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A Linear Compensation Scheme Resolving Inter-departmental Conflicts

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Abstract

In this paper, we deal with inter-departmental conflicts such as marketing-manufacturing conflict We show that the popular compensation schemes such as the ones based on each party's own performance and/or overall performance can not induce the Pareto-Optimal effort from participants. By making one party's reward dependent on the other party's performance in addition to its own and overall performances, we can induce each party to put the Pareto-Optimal effort. By constructing an appropriate compensation scheme, we can resolve the conflict between participating departments and induce optimal amount of cooperative effort.

Keywords: marketing/operations interface

1. Introduction

Within a firm, there are usually several divisions or departments whose cooperation is essential for its success in the competitive business world. But it is not easy to induce the needed cooperation from all the participants. We will study a reward scheme which mitigates the inter-departmental conflicts. In this paper, we will focus on the conflicts between marketing and manufacturing divisions, a typical inter-departmental conflict.

Compared with other pairs of functions, the marketing/ manufacturing interface tends to produce much more frequent and heated disagreement (Hayes and Wheelwright (1984)). Some of the typical marketing-manufacturing conflicts are given in Table 1 It has been stressed that marketing and manufacturing should be coordinated more effectively since they usually try to find each other's fault rather than working together for the corporate's goal.

The areas of necessary cooperation but of potential conflict, causes of conflict, and the ways of managing the conflict by increasing cooperation and minimizing antagonism between the marketing and manufacturing functions were studied by Shapiro (1977). Shapiro gave eight marketing-manufacturing areas of necessary cooperation but of potential conflict, and recommended explicit policies, modified measurements, and people's concern as ways for reducing the conflict. In modified measurements, Shapiro gave an insightful suggestion that marketing managers should be judged on those variables important to the manufacturing operation and vice versa.

Rewarding marketing and manufacturing departments for pursuing opposite goals and evaluating major conflict areas between these two departments were studied by Crittenden (1992), and Crittenden et al. (1993). Conflict reduction mechanisms such as organizational design, evaluation and reward systems, communication, and models were suggested. Through empirical studies, several mechanisms have also been

Table 1. Examples of Marketing-Manufacturing Conflict

Marketing Department	Manufacturing Department
Customization for niche markets	Standardization for economy of scale or quality consistency
Cost up if needed for quality improvement	Reducing unit cost of production
Facility layout for customer convenience	Facility layout for cost and service efficiency
Maintaining surplus capacity for quick response to customers	Reducing capacity idleness
Keeping high inventory for customer service	Reducing inventory level
Promoting new product development	Opposing expensive design changes
Full line of products	Small number of products for manufacturing efficiency

suggested to improve coordination among groups with conflicting responsibilities by John and Hall (1991). The R&D/marketing interface was studied by Souder and Chakrabarti (1978). Souder and Chakrabarti cited the factors causing conflict among organizational subunits as follows: mutual task dependency, task-related asymmetry, differences in criteria for reward, functional specialization, dependence on common resources, and ambiguities in role descriptions and expectations for these units. As one of the ways to resolve the conflict, they suggested a joint reward system in which R&D and marketing share equally in the rewards from a successful effort and its effect was shown to be statistically significant. Bushman et al. (1995) empirically investigated the use of aggregate financial performance criteria measured at an organizational level higher than a manager's business unit.

Coordination in vertical channels of distribution was studied by Eliashberg and Steinberg (1987). In their setting, there exist a distributor and a manufacturer, and the manufacturer works as the leader in Stackelberg game. Products are delivered over a season to the distributor who can vary its processing rate. The manufacturer can decide its production rate during the season. Policies of the distributor and the manufacturer, and contractual price within the channel were derived using optimal control theory. Porteus and Whang (1991) used a specific multi-product newsvendor model of a firm with one marketing manager per product, a single manufacturing manager, and stochastic manufacturing capacity. Each realization of capacity must be allocated to production of the various stock levels. Effort by the manufacturing manager affects the available capacity and that by the marketing managers affects the stochastic demand. Porteus and Whang suggested incentive mechanisms inducing the Pareto-Optimal solution But in their model, the effort of each participant (manufacturing manager and several product managers) was one-dimensional in the sense that no cooperative effort needed between manufacturing and marketing was explicitly incorporated.

Quantity discount pricing between two parties (the buyer and the supplier) having incentive conflicts was studied by many researchers (Lee and Rosenblatt (1986), Kohli and Park (1989), and Weng (1995)). And inventory control policy for multi-echelon system where one party is thought to represent each tier in the system was extensively studied by Clark, Scarf, and many others. One of the representative paper in this area is Clark and Scarf (1960).

In this paper, we analyze several linear reward mechanisms which induce distinct outputs. Specifically we suggest a linear compensation mechanism which induces the Pareto-Optimal output. The problem of inducing optimal effort when one party's effort influences output of the other, has been extensively studied in the principal-agent theory. Our focus in this paper is on the case where two participating departments affect the performance of each other and the firm's overall performance.

Although we will focus on marketing-manufacturing conflicts, we can apply our analysis to any two interacting parties such as R&D and manufacturing, R&D and marketing, or fashion designer and garment manufacturer. The areas are not restricted to the divisions within a company either. The conflict, for example, between a car maker and parts supplier regarding price, quality, cost, on-time delivery and so on can also be reduced by our method.

Considering its practical and academic significance, interdepartmental conflicts have not yet been studied rigorously. We thus construct a model of compensation scheme by which we attempt to solve the inter-departmental conflicts. After deriving optimal compensation scheme, we provide a numerical example. Then we apply our analysis to the previous models dealing with coordination among multiple participants. Finally practical implications and concluding remarks follow.

2. Notations and Assumptions

It is assumed that marketing and manufacturing departments are the only two participants in a firm. Marketing and manufacturing departments are denoted by 1 and 2 respectively. The effort by marketing department is represented by (e_{11}, e_{12}), where e_{11} is the marketing department's effort put for increasing its own performance and e_{12} is the marketing department's cooperative effort for the other party (i.e. manufacturing department). The latter effort, e_{12}, is helpful for increasing manufacturing department's performance and the firm's overall output. Likewise, e_{21} and e_{22} are the manufacturing department's effort for marketing department and for itself respectively. We can cite several examples for e_{ij}. Marketing department's effort for increasing sales amount and customer satisfaction may be examples of e_{11}. And marketing department's effort to rapidly transmit demand/sales data to manufacturing department can be e_{12} since it helps manufacturing set optimal production schedule and control inventory. As for e_{22} we can think of manufacturing department's effort to control production schedule optimally. Interrupting a normal production schedule in order to meet marketing's rush orders may be an example of e_{21}, where manufacturing's effort increases marketing's performance.

