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A MULTI-TASK PRINCIPAL-AGENT APPROACH TO ORGANIZATIONAL FORM*

DAVID BESANKO†
PIERRE RÉGIBEAU‡
KATHARINE E. ROCKETT§

This paper studies the choice of organizational forms in a multi-task principal-agent model. We compare a functional organization in which the firm is organized into functional departments such as marketing and R&D to a product-based organization in which the firm is organized into product lines. Managers' compensation can be based on noisy measures of product-line profits. Measures of a functional area's contribution to total profits are not available, however. This effect favors the product organization. However, if there are significant asymmetries between functional area contributions to organizational success and cross-product externalities within functions, organizing along functional lines may dominate the product organization. The functional organization can also dominate when a function is characterized by strong externalities while the other is not.

I. INTRODUCTION

A SIGNIFICANT PART OF THE BUSINESS COMMUNITY'S THINKING about the internal structure of firms revolves around designing and implementing 'organizational charts.' These schematic representations are part of every consultant's toolbox and have found their ways into most annual reports and quite a few business school cases. Such charts display three important dimensions of the firm's internal design: the number of levels in the hierarchy, the span of control of managers at each of these levels, and the main criterion according

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†Authors' affiliations: Kellogg School of Management, Northwestern University, Evanston, Illinois, U.S.A.
e-mail: d-besanko@kellogg.northwestern.edu
‡Department of Economics, University of Essex, Wivenhoe Park, Colchester, U.K.
e-mail: pregib@essex.ac.uk
§Department of Economics, University of Essex, Wivenhoe Park, Colchester, U.K.
e-mail: kerock@essex.ac.uk

to which the organizational 'tree' is divided into branches. This paper examines this last dimension more closely.

We compare the relative profitability of a firm when it organizes along product lines to that when it organizes along functional lines. Our firm produces two products, each of which requires the contributions of two functional areas (e.g., marketing and manufacturing). Under either organizational form, a manager must supervise two activities. In a product-based organization, the head of a each product division must supervise the two functional activities required to ensure the success of her product line. In a functional organization, the head of each functional division must supervise the function's activities on behalf of each of the firm's two products. Each division head is modelled as a risk-averse agent who must be motivated to expend effort on supervising each activity under her control. The principal can induce such efforts by tying the manager's reward to the imperfectly measured profits of each product line.[1] On the other hand measures of the profits generated by each functional area are assumed not to be available.

To focus on the choice of the organization's 'organizing dimension' (functional versus product), our model does not consider the other key elements of the organizational structure problem: the number of levels in the hierarchy and the span of control of managers. For this reason, this paper does not provide a complete theory of endogenous organizational structure. Our objective instead is to identify economic forces that systematically favor organizing along a product dimension versus a functional dimension.

The key findings of our analysis are as follows. When all products and all functions enter symmetrically into the profit and effort functions, the product-based organization involves a lower agency cost than the functional organization. The intuition is that tying a product manager's reward to the profits of her own product line is sufficient to induce symmetric levels of efforts in the supervision of each of the two activities under her control. By contrast, because the principal can only use measures of product line profits, the pay of functional managers must be tied to all profit measures to elicit positive effort on all tasks. Hence, the reward of a product division manager can be tied to the profits of other product divisions in order to provide her with some insurance so that the same level of effort can be implemented at lower cost than in the functional organization as the product managers bear less risk. For example, if the measures of profits for the two product lines are positively correlated, a product manager's reward can be linked negatively to the profits of the other product division, lessening the manager's exposure to risk.

[1] Hence, in contrast to Maskin, Qian and Xu [2000], the information structure of both product and functional organisations is the same in our model. We discuss the significance of this in section 3.1.

We then consider the effect of various asymmetries on the relative performance of the two organizations. We show that asymmetries between functions as well as asymmetries in the function/product mix improve the relative performance of the functional form. When asymmetries are present across products or functions, the owner wishes to differentiate incentives for the activities under the control of a manager. If she wishes to differentiate incentives across products, she can put different weights on the profit of products 1 and 2. If she wishes to differentiate incentives across functions, she can tie the compensation of one functional area general manager more closely to profit than the other. Both forms of differentiation are possible in the functional organization, but only the first is present in the product organization. This inherent advantage to the functional organization in the presence of asymmetries is what we call the 'incentive flexibility effect.' We show that this effect actually reverses the ranking of the two organizational forms if the correlation between the profits of the two product lines is sufficiently negative. We next introduce cross-functional externalities to capture the idea that effort expended on, say, R&D for one product line can also be useful for the other product line. Combined with functional asymmetries, such externalities can also make the functional form more profitable than the product-based organization. Further, if the externalities are themselves asymmetric, they can also make the functional organization more profitable even in the absence of asymmetries across the functions. We conclude by considering various extensions, including the possibility of diseconomies of span and the possibility of hiring agents who are capable of performing all four tasks.

