit net of λ, and corporate profits rise.

This analysis is illustrated by first considering the salary compensation plan with a divisional profit constraint of zero. A high cost of capital (λ) forces the manager to decrease division size and converge to the profit maximizing output of 51 in our example. As in the analysis leading to Equation (12), the output decision equation is now:

$$x_i = 102 - 10\lambda;$$

for $\lambda = 5.1$, the profit maximizing output is achieved.

Now consider the profit sharing compensation scheme when a cost of capital is introduced. The change in profit due to a change in output (x_i) is now $102 - 2x - 10\lambda$. Figure 2 shows the manager's optimal output decision as the cost of capital is varied (all other terms in Equation (15) are held fixed at their previously assigned values).

CORPORATE PROFIT CONSTRAINTS, BARGAINING, AND ITERATIVE SOLUTIONS

The impact of divisional profit constraints under a salary compensation plan was de-

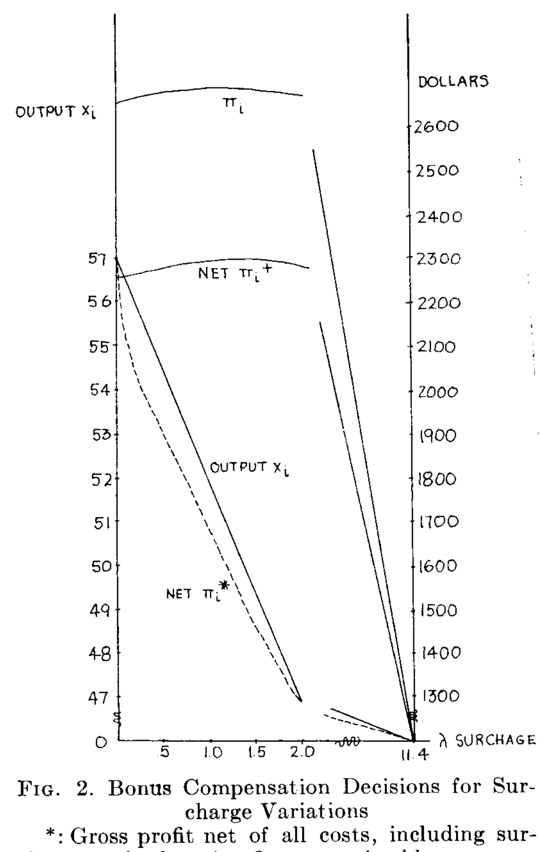

FIG. 2. Bonus Compensation Decisions for Surcharge Variations

*: Gross profit net of all costs, including surcharge and salary (profit as perceived by manager i).

†: Gross profit net of manufacturing cost and salary (true corporate profit).

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scribed above. The alternative of assigning division constraints based on total corporate profit was not discussed in detail. This alternative introduces a further complication since each manager must now make some assumption about the decision-making behavior of the other manager. For example (in the context of the numerical illustration), if Manager 2 behaves as a team member, he will attempt to maximize company profit and earn a division profit of \$2601 (ignoring company fixed cost). If Manager 2 does set $x_2 = 51$, Manager 1 can set $x_1 = 102$ and achieve a high level of personal satisfaction. It is apparent that each manager's decision depends on the choice of the other manager. This situation is the familiar prisoner's dilemma and is summarized in Table 2. Each manager would prefer to choose the higher output decision without getting fired. However, earning a profit less than zero (being fired) is the least preferred alternative (either a 4 or a 5).

The conditions under which managers would tend to choose high or low values for the x_i have been investigated extensively (see Lave, 1965, for references). Until managers perceive the nature of the interaction between divisions, it is unlikely that stability will emerge. In an experimental context, the bargaining aspect of this situation dominates and subjects tend to converge to the least desired part of the matrix,

TABLE 2
DECISION-PROFIT TABLE FOR COMPANY*

Manager 1	Manager 1		
	$x_2 = 51$	$x_2 = 91$	$x_2 = 102$
$x_1 = 51$	$\delta = 3202$ (3, 3)	$\delta = 1602$ (3, 2)	$\delta = 601$ (3, 1)
$x_1 = 91$	$\delta = 1602$ (2, 3)	$\delta \approx 0$ (2, 2)	$\delta = -999$ (5, 4)
$x_1 = 102$	$\delta = 601$ (1, 3)	$\delta = -999$ (4, 5)	$\delta = -2000$ (4, 4)

* $\delta \equiv$ company profits; $(\cdot,\cdot) \equiv$ outcome preference ordering by division (1, 2), where $1 > 2 > \cdots > 5$.

so that firing would be the outcome which most frequently characterized this situation.

Bargaining in this context will arise if there is a limitation on working capital available within the corporation. For the example data, how might \$3000 in working capital be divided among the divisions? In answering this question, we assume that compensation is based on corporate rather than division profit.