We denote $f(e_{11}, e_{22}, e_{12}, e_{21})$ as the firm's overall output. And V_1 and V_2 are the performance measures for marketing and manufacturing departments respectively. We should note that V_i is not necessarily represented by monetary terms. For example, V_1 may be annual sales amount, profitability, market share, or line breadth of products. And V_2 may include annual mean inventory level, manufacturing cost, production output rate, manufacturing lead-time, ratio of achieving budget level. We model both V_1 and V_2 as functions:

$$V_1 : (e_{11}, e_{21}) \rightarrow R^+, \; V_2 : (e_{22}, e_{12}) \rightarrow R^+.$$

The first function above tells us that marketing department's performance is determined by its own effort for itself and the cooperative effort from the other department. The same applies to the performance measure of manufacturing department, V_2. We have cost functions for each department, C_1 and C_2 respectively, and the domain for C_1 is (e_{11}, e_{12}). That is, marketing department's cost is determined by the effort for its own performance and its cooperative effort for the manufacturing department. Likewise, C_2 is a function of (e_{22}, e_{21}) to R^+. We can also think of a special case of cost function where each department's effort incurs identical cost regardless of whether it is for its own or for the other department. In this case, the cost functions should be of the form: $C_1(e_{11} + e_{12})$ and $C_2(e_{22} + e_{21})$.

The followings are assumed for detailed analysis:

f and V_i are concave, and C_i is convex
f, V_i, and $C_i \geq 0$, and they are twice continuously differentiable
The functional forms of f, V_i, and C_i are known.
The objectives of marketing and manufacturing departments are increasing their own net benefits.
$\partial f/\partial e_{ij} > 0$ for $i, j = \{1, 2\}$ That is, the overall output of the firm is increasing with respect to the effort component. We should note especially that $\partial f/\partial e_{12} > 0$ and $\partial f/\partial e_{21} > 0$
$\partial V_1(e_{11}, e_{21})/\partial e_{11} > 0$ and $\partial V_1(e_{11}, e_{21})/\partial e_{21} > 0$ Likewise the first order partial derivatives of V_2 with respect to the first and the second variable are positive
$\partial C_1(e_{11}, e_{12})/\partial e_{11} > 0$ and $\partial C_1(e_{11}, e_{12})/\partial e_{12} > 0$ Likewise the first order partial derivatives of C_2 with respect to the first and the second variable are positive

Thus in our model, the interdependency between marketing-manufacturing is denoted by the influence of e_{ij} ($i \neq j$) on the other department's performance, V_j. Also those efforts are needed to improve the other department's performance as well as the firm's overall performance, and these are represented by the positive partial derivatives.

3. Compensation Schemes

3.1 Pareto-Optimal Effort Allocation

We first consider the Pareto-Optimal effort allocation of each department. Pareto-Optimality here means that we get the maximum residual for the firm as a whole. The marketing department should consider not only the total amount of its effort (i.e., $e_{11} + e_{12}$) but also its allocation. The same applies to the manufacturing department. The social welfare surplus is

$$f(e_{11}, e_{22}, e_{12}, e_{21}) - C_1(e_{11}, e_{12}) - C_2(e_{22}, e_{21})$$

The Pareto-Optimal effort combination is denoted by $e^P \equiv (e^P_{11},$

e^P_{22}, e^P_{12}, e^P_{21}), and satisfies $f(e^P) - C_1(e^P) - C_2(e^P) \geq 0$. It is assumed that e^P is an interior point such that $e^P_{ij} > 0$ for all i, j. This is because $e^P_{ij} > 0$ is the only meaningful case where we put positive efforts in order to maximize the social welfare. The simultaneous equations for deriving e^P are:

$$\frac{\partial f}{\partial e_{ij}} - \frac{\partial C_i}{\partial e_{ij}} = 0, i, j = 1, 2. \tag{1}$$

As possible ways to induce Pareto-Optimal solution, we focus in this paper on linear compensation schemes in which rewards are linear combinations of performance measures. Linear compensation schemes are easy to implement. There are three kinds of constraints to consider in designing a compensation scheme. First, the compensation scheme should induce the Pareto-Optimal effort which offers the maximum social welfare surplus. This is called *Pareto-Optimality inducing constraint*. The second is *non-deficit constraint* which tells that the sum of compensations for both departments cannot exceed the total output produced: $R_1 + R_2 \leq f$, where R_i is the compensation to department i. The last is called *participation constraint* which says that each department will not work for the firm unless its reward minus cost is greater than or equal to its reservation utility level: $R_i - C_i \geq 0$ assuming reservation level being 0.

We say that (R_1, R_2) is a *full allocation* scheme when no residual is left for the principal, i.e., $R_1 + R_2 = f$. The firm performance, f, can take one of the following two meanings. First, f is the output of efforts from those two departments only. In this case, both departments deserve to ask for full allocation. And full allocation is likely to be an outcome unless either or both departments concede part of their output to the principal. The other context is that f results not only from marketing and manufacturing departments but also from some other factors (e.g., reputation of the firm, general administrative support from the company, facility usage, etc.). In the second case, a 'pseudo department' can be created to claim the residual. In this paper, we mainly consider the first case.

We will now examine four types of linear compensation schemes to see whether they can offer Pareto-Optimal solution.

3.2 Compensation Scheme 1

We first consider allocating the firm's overall output between marketing and manufacturing departments. Suppose α_i fraction of f is given to department i. Since it is not possible to allocate more than what has been produced (non-deficit constraint), we have the following conditions for α_1 and α_2:

$$\alpha_1 + \alpha_2 \leq 1,$$

We restrict, for convenience, our feasible effort allocation to e such that $C_1(e) > 0$ and $C_2(e) > 0$. Then we have the extra conditions of

$$\alpha_1,\ \alpha_2 > 0$$

from the participation constraints. Here we use the overall output f as a base for compensating each department's effort, and we call it compensation scheme 1. We use the overall output as a compensation base to induce the cooperation between the two interacting departments. Their cooperation may result from the incentive to increase the overall output since part of the increment will be allocated to each department. In compensation scheme 1, the objective functions of each department are then:

$$\alpha_1 f(e_{11},\ e_{22},\ e_{12},\ e_{21}) - C_1(e_{11},\ e_{12}),$$
$$\alpha_2 f(e_{11},\ e_{22},\ e_{12},\ e_{21}) - C_2(e_{22},\ e_{21}).$$

Therefore the first order necessary conditions for maximization (i.e., Nash equilibrium conditions) are:

$$\alpha_i \frac{\partial f}{\partial e_{ij}} - \frac{\partial C_i}{\partial e_{ij}} = 0, i, j = 1, 2. \tag{2}$$

Since $0 < \alpha_i < 1$ and $\partial f/\partial e_{ij} > 0$, $i, j = 1,2$, we have

$$\alpha_i \frac{\partial f}{\partial e_{ij}} < \frac{\partial f}{\partial e_{ij}}, i, j = 1, 2.$$

From these and equations (1) to (2), we know that the Nash equilibrium effort exerted by marketing and manufacturing departments under compensation scheme 1, denoted by e^1, satisfies that

$$e^1 \equiv (e_{11}^1, e_{22}^1, e_{12}^1, e_{21}^1) < e^P.$$

This tells us that the effort induced by compensation scheme 1 is less than Pareto-Optimal effort level componentwise, and let us call this phenomenon *under-effort*. Under compensation scheme 1 where only the overall output is used as a compensation base for each participating department, Pareto-Optimal effort allocation cannot be achieved. This *free rider problem* occurs because each department cannot be rewarded fully but partially (α_1 or α_2) from f, and thus compensation scheme 1 cannot induce Pareto-Optimal effort.