The broad theme of this paper is that alternative organizational forms can affect profitability differently because they alter the nature of optimal incentive contracting. Our focus on the role played by incentive contracting in determining the effectiveness of an organizational form can be justified broadly from both an empirical and a theoretical perspective. From an empirical perspective, the selection of organizational and incentive structures are often interrelated. Real world firms often make major changes in organizational form and incentive compensation structure at the same time. For example, when Citibank reorganized its corporate banking business in the mid 1990's, it dramatically changed both the structure of its organization and its incentive compensation program for senior managers.[2] The simultaneous choice of organizational structure and incentive systems suggests that these two elements of the firm's 'organizational strategy' are often dependent on each other for success: the optimal incentive structure depends on organizational form and the benefits from changing organizational form can only be realized if incentives are adjusted.

[2] Baron and Besanko [2001] studies this example in detail.

From a theoretical perspective, almost any study of organizational structure using microeconomic theory runs into the difficulty that organizational structure would be irrelevant in the absence of some sort of hidden action or hidden information problems inside the organization. Without such problems, managers in the organization could be ordered to make operating and resource allocation decisions to maximize corporate profit, and organizational structure would be irrelevant. Since incentive contracting models have become an important part of the economist's toolkit for analyzing solutions to hidden action and hidden information problems, it seems natural to explore whether incentive contracting models can deliver intuitively appealing insights about organizational structure. The purpose of this paper is to push this inquiry forward in the context of an organization in which there are hidden action problems but no issues involving private information.

Our paper is only superficially related to the vast literature on the respective merits of the U-form and the M-form. Although the U-form is organized along functional lines and the M-form is often made of separate product or area divisions, these two organizations are also assumed to differ in their levels of centralization. In the M-form, most decisions are made by the heads of the company's independent divisions. In the U-form, most decisions are taken at the company's headquarters, ensuring better coordination of activities across divisions but also leading to congestion at the top. In fact, the greater centralization of the U-form is at the heart of the usual comparisons between the two organizational structures.[3] While the U-form allows for better coordination across product lines, closer monitoring of top managers, and economies of scale in functional activities, the M-form allows decisions to be made by agents who are closer to the source of information, improving the quality of that information, and is better designed to avoid informational bottlenecks. All of these effects are absent from our model. Our two organizational structures differ only in the way in which activities are grouped under the control of divisional managers. Otherwise they both involve the same number of hierarchical tiers, the same spans of control and the same degree of decentralization. Moreover, in the absence of externalities, our framework explicitly avoids any kind of team effects.

Our modelling approach is similar to that of Aghion and Tirole [1995] who, like us, consider two products and two functions leading to four activities that must be allocated pairwise between two managers. However, Aghion and Tirole do not consider monetary incentives, focusing instead on career concerns. Furthermore, in their model, the choice of organization depends on the trade-off between the greater economies of scale (in training)

[3] See, for example, Burton and Obel [1988], Holmstrom and Tirole [1989] or Williamson [1975].

provided by the U-form and the lighter 'overload' associated with the M-form. Both factors are absent in our model. Our approach also differs significantly from that of Maskin, Qian, and Xu [2000], who focus on the case when alternative organizational forms of a planned economy can affect profitability by changing the structure of information available to evaluate managerial performance. In our model the measures of performance that can be used to provide incentives are the same for all organizational forms.

Since our two organizational forms only differ in the way activities are allocated between managers, it is related most closely to the literature on 'task assignment' (e.g. Holmstrom and Milgrom [1991] and Itoh [1991] and [1992]). Indeed we will argue in Section 3 that our benchmark result for symmetric organizations has the same flavor as Holmstom and Milgrom's 'task specialization' principle which states that each task ought to be the responsibility of a single agent. However, as will become clear later, the precise mechanisms leading to task specialization are quite different. Most closely related to our work is a recent paper by Corts [2005] who considers how to allocate two sets of tasks given that sales to any given customer are jointly determined by these tasks and that the firm can only measure (imperfectly) revenues per customer. As in our paper, allocating one agent performing both tasks to each customer (the equivalent of our product organization) has the advantage of lowering the level of risk borne by the agent but the disadvantage of not allowing for the provision of differential incentives for each of the two tasks.