With a constraint of \$3000 on working capital, the company profit (from Equation 4) is:

$$\pi = (112 - x_1)x_1 + (112 - x_2)x_2 - 10(x_1 + x_2) - 2000 + \lambda(1000 - 10[x_1 + x_2]),$$

and each manager attempts to apply the solution rule in Equation (15), where $\pi_i = \pi$. Now from the solution under Theorem I we know that the optimal $\lambda = 0.2$, so that solving (15) for the original parameters gives $x_1 = 56$. But, by symmetry, Manager 2 will also attempt to choose $x_2 = 56$ as the output which maximizes his utility (assuming the same parameter values for U_2). Clearly, $x_1 = x_2 = 56$ is infeasible in this case since it violates the working capital constraint. The feasible range on each division's output is $44 \leq x_i \leq 56$ and the comparable range on total profits is $3128 \leq \pi \leq 3200$ where $\pi = 3200$ at $x_1 = x_2 = 50$ and $\pi = 3128$ at either boundary ($x_1 = 56$, $x_2 = 44$) or ($x_1 = 44$, $x_2 = 56$). The specific output solution will be determined through bargaining between each division and headquarters with each manager appealing for an increasing share of the budget up to the desired 56 percent allotment. Note in this case that while the relative bargaining power of the two managers determines the final production output, imposition of the budget constraint has effectively bounded company gross profits to the range $\pi \geq \$3128$.

From Table 2 we see that by varying the cost of capital to the division (λ), headquarters can move the division manager's output decision towards the profit maximiz-

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ing value. Imposition of a division profit constraint within this system can force converging to the optimal decision quantity even more rapidly. Under a salary compensation system this control process by headquarters has the disadvantage of being rather obvious to the division manager and, consequently, he can react and bargain against it fairly easily. That is, as the transfer price on the cost of division working capital is increased, the division manager will balk and attempt to bargain with headquarters against further increases or for more favorable terms (Winston, 1964). However, when transfer pricing is combined with a bonus compensation plan, the structure of the situation is much less obvious to a manager and it becomes much easier for headquarters to arrive at a cost of capital which maximizes company profits through more effective control of decentralized decision-making behavior. In this regard, manipulation of the division's cost of capital is a mechanism for penalizing a division manager for too large (or too inefficient) an operation. To this end it provides an instrument for reducing goal conflict in decentralized decision-making behavior; that is, from our example it can be used to force the manager's marginal utility for "power" $(\partial U_i/\partial P_i)$ to assume negative values before company profits begin to decline.[8]

The preceding analysis is depicted by the data presented in Table 3. In this case we have not made any explicit assumptions about the mechanism by which division managers make decisions but rather illustrate a range of possible output decisions for the numerical example. That is, whether or not a utility function is employed by each manager in the decision making process is immaterial. We assume each manager is compensated on the basis of division output and *perceived division profits* where the latter are computed net the transfer price on working capital and a prorated joint cost of $1000. Company profits are net of total production cost and managers' compensation; however, the cost of capital to the company is ignored. Then given that managers are motivated by compensation, we see that the transfer price and profit sharing compensation system provide headquarters with leverage to control decentralized output decisions in the direction of profit maximizing behavior. For example, if Manager 1 has selected an output of, say, $x_1 = 61$ on the basis of a perceived division profit of $2050 at $\lambda = 0$, company headquarters can move the manager's decision to $x_1 = 57$ by increasing the transfer price to $\lambda = 0.5$ (where $\pi_1 = \$2049.50$). Note in this case that company profit (π) increases from $2470 to $2606.10. Note also that π is maximized in all cases for $x_i = 51$, whereas π_i is maximized for $x_1 = 55$, for the data shown. However, as the transfer price is increased the optimal output solution for π and π_1 converge to the common value $x_1 = 51$.

This analysis is summarized by:

Proposition 4: The combination of transfer pricing and a profit sharing compensation plan can lead to corporate profit maximization under decentralization.

One major qualification on the use of a high λ must be stated. Insofar as divisions are using λ to guide their investments in plant and equipment, a high λ will lead to too little investment. This bias could be serious for large λ.

Investigators have been somewhat mystified by the high rates of return (or short payback periods) corporations insist upon for internal allocation of funds. In a market where the prime interest rate is about 5 percent, major corporations insist upon λ's of 20, 30, or (even) 40 percent. Conventional arguments explain the difference in terms of uncertainty and the reluctance of corporations to accept outside control which is alleged to come with externally negotiated

[8] Note that the optimal λ (the one leading to maximum profit) is a function of $\partial u_i/\partial p_i$. Since the marginal utility of power differs among managers, a single value of λ cannot lead all managers to maximize profit.