In addition to the under-effort phenomenon, there is an *adverse selection* problem such that the more talented party might leave the firm since it does not want to dilute its reward by the other party's bad performance

3.3 Compensation Scheme 2

In compensation scheme 2, we may try using each department's own performance measure, V_1 and V_2 (not the overall firm performance) as our compensation base in order to increase effort level and to avoid effort shortage seen in compensation scheme 1. In compensation scheme 2, the objective functions of each department are:

$$\delta_1 V_1(e_{11}, e_{21}) - C_1(e_{11}, e_{12}),$$
$$\delta_2 V_2(e_{22}, e_{12}) - C_2(e_{22}, e_{21}),$$

where δ_is are such that full allocation is achieved. As depicted in above equation, the performance measure of department 1, V_1, is determined by (e_{11}, e_{21}), and not influenced by e_{22}. The cost function, C_1, is determined by its effort (e_{11}, e_{12}). We can clearly see that

$$\frac{\partial}{\partial e_{ij}}(\delta_i V_i - C_i) = -\frac{\partial C_i}{\partial e_{ij}} < 0, i \neq j. \tag{3}$$

This is because $\partial V_1/\partial e_{12} = 0$, $\partial C_1/\partial e_{12} > 0$, $\partial V_2/\partial e_{21} = 0$, and $\partial C_2/\partial e_{21} > 0$. Therefore under compensation scheme 2, each department is better off by reducing its effort for helping the other department since that incurs cost without any return to itself, and thus the solution will be on the boundary By denoting the effort induced under compensation scheme 2 as $e^2 \equiv (e^2_{11}, e^2_{22}, e^2_{12}, e^2_{21})$, it is derived that

$$(e^2_{12}, e^2_{21}) = (0, 0),$$

which does not satisfy Pareto-Optimality condition. This indicates that each party tends to be stingy on exerting cooperative effort for the other party. Even though the effort for the other is beneficial for the company as a whole, the department is not directly rewarded for its sacrifice and thus does not put the cooperative effort. We will call this phenomenon 'no cooperative effort'.

3.4 Compensation Scheme 3

In compensation scheme 3, we try to use the advantages of compensation schemes 1 and 2 by utilizing both f and V_i as bases for compensating department i. In scheme 3, we set the objective functions of each department for maximization as follows

$$\alpha_1 f(e_{11}, e_{22}, e_{12}, e_{21}) + \beta_1 V_1(e_{11}, e_{21}) - C_1(e_{11}, e_{12}),$$
$$\alpha_2 f(e_{11}, e_{22}, e_{12}, e_{21}) + \beta_2 V_2(e_{22}, e_{12}) - C_2(e_{22}, e_{21}).$$

As in compensation scheme 1, (α_i, β_i) is set in such a way that:

$$(\alpha_1 + \alpha_2) f(e^3) + \beta_1 V_1(e^3) + \beta_2 V_2(e^3) \leq f(e^3),$$
$$\alpha_i f(e^3) + \beta_i V_i(e^3) \geq C_i(e^3), i = 1, 2.$$

Here $e^3 \equiv (e^3_{11}, e^3_{22}, e^3_{12}, e^3_{21})$ denotes the effort induced under compensation scheme 3.

The first order necessary conditions for maximization are:

$$\alpha_1 \frac{\partial f}{\partial e_{11}} + \beta_1 \frac{\partial V_1}{\partial e_{11}} - \frac{\partial C_1}{\partial e_{11}} = 0, \tag{4}$$

$$\alpha_1 \frac{\partial f}{\partial e_{12}} + \beta_1 \frac{\partial V_1}{\partial e_{12}} - \frac{\partial C_1}{\partial e_{12}} = 0, \tag{5}$$

$$\alpha_2 \frac{\partial f}{\partial e_{22}} + \beta_2 \frac{\partial V_2}{\partial e_{22}} - \frac{\partial C_2}{\partial e_{22}} = 0, \tag{6}$$

$$\alpha_2 \frac{\partial f}{\partial e_{21}} + \beta_2 \frac{\partial V_2}{\partial e_{21}} - \frac{\partial C_2}{\partial e_{21}} = 0. \tag{7}$$

As in the analysis of compensation scheme 2, equations (5) and (7) can be simplified as follows:

$$\alpha_1 \frac{\partial f}{\partial e_{12}} - \frac{\partial C_1}{\partial e_{12}} = 0,$$

$$\alpha_2 \frac{\partial f}{\partial e_{21}} - \frac{\partial C_2}{\partial e_{21}} = 0$$

Suppose $e^3 = e^P$. Then four conditions above become

$$(\alpha_1 - 1) \frac{\partial f}{\partial e_{11}} (e^3) + \beta_1 \frac{\partial V_1}{\partial e_{11}} (e^3) = 0, \tag{8}$$

$$(\alpha_1 - 1) \frac{\partial f}{\partial e_{12}} (e^3) = 0, \tag{9}$$

$$(\alpha_2 - 1) \frac{\partial f}{\partial e_{22}} (e^3) + \beta_2 \frac{\partial V_2}{\partial e_{22}} (e^3) = 0, \tag{10}$$

$$(\alpha_2 - 1) \frac{\partial f}{\partial e_{21}} (e^3) = 0. \tag{11}$$

Since e^P is assumed to be an interior point, we derive $\alpha_1 = \alpha_2 = 1$ and $\beta_1 = \beta_2 = 0$ from the conditions above. This contradicts the non-deficit condition. Therefore we conclude that e^3 cannot be equal to e^P, and compensation scheme 3 cannot induce the Pareto-Optimal solution either.