The rest of the paper is organized as follows. Section 2 describes the model. Section 3 presents our 'benchmark' result of dominance of the product organization under symmetry. Section 4 examines the effect of asymmetries on the relative performance of the two organizational forms and illustrates conditions under which the functional form dominates. Section 5 studies the impact of various modifications to the basic framework. Section 6 summarizes and concludes. The proofs of all propositions are in the Appendix.

II. THE MODEL

II(i). *Basic Model Set-Up*

We consider a hypothetical firm that consists of a risk-neutral owner and two risk-averse agents, hereafter referred to as division managers. Our 'firm' could either be a stand-alone firm or an autonomous business unit within a larger company. The question we address is how the owner of the firm would want to structure her firm to obtain the best possible performance from its division managers.

The firm sells two products, 1 and 2. Two functional areas, X and Y, contribute to the success of these products. One can, for example, think of these functional areas as R&D and marketing.

The profit π_i generated by product i depend on x_i and y_i, the efforts expended on functions X and Y for this product, and we assume that this relationship is linear

$$\pi_i = \beta_i x_i + \gamma_i y_i + \theta\beta_j x_j + \xi\gamma_j y_j \text{ for } i = 1, 2, i \neq j.$$

The quantities x_i and y_i have several possible interpretations. They could represent the effort that a division manager devotes to monitoring or motivating subordinates, determining the best mix of operating decisions within the areas under the manager's control, or identifying the best set of investment projects.[4] The parameters β_i and γ_i measure the marginal impact that functional efforts x_i and y_i have on the profit of product i, and the parameters $\theta, \xi \in [0, 1]$ indicate cross-product externalities within a particular functional area. These impact parameters capture the idea that marketing or R&D efforts expended on behalf of one product can often benefit the firm's other products as well.

We assume the firm's accounting system generates a verifiable signal $\tilde{\pi}_i$ of the profitability of product i. This signal equals the actual product profit plus an additive, mean-zero measurement error $\tilde{\varepsilon}_i$, i.e.,[5]

$$\tilde{\pi}_i = \pi_i + \tilde{\varepsilon}_i \text{ for } i = 1, 2.$$

We assume that $(\tilde{\varepsilon}_1, \tilde{\varepsilon}_2)$ is drawn from a bivariate normal distribution with a variance-covariance matrix Ω given by

$$\Omega = \begin{pmatrix} \sigma^2 & r\sigma^2 \\ r\sigma^2 & \sigma^2 \end{pmatrix},$$

where σ^2 is the variance of measured profit, and $r \in [-1, 1]$ is the correlation between measured product-line profits. Note that if $r = -1$, $\mathrm{Var}(\tilde{\varepsilon}_1 + \tilde{\varepsilon}_2) = 0$, and thus total profit $\pi_1 + \pi_2$ can be measured without noise. We will use this interpretation below.

The owner of the firm must choose an organizational form. Once that organizational structure is chosen, the owner then chooses contracts to motivate managers within that structure. The organizational structure choice is a task assignment problem: which two agents are responsible for the four tasks x_1, y_1, x_2, y_2 that must be performed to make the organization profitable. To develop intuition about the economics of organizational forms employed by real firms, we focus on two specific allocations of tasks to agents: a functional organization and a product-based organization. In a

[4] We ignore the problem of motivating the agents under the manager's control. One can, if one wishes, just think of these agents as infinitely risk-averse.

[5] Alternatively, we could interpret $\tilde{\varepsilon}_i$ as the sum of measurement error and product market uncertainty.

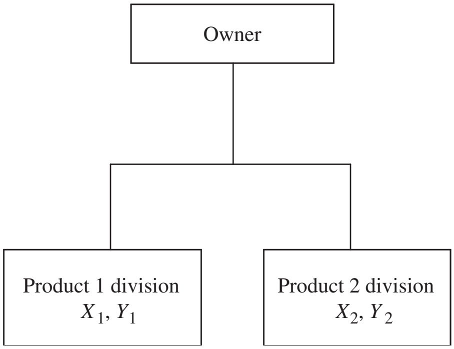

Figure 1
Product-based organization

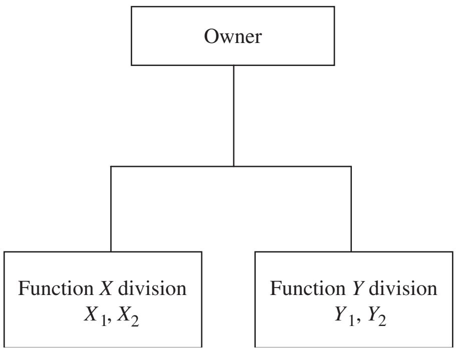

Figure 2
Functional organization

functional organization, all activities related to the same function are under the control of one division manager. That is, the vector $v_X^T \equiv (x_1, x_2)$ of efforts of function X are determined by one division manager, while the vector $v_Y^T \equiv (y_1, y_2)$ of efforts of function Y are determined by another.[6] In a *product-based* organization, each division manager is responsible for the two functional activities relating to his product line. The division manager for product line i thus chooses a vector $z_i^T \equiv (x_i, y_i), i = 1, 2$, of functional area efforts on behalf of product i. Figures 1 and 2 depict these two organizational forms.