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TABLE 3

SUMMARY STATISTICS ON BONUS COMPENSATION AND TRANSFER PRICING CONTROL SYSTEM FOR TWO-DIVISION COALITION*

Output $x_1 = x_2$	Price $p_1 = p_2$	Total Revenue	Company Profits (π) and Perceived Division Profits (π_i) for Different Transfer Prices (λ)							
			$\lambda = 0$		$\lambda = 0.5$		$\lambda = 1.0$		$\lambda = 1.5$	
			π	π_i	π	π_i	π	π_i	π	π_i
111	1	222.00	−4020.00	−1000.00	−4008.90	−1055.50	−3997.80	−1111.00	−3986.70	−1166.50
102	10	2040.00	−2187.60	−82.00	−2177.40	−138.00	−2167.20	−184.00	−2157.00	−235.00
91	21	3822.00	−344.00	820.00	−334.90	774.50	−325.80	729.00	−316.70	−683.50
81	31	5022.00	954.00	1430.00	962.10	1389.50	970.20	1349.00	978.30	1308.50
71	41	5822.00	1892.00	1840.00	1899.10	1804.50	1906.20	1769.00	1913.30	1733.50
61	51	6222.00	2470.00	2050.00	2476.10	2019.50	2482.20	1989.00	2488.30	1958.50
57	55	6270.00	2600.40	2078.00	2606.10	2049.50	2611.80	2021.00	2617.50	1992.50
55	57	6270.00	2644.00	2080.00	2649.50	2052.50	2655.00	2025.00	2600.50	1997.50
51	61	6222.00	2688.00	2060.00	2693.10	2034.50	2698.20	2009.00	2703.30	1983.50
41	71	5822.00	2546.00	1870.00	2550.10	1849.50	2554.20	1829.00	2558.30	1808.50
31	81	5022.00	2044.00	1480.00	2047.10	1464.50	2050.20	1449.50	2053.30	1433.50
21	91	3822.00	1182.00	890.00	1184.10	879.50	1186.20	869.00	1188.30	858.50
10	102	2040.00	−182.00	10.00	−181.00	5.00	−180.00	0	−179.00	−5.00

* Where $p_1 = p_2 = (112 - x_i)$; Total Revenue $\equiv \text{TR}_i = 2(112 - x_i)x_i$; Income Compensation for Manager 1 (manager 2) $\equiv f_1 = f_2 = x_1 + 0.1\ \pi_1$; Perceived Division Profits $\equiv \pi_1 = (112 - x_1)x_1 - (1 + \lambda)x_1 - 1000$; Total Costs $\equiv \text{TC} = 10(x_1 + x_2) + 2000 + f_1 + f_2$; Company Profit $\equiv \pi = \text{TR} - \text{TC}$.

loans. Neither of these arguments seems capable of accounting for the difference between 5 and 20 percent, much less the difference between 5 and 40 percent. We suggest that a large part of this discrepancy is the attempt by corporations to reduce goal conflict in a decentralized firm.

DISCUSSION

When income is proportional to responsibility, a manager is motivated to increase the size of his division beyond economic proportions, thus lowering profit. Goal conflict is maximized by this reward system, and constraints are necessary to keep the situation from degenerating into one involving large losses for the corporation. However, constraints such as a minimum acceptable profit can do no more than place a floor under corporate inefficiency. It remains true that goal conflict is at a maximum and managers may be motivated to go to extremes in expanding the size of their divisions.

A profit sharing compensation plan reduces goal conflict and begins to bring the manager's goals into line with corporate goals. Compared to a system which rewards responsibility, profit sharing can increase the satisfactions of the manager *and* the profit of the company. However, profit sharing can never lead to maximum corporate profit as long as the manager derives satisfaction from non-income related goals (such as power), and he is not penalized for uneconomic division expansion. The larger his compensation from profit sharing relative to compensation from responsibility, the closer will the manager come to maximize corporate profit.

Within either compensation system, efficiency is increased by introducing a transfer price for the cost of capital. In conjunction with a profit constraint such a transfer price can induce the manager to maximize corporate profit under a salary compensation plan. Under profit sharing plans, a high transfer price can be even more effective in inducing managers to maximize corporate profit.

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The process of evolution seems at first sight to run contrary to the general principle of diminishing potential. We are dangerously close to some metaphysical shoals at this point, and we must turn quickly away from some fascinating but unanswerable question about the origin and the end of the universe. What we see in the evolutionary process, however, may be described as the use of energy to segregate entropy. Entropy can also be thought of as a measure of chaos—which may be defined, oddly enough, as the most probable state of any system. Negative entropy can then be thought of as measuring the degree of organization, structuring, or improbability of a system. Evolution moves the world toward less probable and more complicated arrangements, system patterns, and structures, whether in biology or in society. Thus even though the principle of diminishing potential is moving the universe as a whole toward increasing entropy and increasing chaos, the evolutionary process operates to create more order at some points at the cost of creating less order elsewhere. This is what I mean by the segregation of entropy.

KENNETH E. BOULDING,
The Meaning of the Twentieth Century

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