3.5 Compensation Scheme 4

Finally in compensation scheme 4, we enlarge compensation base to (f, V_1, V_2) for rewarding each department. V_2 is included for rewarding department 1. Therefore one department's compensation is affected by the other's performance. The objective function of department 1 for maximization in compensation scheme 4 is:

$$\alpha_1 f(e_{11}, e_{22}, e_{12}, e_{21}) + \beta_1 V_1(e_{11}, e_{21}) + \gamma_1 V_2(e_{22}, e_{12}) - C_1(e_{11}, e_{12}).$$

Likewise department 2's objective function is

$$\alpha_2 f(e_{11}, e_{22}, e_{12}, e_{21}) + \beta_2 V_2(e_{22}, e_{12}) + \gamma_2 V_1(e_{11}, e_{21}) - C_2(e_{22}, e_{21}).$$

As in compensation scheme 1, $(\alpha_i, \beta_i, \gamma_i)$ is set in such a way that:

$$(\alpha_1 + \alpha_2) f(e^4) + (\beta_1 + \gamma_2) V_1(e^4) + (\beta_2 + \gamma_1) V_2(e^4) \le f(e^4),$$
$$\alpha_1 f(e^4) + \beta_1 V_1(e^4) + \gamma_1 V_2(e^4) \ge C_1(e^4),$$
$$\alpha_2 f(e^4) + \beta_2 V_2(e^4) + \gamma_2 V_1(e^4) \ge C_2(e^4).$$

The first condition above represents the non-deficit constraint. And the second and the third ones are the participation constraints for departments 1 and 2 respectively. Here $e^4 \equiv (e^4_{11}, e^4_{22}, e^4_{12}, e^4_{21})$ denotes the effort induced under compensation scheme 4.

The conditions for Nash equilibrium are.

$$\alpha_i \frac{\partial f}{\partial e_{ii}} + \beta_i \frac{\partial V_i}{\partial e_{ii}} - \frac{\partial C_i}{\partial e_{ii}} = 0,$$

$$\alpha_j \frac{\partial f}{\partial e_{jk}} + \gamma_j \frac{\partial V_k}{\partial e_{jk}} - \frac{\partial C_j}{\partial e_{jk}} = 0, j, k = 1, 2, j \neq k.$$

In order to satisfy Pareto-Optimality inducing constraint, the simultaneous equations above should have e^P as a solution. For this, we should choose appropriate coefficients for compensation, $(\alpha_i, \beta_i, \gamma_i, i = 1,2)$, among the possible combinations satisfying the relevant conditions. We first substitute β_i and γ_i with α_i. Then we get the followings:

$$\beta_1 = \frac{\partial C_1 / \partial e_{11}(e^P)}{\partial V_1 / \partial e_{11}(e^P)} - \frac{\partial f / \partial e_{11}(e^P)}{\partial V_1 / \partial e_{11}(e^P)} \alpha_1, \tag{12}$$

$$\gamma_1 = \frac{\partial C_1 / \partial e_{12}(e^P)}{\partial V_2 / \partial e_{12}(e^P)} - \frac{\partial f / \partial e_{12}(e^P)}{\partial V_2 / \partial e_{12}(e^P)} \alpha_1, \tag{13}$$

$$\beta_2 = \frac{\partial C_2 / \partial e_{22}(e^P)}{\partial V_2 / \partial e_{22}(e^P)} - \frac{\partial f / \partial e_{22}(e^P)}{\partial V_2 / \partial e_{22}(e^P)} \alpha_2, \tag{14}$$

$$\gamma_2 = \frac{\partial C_2 / \partial e_{21}(e^P)}{\partial V_1 / \partial e_{21}(e^P)} - \frac{\partial f / \partial e_{21}(e^P)}{\partial V_1 / \partial e_{21}(e^P)} \alpha_2. \tag{15}$$

From the Pareto-Optimality conditions, we can derive

$$\frac{\partial f}{\partial e_{ij}}(e^P) = \frac{\partial C_i}{\partial e_{ij}}(e^P), i, j = 1,2. \tag{16}$$

Using these and the substitutions above (equations (12) to (15)and (16)), we can simplify the non-deficit condition We first define the following notations for simplicity

$$A \equiv f(e^P) - \frac{\partial C_1 / \partial e_{11}(e^P)}{\partial V_1 / \partial e_{11}(e^P)} V_1(e^P) - \frac{\partial C_1 / \partial e_{12}(e^P)}{\partial V_2 / \partial e_{12}(e^P)} V_2(e^P),$$

$$B \equiv f(e^P) - \frac{\partial C_2 / \partial e_{21}(e^P)}{\partial V_1 / \partial e_{21}(e^P)} V_1(e^P) - \frac{\partial C_2 / \partial e_{22}(e^P)}{\partial V_2 / \partial e_{22}(e^P)} V_2(e^P),$$

$$D \equiv f(e^P) - [\frac{\partial C_1 / \partial e_{11}(e^P)}{\partial V_1 / \partial e_{11}(e^P)} + \frac{\partial C_2 / \partial e_{21}(e^P)}{\partial V_1 / \partial e_{21}(e^P)}] V_1(e^P)$$
$$- [\frac{\partial C_1 / \partial e_{12}(e^P)}{\partial V_2 / \partial e_{12}(e^P)} + \frac{\partial C_2 / \partial e_{22}(e^P)}{\partial V_2 / \partial e_{22}(e^P)}] V_2(e^P).$$

Using these notations, we can represent the non-deficit condition as:

$$A\alpha_1 + B\alpha_2 \leq D.$$

For the following analysis of non-deficit condition, we assume that $AB \neq 0$ in order to have half-space as our region of (α_1, α_2) satisfying non-deficit condition. For general forms of (f, V_1, V_2, C_1, C_2), the condition of $AB \neq 0$ is not restrictive. An important case where $AB \neq 0$ is not satisfied is that $f = V_1 + V_2$ In this special case, we note that $A = B = 0$, $D < 0$, and thus there is no (α_1, α_2) satisfying the non-deficit condition among Pareto-Optimality inducing compensation scheme 4.

Proposition 1. *The non-deficit condition excludes the points of* $(\alpha_1, \alpha_2) = \{(1,0),(0,1),(1,1)\}$.

This proposition can be easily proved using the fact that e^P is an interior point and the functions f, C_i, and V_i are increasing.

Defining

$$E \equiv [C_1 - \frac{\partial C_1 / \partial e_{11}(e^P)}{\partial V_1 / \partial e_{11}(e^P)} V_1 - \frac{\partial C_1 / \partial e_{12}(e^P)}{\partial V_2 / \partial e_{12}(e^P)} V_2](e^P),$$

$$F \equiv [C_2 - \frac{\partial C_2 / \partial e_{21}(e^P)}{\partial V_1 / \partial e_{21}(e^P)} V_1 - \frac{\partial C_2 / \partial e_{22}(e^P)}{\partial V_2 / \partial e_{22}(e^P)} V_2](e^P),$$

the inequality representing the participation constraint for department 1 ($[\alpha_1 f + \beta_1 V_1 + \gamma_1 V_2](e^P) \geq C_1(e^P)$) can be represented as

$$\alpha_1 A \geq E.$$

Likewise the corresponding constraint for department 2 in terms of α_2 is

$$\alpha_2 B \geq F.$$

From these participation constraints, we can derive the following characteristic.