[6] Throughout, the superscript 'T' denotes a matrix transpose.

Two remarks are in order about the set of organizational structures we consider in this analysis:

1) Throughout this analysis, we hold the firm's employment fixed at two agents. Dropping this assumption would allow us to consider other organizational structures. For example, the firm could disaggregate the choice of efforts even more by hiring four agents and assigning one agent to choose x_1, another agent to choose y_1, and so forth. By holding firm employment fixed at two agents, we focus attention on the trade-offs involved in the assignment of organizational tasks for a given amount of managerial authority.
2) Both organizational forms we study involve task specialization: i.e., one agent supplies all of the effort for two tasks (e.g., x_1 and y_1) while the other agent supplies all of the effort for the other two tasks (e.g., x_2 and y_2). We do not allow both agents to supply some effort to each of the four tasks. We justify this by assuming that prospective division managers have specialized know-how: the firm can hire product specialists or functional specialists, but it cannot find managers who can productively do all four tasks simultaneously. In the final section of the paper, we return to the issue of specialization and compare the specialized structures considered here to the performance of a firm composed of task generalists.

The owner of the firm cannot directly monitor the effort levels of her divisional managers. We assume that the only variables that are observable and verifiable are the noisy signals $\tilde{\pi}_i$ of product-line profitability. In particular, signals of the profit contribution of any particular functional area are not available. The assumption that the firm can measure product-line profit contributions but not functional area profit contributions is meant to capture the generally accepted idea that in most firms it is *easier* to measure a product's contribution to total profits than it is to measure a functional area's contribution to total profits.[7] The key difficulty in generating reliable product-line profit data is the assignment of costs to different products. This is not an easy task, but the problem can be minimized by grouping together products that are linked on the cost side and by using accounting techniques, such as activity-based costing, to assign costs to different products. By contrast, computing the 'profit' of a functional division is a more daunting task because of the absence of market mechanism to determine the relevant revenues. Despite advances in accounting methods, few firms have developed reliable measures of functional area performance.

[7] See Tirole [1989], pp. 47–48 or Holmstrom and Tirole [1989], pp. 125–126 for a similar argument.

For simplicity we further restrict the compensation contracts to be linear functions of the product-line profit levels.[8] Thus, the compensation $\widetilde{W}_i$ received by the manager of division i is

$$\widetilde{W}_i = a_{i0} + \widetilde{\pi}^T a_i \quad \text{for } i \in \{1, 2\},$$
$$\widetilde{W}_i = \alpha_{i0} + \widetilde{\pi}^T \alpha_i \quad \text{for } i \in \{X, Y\},$$

where $a_i^T \equiv (a_{i1}, a_{i2})$, $\alpha_X^T \equiv (\alpha_{X1}, \alpha_{X2})$, $\alpha_Y^T \equiv (\alpha_{Y1}, \alpha_{Y2})$, $\widetilde{\pi}^T \equiv (\widetilde{\pi}_1, \widetilde{\pi}_2)$, and a_{i0}, α_{i0} are scalars.

Division managers are risk averse and effort averse. The disutility of effort for a divisional manager is quadratic and is given by

$$\Delta_i \equiv \begin{cases} \frac{1}{2} z_i^T D z_i & \text{for } i \in \{1, 2\} \\ \frac{1}{2} v_i^T D v_i & \text{for } i = \{X, Y\}. \end{cases}$$

where $D \equiv \begin{bmatrix} 1 & \delta \\ \delta & 1 \end{bmatrix}$, and $\delta \in [0, 1)$ measures the extent of *diseconomies of span*, i.e., the extra cost that results when a manager must split his time and attention between different tasks. In the limit, as $\delta \to 1$, we have a multi-task effort allocation model in which disutility depends on the total effort exerted by the division manager. For $\delta < 1$, the agents show some preference for 'task variety' in the sense that a total amount of effort is less costly if it is split across two tasks than if it is concentrated on a single one.[9]