Propositon 2. The (α_1, α_2) *satisfying participation constraints should include* (1,0) and (0,1).

Proof: Since $f(e^P) \geq C_1(e^P)$, we have $A \geq E$. This implies that $(\alpha_1, \alpha_2) = (1,0)$ should be in the region where the participation constraint for department 1 is satisfied. The same logic applies to the case of department 2

We are now going to show that the point, $(E/A, F/B)$, is in the region of $A\alpha_1 + B\alpha_2 \geq D$, which defines the non-deficit region.

Proposition 3. $(\frac{E}{A}, \frac{F}{B})$ *satisfies the non-deficit constraint of* $A\alpha_1 + B\alpha_2 \leq D$.

Proof:

$$A\frac{E}{A} + B\frac{F}{B}$$
$$= E + F$$
$$= [(C_1 + C_2) - \left[\frac{\partial C_1 / \partial e_{11}(e^P)}{\partial V_1 / \partial e_{11}(e^P)} + \frac{\partial C_2 / \partial e_{21}(e^P)}{\partial V_1 / \partial e_{21}(e^P)}\right]V_1$$
$$- \left[\frac{\partial C_1 / \partial e_{12}(e^P)}{\partial V_2 / \partial e_{12}(e^P)} + \frac{\partial C_2 / \partial e_{22}(e^P)}{\partial V_2 / \partial e_{22}(e^P)}\right]V_2](e^P) \leq D$$

The last inequality is equal to $[C_1 + C_2](e^P) \leq f(e^P)$, which is assumed from the existence of e^P

We should note that Propositions 1 through 3 hold regardless of the signs of A, B, D, E, and F. We see that the (α_1, α_2) combinations in the shaded area of Figure 1 could induce the Pareto-Optimal effort allocation via compensation scheme 4. We will call this region of (α_1, α_2) a *feasible triangle.* Assume that $D > 0$ from now on. For the cases where $D \leq 0$, we have the feasible triangle in different forms but can analyze in a similar manner. Due to the positive first order partial derivatives, we have $0 < D < A$, $0 < D < B$, and thus the intersections along the axes of the non-deficit constraint are smaller than 1. Thus,

$$0 < D/A < 1,\ 0 < D/B < 1.$$

We can also refine the feasible triangle using the following proposition.

Proposition 4. *When* $D > 0$, *we have* $E > D - B$ *and* $F > D - A$. *That is,* $(\hat{\alpha}_1, \hat{\alpha}_2)$ *achieving Pareto-Optimality should satisfy* $(\hat{\alpha}_1, \hat{\alpha}_2)$

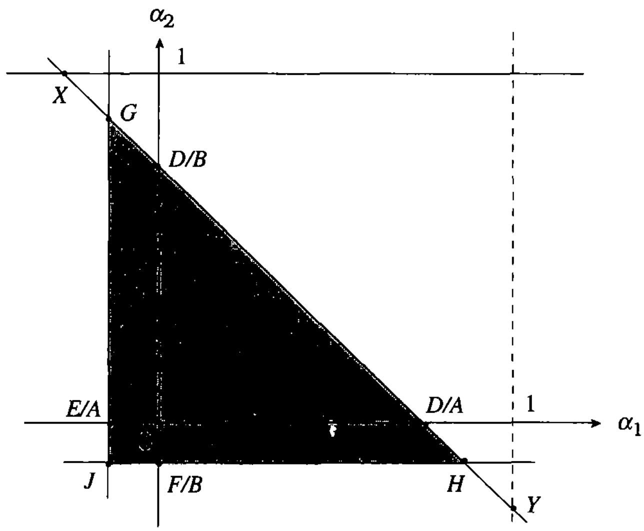

Figure 1. Feasible Triangle

< (1,1).

Proof: Let X be the point intersected by $A\alpha_1 + B\alpha_2 = D$ and $\alpha_2 = 1$. Then we get $X = ((D - B)/A, 1)$. Since $E - (D - B) = C_1(e^P) > 0$, we have

$$E/A > (D - B)/A$$

This implies that $\hat{\alpha}_2 < 1$. Likewise, we get $F/B > (D - A)/B$ and thus $\hat{\alpha}_1 < 1$. And the result follows.

We have shown in Proposition 4 that all (α_1, α_2) combinations inducing Pareto-Optimal solutions should satisfy $\alpha_i < 1$ when $D > 0$. The (α_1, α_2) combinations on the line segment (G, H) are the fractions by which Pareto-Optimal surplus are fully distributed between the two departments with no residual. They are Pareto-Optimal full allocation compensation schemes. The point J represents the case where both departments are rewarded just to meet their reservation levels. According to Proposition 2, J should be in the third quadrant as in Figure 1. Suppose M in the feasible triangle is chosen as a compensation scheme coefficient, then the Pareto-Optimal effort allocation is induced (with appropriate β_i and γ_i) but there occurs positive amount of residual. Now let us check the sign of (β_i, γ_i)

Proposition 5. *In the optimal compensation scheme 4 where D > 0, we should give positive reward according to each department's individual performance. That is,* $(\beta_i, \gamma_i) > (0, 0)$ *for* $i = 1, 2$ *when* $D > 0$.

Proof: Now using the Pareto-Optimality conditions (equations (16)) and $\hat{\alpha}_i < 1$ from Proposition 4, we get

$$\beta_i = \frac{\dfrac{\partial C_i}{\partial e_{ii}}(e^P)}{\dfrac{\partial V_i}{\partial e_{ii}}(e^P)}(1-\alpha_i) > 0, i = 1, 2, \tag{17}$$

$$\gamma_j = \frac{\dfrac{\partial C_j}{\partial e_{jk}}(e^P)}{\dfrac{\partial V_k}{\partial e_{jk}}(e^P)}(1-\alpha_j) > 0, j \neq k. \tag{18}$$

Therefore we have shown that the coefficients for each department's performance in compensation scheme 4 inducing Pareto-Optimality should be positive, that is, $(\beta_1, \beta_2, \gamma_1, \gamma_2) > 0$ when $D > 0$.

And we finally summarize one of our main results in Theorem 1

Theorem 1. *Among the four reward schemes, compensation scheme 4 is the only one which induces the Pareto-Optimal effort,* e^P.

This theorem says that compensation scheme 4 lets both departments to share the largest pie and thus is Pareto-better than other compensation schemes. The reason for this is that each department had better help the other since its reward comes partly from the performance of the other. Here, not only its own performance (V_i) but also the other party's performance (V_j) in addition to the overall output, f, are included in a base for rewarding i. In compensation scheme 4, one department's helping the other is consistent with increasing its own reward.

In case $D \leq 0$, the feasible triangle does not contain (0, 0) for $(\hat{\alpha}_1, \hat{\alpha}_2)$. This implies that with only (V_1, V_2) as a linear compensation base, we can not achieve the Pareto-Optimal solution. In this case, we need f in addition to a linear combination of V_1 and V_2 for inducing the Pareto-Optimal solution. Even when $D > 0$ and thus $E \leq 0$ and $F \leq 0$, *full allocation* compensation is not achievable with a linear combination of V_1 and V_2 while excluding the overall performance, f.

The exact compensation scheme coefficients (represented by a point in the feasible triangle) can be determined by a bargaining process among the participants. Regarding the equilibrium of the bargaining, readers can refer to Eliasberg (1986), Nash (1950), and Kalai and Smordinsky (1975).

4. Numerical Example

In this section, a numerical example is considered. The overall output function, cost functions, and individual performance measures are given as follows.

$$f = 15 + e_{12}e_{21} - [(e_{11} - 1)^2 + (e_{22} - 1)^2 + (e_{12} - 1)^2 + (e_{21} - 1)^2],$$

$$C_1 = e_{11} + e_{12},$$

$$C_2 = e_{22} + e_{21},$$

$$V_1 = 4 - (e_{11} + e_{21} - 2)^2,$$

$$V_2 = 4 - (e_{22} + e_{12} - 2)^2,$$

$$0 \leq e_{ij} \leq 1, i, j = 1, 2.$$

In f, we can see the effects of inter-departmental help The separate effects are represented by $-(e_{12} - 1)^2$ and $-(e_{21} - 1)^2$, and joint effect is denoted by the term, $e_{12}e_{21}$.

4.1 Pareto-Optimal Solution

Let $\pi \equiv f - C_1 - C_2$. We can see that C_i is a linear function and thus convex. Also V_i is concave and increasing function on the domain. We can verify the concavity of f using the Hessian of f.

The first order necessary conditions for maximizing π are:

$$\frac{\partial \pi}{\partial e_{11}} = -2(e_{11} - 1) - 1 = 0,$$
$$\frac{\partial \pi}{\partial e_{22}} = -2(e_{22} - 1) - 1 = 0,$$
$$\frac{\partial \pi}{\partial e_{12}} = -2(e_{12} - 1) + e_{21} - 1 = 0,$$
$$\frac{\partial \pi}{\partial e_{21}} = -2(e_{21} - 1) + e_{12} - 1 = 0.$$

From these four equations, we get the following Pareto-Optimal effort allocation:

$$e^P = (1/2, 1/2, 1, 1).$$

The overall output, costs, and social welfare(π) are:

$$f(e^P) = 15.5, \; C_1(e^P) = 1.5, \; C_2(e^P) = 1\ 5, \; \pi(e^P) = 12.5$$

4.2 Compensation Scheme 1

For simplicity, let us use the fair partition of the total output in compensation scheme 1 by taking $\alpha_1 = \alpha_2 = 0.5$. Then the residual for each department are:

$$\pi_1 = 0.5f - C_1,$$
$$\pi_2 = 0.5f - C_2.$$

Suppose that two departments play a simultaneous game, i.e., they put their effort simultaneously, not sequentially. Then we get the following four equations for a Nash equilibrium.

$$\frac{\partial \pi_1}{\partial e_{11}} = -(e_{11} - 1) - 1 = 0,$$
$$\frac{\partial \pi_1}{\partial e_{12}} = -(e_{12} - 1) + 0.5e_{21} - 1 = 0,$$
$$\frac{\partial \pi_2}{\partial e_{22}} = -(e_{22} - 1) - 1 = 0,$$

$$\frac{\partial \pi_2}{\partial e_{21}} = -(e_{21}-1) + 0.5e_{12} - 1 = 0.$$

From these equations, we get:

$$e^1 = (0,0,0,0),\ \ f(e^1) = 11,\ \ C_1(e^1) = C_2(e^1) = 0,\ \ \pi = \pi_1 + \pi_2 = 11.$$

Thus using compensation scheme 1, we lose the social welfare by 1.5 behind the Pareto-Optimal solution. The efforts induced from compensation scheme 1 is less than those from the Pareto-Optimal solution componentwise, and thus the free-rider problem occurs.

4.3 Compensation Scheme 2

The utility of department 1 is:

$$\pi_1 = \delta V_1 - C_1 = \delta[4-(e_{11}+e_{21}-2)^2] - (e_{11}+e_{12}).$$

Since $\partial\pi_1/\partial e_{12} = -1 < 0$, $e_{12}^2 = 0$. Likewise, we get $e_{21}^2 = 0$. Choosing δs such that we have a full allocation scheme, we derive $\delta_1 = \delta_2 = 13/6$, $e_{11}^2 = 1$, and $e_{22}^2 = 1$. We can summarize the results as follows:

$$e^2 = (1,1,0,0),\ \ f(e^1) = 13,\ \ \pi_1(e^2) = \pi_2(e^2) = 5.5,$$
$$\pi(e^2) = f(e^2) - C_1(e^2) - C_2(e^2) = 11.$$

Thus we are still 1.5 behind the Pareto-Optimal solution. Again, the cooperation for the other department becomes smaller than that in the Pareto-Optimal solution.

4.4 Compensation Scheme 3

In compensation scheme 3, the utility of department i is:

$$\alpha_i f + \beta_i V_i - C_i.$$

Using the symmetry of functions involved (f, C_i, V_i), let us restrict our attention to the case of $\alpha_1 = \alpha_2$ and $\beta_1 = \beta_2$. The equations for maximizing π_1 and π_2 are:

$$2\alpha(1 - e_{11}) + 2\beta(1 - e_{11} - e_{21}) = 1, \tag{19}$$

$$\alpha(e_{21} - 2e_{12} + 2) = 1, \tag{20}$$

$$2\alpha(1 - e_{22}) + 2\beta(1 - e_{22} - e_{12}) = 1, \tag{21}$$

$$\alpha(e_{12} - 2e_{21} + 2) = 1. \tag{22}$$

From the equations (20) and 22),

$$e_{12} = e_{21} = 2 - \frac{1}{\alpha}.$$

Since $\alpha \leq 0.5$ from the non-deficit condition, we have $2 - 1/\alpha \leq 0$ and thus get

$$e_{12}^3 = e_{21}^3 = 0.$$

Then from the equations (19) and (21), we can derive

$$e_{11}^3 = e_{22}^3 = 1 - \frac{1}{2(\alpha + \beta)}$$

Thus given (α, β), the effort induced in compensation scheme 3 is

$$e^3 = (1 - \frac{1}{2(\alpha + \beta)},\ 1 - \frac{1}{2(\alpha + \beta)},\ 0,\ 0).$$

We can easily derive

$$f(e^3) = 13 - \frac{1}{2(\alpha + \beta)^2},$$

$$C_1(e^3) + C_2(e^3) = 2 - \frac{1}{\alpha + \beta},$$

$$\pi(e^3) = 11 + \frac{1}{\alpha + \beta} - \frac{1}{2(\alpha + \beta)^2}.$$

We will show that, for any pair of (α, β), the π in compensation scheme 3 is worse than the Pareto-Optimal solution. It suffices to show that

$$\frac{2(\alpha+\beta)-1}{2(\alpha+\beta)} < 1.5.$$

Denoting $x = \alpha + \beta$ and $g(x) = (2x - 1)/(2x^2)$, we see that $g(x) < 1.5$ for every real number x since $3x^2 - 2x + 1 = 3(x - 1/3)^2 + 2/3 > 0$. Thus,

$$\max_{(\alpha,\beta)} \pi(e^3(\alpha,\beta)) < \pi(e^P).$$

Actually the valid (α, β) for consideration from non-deficit constraint should satisfy the following.

$$2(13\alpha+3\beta)(\alpha+\beta)^2 + 0\ 5 \le 13(\alpha+\beta)^2 + 2\beta(\alpha+\beta) + \frac{2\alpha+\beta}{2}.$$

In the special case of $\alpha = 0.25$ and $\beta = 1$, we get $f = 12.68$ and $\pi = 11.48$, which is worse than the Pareto-Optimal solution.

4.5 Compensation Scheme 4

We should first find the appropriate coefficients $(\alpha_i, \beta_i, \gamma_i)$ for compensation scheme 4 which induce the Pareto-Optimal solution. We can easily derive the followings:

$$\frac{\partial C_1}{\partial e_{11}}(e^P) = 1,\ \frac{\partial C_2}{\partial e_{22}}(e^P) = 1,\ \frac{\partial C_1}{\partial e_{12}}(e^P) = 1,\ \frac{\partial C_2}{\partial e_{12}}(e^P) = 1,$$

$$\frac{\partial V_1}{\partial e_{11}}(e^P) = 1,\ \frac{\partial V_2}{\partial e_{22}}(e^P) = 1,\ \frac{\partial V_1}{\partial e_{21}}(e^P) = 1,\ \frac{\partial V_2}{\partial e_{12}}(e^P) = 1.$$

Now we check the constraint ($*$) for compensation scheme 4:

$$2V_1(e^P) + 2V_2(e^P) < f(e^P).$$

This is satisfied since the left hand side is 15 and $f(e^P) = 15.5$. We can calculate:

$$A = B = 8,\ D = 0.5,\ E = F = -6.$$

The symmetric Pareto-Optimal full allocation scheme is when

$$\alpha_1 = \alpha_2 = \frac{1}{32}, \text{ and}$$

$$\beta_1 = \beta_2 = \gamma_1 = \gamma_2 = \frac{31}{32}$$

4.6 Summary Table of the Example

	Scheme 1	Scheme 2	Scheme 3	Scheme 4
Reward to dept 1	0 5f	V_1	0 25f+V_1	1/32f+31/32V_1+31/32V_2
Reward to dept 2	0.5f	V_2	0.25f+V_2	1/32f+31/32V_1+31/32V_2
e^i	(0,0,0,0)	(1,1,0,0)	(0 6,0.6,0,0)	(0.5,0 5,1,1)
f	11	13	12 68	15 5
C_1+C_2	0	2	1 2	3
π	11	11	11 48	12 5

5. Connections to Previous Works

We can apply our method to get the Pareto-Optimal solution for the following sample cases where coordination among multiple parties is required We took the same notations in the original papers for comparison purpose.

5.1 Multi-Echelon Inventory

We can apply our analysis to (Clark and Scarf 1960). Let $V_1^n \equiv C_n(x_1, w_1)$ and $\tilde{V}_2^n \equiv \min_{z\geq 0}\{c(z) + \tilde{L}(x_2) + \alpha \int_0^\infty g_{n-1}(x_2 + z - t)\phi(t)dt\}$. Substituting $V_2^n \equiv \tilde{V}_2^n + \Lambda_n(x_2)$, we can use (V_1^n, V_2^n) as a compensation scheme for echelon 1 and 2 for $n-th$ stage decision. By allocating $\alpha_1 R^n - \beta_1 V_1^n$ to echelon 1 and $\alpha_2 R^n - \beta_2 V_2^n$ to echelon 2 where R^n is the sales revenue from the outside consumers, we can induce the optimal decision of each echelon by setting the coefficients appropriately.

5.2 Cooperative Quantity Discount Policy

For the model of Kohli and Park (1989), let $V_1 = \Pi(x)$ and $V_2 = R - C(x)$, where $R = p^r D$ is the sales revenue from the outside consumers per unit time and p^r = retail price per unit. Then by allocating $\beta_1 V_1 + \gamma_1 V_2$ to the seller and $\beta_2 V_2 + \gamma_2 V_1$ to the buyer, where

$$\beta_1 = \gamma_1 = \frac{\Pi(0) + D(p^* - p_{min})}{\Pi(0) - C(0) + D(p^r + p_{max} - p_{min})},$$
$$\beta_2 = \gamma_2 = 1 - \beta_1,$$

we can induce both the seller and the buyer to follow the Pareto-Optimal solution. Any value of $\beta_1 = \gamma_1$ with $\beta_2 = \gamma_2 = 1 - \beta_1$ in the following band induce the Pareto-Optimal solution:

$$\frac{\Pi(0)}{\Pi(0) - C(0) + D(p^r + p_{max} - p_{min})} \le \beta_1$$
$$\le \frac{\Pi(0) + D(p_{max} - p_{min})}{\Pi(0) - C(0) + D(p^r + p_{max} - p_{min})}.$$

5.3 Channel Coordination Thru Quantity Discount

Regarding the model in Weng (1995), we can take $V_1(p) = (p - c)D(x) - S_s D(x)/Q - h_s Q/2$ and $V_2(x, Q) = (x - p)D(x) - S_b D(x)/Q - h_b Q/2$. Then allocating $q(V_1 + V_2)$ and $(1 - q)(V_1 + V_2)$ to the seller and to the buyer respectively, we can induce the optimal solution by choosing q such that

$$q_{min} \le q \le q_{max},$$

where $q_{min} \equiv G_b^*/G_J^*$ and $q_{max} \equiv 1 - G_s^*/G_J^*$, and G_J^* is the joint optimal objective function value.

6. Practical Implications

When there is no relevance between the two departments, mutual help is not needed for Pareto-Optimality. However in an industry with highly positive cross impacts, we had better induce each other's cooperation in order to maximize the pie for distribution. We have to utilize the characteristic

$$\frac{\partial f}{\partial e_{ij}}, \ \frac{\partial V_i}{\partial e_{ij}} >> 0, i \neq j.$$

Here, one department should devote some of its effort for the other since the effort may be extremely beneficial to the firm's overall output. Thus, a compensation mechanism which gives an incentive to help each other is needed.

Intuitively we can suggest both the firm's overall output and a department's performance as a compensation base. But it was shown that this kind of compensation schemes (compensation scheme 3) cannot induce full amount of cross-helping effort which is required for Pareto-Optimality. We thus recommended a compensation scheme which combines the overall output and both parties' performances altogether as a compensation base. This result may have a practical implication in setting up a compensation scheme to induce cooperative team work.

We now take the case of Salomon Brothers Inc. as a practical example. In October, 1994, Salomon introduced a new compensation scheme for managing directors in customer businesses. In the new scheme, managing directors were supposed to be paid a fixed minimum amount (average of 35% of 1994 pay) plus 40% of the earnings of the client-driven business in excess of an after-tax return to shareholders (initially set at 7%). With the new pay system, Salomon began managing its client-driven business as a single integrated global operation using one pay pool instead of a group of 11 related but separate businesses. As a result, managing directors in Salomon's customer businesses have their pay linked to the performance of a wide variety of businesses, ranging from investment banking to equities to fixed income. The motives for this scheme may be risk-pooling effect among employees and increasing the performance of the company as a whole and thus increasing stockholders' value. It was expected that under the new scheme each director would have the incentive to pass over a valuable information to those in other divisions since doing so would increase the firm's overall profit. The effort for increasing the overall profit f would be induced and this would benefit the stock prices Introduction of the new scheme can be interpreted as the transition from compensation scheme 2 to compensation scheme 1 in our model. Reward in the new system can be represented as $m + 0.4[f - F]^+$, where m is the minimum payment assured, F is the fixed amount to be handed over to stockholders, and $[x]^+ = x$ if $x \geq 0$ and 0 otherwise.

Contrary to the expectations, the overall profit and stock prices fell sharply(from \$52 1994 to \$34 May, 1995) undermining the company value as a whole, and many competitive traders and investment bankers left the company. These are under-effort phenomenon and the adverse selection respectively, and could have been expected from the analysis of compensation scheme 1 in this paper. New executives' compensation in 1996 came to be based on a combination of the firm's return on equity, the profits generated by each particular business unit and individual productivity.

7. Concluding Remarks

In this paper, we showed that in order to achieve the Pareto-Optimal solution, we need (f, V_1, V_2) as a linear compensation base. That is, the reward to department 1 should be dependent not only on the overall performance(f) and its own performance (V_1) but also on the other party's outcome (V_2). Under the above compensation scheme, we could induce the Pareto-Optimal solution since one department had better help the other for its own benefit. By using the reward calculated from linear combination of (f, V_1, V_2) with appropriate coefficients, we could exactly align the incentives of all the parties involved. We showed that in general utilizing a part of (f, V_1, V_2) as a compensation base could not induce the Pareto-Optimal full allocation.

Conflicts among participants usually involve in fighting over limited resources. There are several cases where each devision within a firm tries to take larger portion of a limited resources such as manufacturing capacity, human resources, and financial resources. Even to these cases, our compensation scheme can also be applied by inducing each other's sacrifice for its own benefit.

To make one participant's goal congruent to that of the other participant. we might also suggest other mechanisms than reward schemes such as organization design and communication among the participants. In implementing compensation scheme 4 in the highly cross-impact industry, we may have difficulty in figuring the appropriate forms of V_i even though C_i is known widely. In this case, we should consider combining these two closely related departments (organization design). If we successfully combine those two parties and once they have the same objective, then we may induce the first best solution. Currently, several firms use task force or project team in many instances where close cooperations are necessary for success. And they try to have the team members share the same goal throughout the project. This trend is consistent with the suggestion made in this paper Also we can encourage corporate culture and communication among the participants which make the members value cooperation highly (communication). This approach is extremely profitable since it covers more than just monetary compensation. And there are lots of companies whose successes are mainly dependent on organization design and/or communication mechanism.

Although a reward scheme seems to be a good mechanism for resolving conflict and inducing cooperation among parties involved, we should study in depth the conditions that limit its effectiveness. Empirical studies testing the validity of our model and further research on which mechanism is more effective in inducing cooperation should follow in the future.

References

Bushman, R.M , Indjejikian, R J and A. Smith, 1995, Aggregate Performance Measures in Business Unit Manager Compensation The Role of Intrafirm Interdependencies, *Journal of Accounting Research* 33, 101-128

Clark, A J and H Scarf, 1960, Optimal Policies for a Multi-Echelon Inventory Problem, *Management Science* 6, 475-490.

Crittenden, V L , 1992, Close the Marketing/Manufacturing Gap, *Sloan Management Review*, Spring, 41-52.

Crittenden, V.L., L.R. Gardiner, and A Stam, 1993, Reducing Conflict between Marketing and Manufacturing, *Industrial Marketing Management*, 22, 299-309.

Eliashberg, J , 1986, Arbitrating a Dispute· A Decision Analytic Approach, *Management Science*, 32, 963-974.

Eliashberg, J. and R. Steinberg, 1987, Marketing-Production Decisions in an Industrial Channel of Distribution, *Management Science*, 33, 981-1000.

Hayes, R H. and S.C. Wheelwright, 1984, *Restoring Our Competitive Edge: Competing Through Manufacturing* (John Wiley & Sons, New York).

Holmstrom, B., 1982, Moral Hazard in Teams, *Bell Journal of Economics*, 13, 324-340

Kalai, E. and D. Smordinsky, 1975, Other Solutions to Nash's Bargaining Problem, em *Econometrica*, 43, 513-518

Kohli, R. and H. Park, 1989, A Cooperative Game Theory Model of Quantity Discounts, *Management Science* 35, 693-707

Lee, H. L. and M. J Rosenblatt, 1986, A Generalized Quantity Discount Pricing Model to Increase Supplier's Profits, *Management Science*, 32, 1177-1185

John, C.H. St. and E.H Hall, Jr., 1991, The Interdependency Between Marketing and Manufacturing, *Industrial Marketing Management*, 20, 223-229

Nash, J. F., 1950, The Bargaining Problem, *Econometrica*, 18, 155-162.

Porteus, E. L and S. Whang, 1991, On Manufacturing/Marketing Incentives, *Management Science*, 37, 1166-1181

Shapiro, B P , 1977, Can marketing and manufacturing coexist?, *Harvard Business Review*, Sept.-Oct. 104-114.

Souder, W.E and A K. Charkabarti, 1978, The R&D Marketing Interface Results from an Empirical Study of Innovation Projects, *IEEE Transactions on Engineering Management*, Nov., 88-93.

Weng, Z. K., 1995, Channel Coordination and Quantity Discounts, *Management Science*, 41, 1509-1522