The expected utility function of a manager is:

$$EU_i \equiv E(\widetilde{W}_i) - \frac{\rho}{2} \mathrm{Var}(\widetilde{W}_i) - \Delta_i \text{ for } i \in \{1, 2\} \text{ or for } i \in \{X, Y\},$$

where $\rho > 0$ measures the risk aversion of the managers.[10] It is worth noting that, while we initially assumed that the compensation contracts are linear, linear contracts are in fact optimal given our constant absolute risk aversion

[8] This can be justified by assuming that agents choose effort in continuous time to control the drift vector of a Brownian motion process and in which the agent can observe his accumuated performance before acting at any instant in time. Holmstrom and Milgrom [1987] show that in this context, the optimal wage contract for an agent with constant absolute risk aversion is a linear function of the final observable outcome.

[9] The extent of such 'preference for variety' is a matter of debate. For two classic references supporting the existence of such preference, see Hackman and Lawler [1971] and Hackman and Oldham [1976]. For a dissenting opinion, see Buchanan [1994].

[10] Although the assumption of managerial risk aversion is maintained throughout this analysis, it is not essential for our results. An alternative modeling assumption that generates the same results is that the managers receive private information *after* contracting with the firm's owner and that this *ex post* information affects their effort choices. Baker [1992] analyzes an agency model of this type where convex effort costs combined with *ex ante* uncertainty about effort-relevant private information work in exactly the same way as risk aversion in terms of their effect on optimal contracts. The results in this paper go through if we assume this specification.

utility function.[11] Letting

$$Q_1 \equiv \begin{bmatrix} \beta_1 & \theta\beta_1 \\ \gamma_1 & \xi\gamma_1 \end{bmatrix}, Q_2 \equiv \begin{bmatrix} \theta\beta_2 & \beta_2 \\ \xi\gamma_2 & \gamma_2 \end{bmatrix}, R_X \equiv \begin{bmatrix} \beta_1 & \theta\beta_1 \\ \theta\beta_2 & \beta_2 \end{bmatrix},$$
$$R_Y \equiv \begin{bmatrix} \gamma_1 & \xi\gamma_1 \\ \xi\gamma_2 & \gamma_2 \end{bmatrix},$$

we can express EU_i in matrix notation as follows

$$EU_i = \begin{cases} a_{i0} + \left(\sum_{j \in \{1,2\}} z_j^T Q_j \right) a_i - \frac{\rho}{2} a_i^T \Omega a_i - \frac{1}{2} z_i^T D z_i, \ \text{for } i \in \{1,2\}. \\ \alpha_{i0} + \left(\sum_{j \in \{X,Y\}} v_j^T R_j \right) \alpha_i - \frac{\rho}{2} \alpha_i^T \Omega \alpha_i - \frac{1}{2} v_i^T D v_i, \ \text{for } i \in \{X,Y\}. \end{cases}$$

We normalize a manager's outside option to zero. The owner will choose the intercepts a_{i0} and α_{i0} of manager i's compensation so that $EU_i = 0$, which implies that the owner's objective is to maximize total surplus (profit minus risk premia minus effort disutilities), subject to incentive compatibility constraints on the managers' choices of efforts.

II(ii). *Optimal Contracting: Product Organization*

In a product organization, the owner's maximization problem is

$$\max_{\{a_i, z_i\}} \Pi = \sum_{i \in \{1,2\}} \left\{ u^T Q_i^T z_i - \frac{\rho}{2} a_i^T \Omega a_i - \frac{1}{2} z_i^T D z_i \right\}, \tag{1}$$

$$\text{subject to: } Q_i a_i = D z_i, \ i \in \{1,2\}, \tag{2}$$

where $u^T \equiv (1,1)$. Equation (2) is the system of incentive compatibility constraints for the product division managers and it can be solved for the vector of efforts Z_i, as in equation (3). This system is simply the set of first order conditions from the agent's expected utility maximization problem.

$$z_i = D^{-1} Q_i a_i, \ i \in \{1,2\}. \tag{3}$$

Substituting (3) into (1), we can restate the owner's optimization problem over the slopes a_i of the compensation schedule:

[11] See Holmstrom and Milgrom [1987] for the single-task case and Laffont and Martimort [2002], pp. 384–387, for a multi-task extension.

$$\max_{\{a_i\}} \Pi = \sum_{i \in \{1,2\}} \left\{ u^T \Theta_i^T a_i - \frac{\rho}{2} a_i^T \Omega a_i - \frac{1}{2} a_i^T \Theta_i a_i \right\}, \tag{4}$$

where

$$\Theta_i \equiv Q_i^T D^{-1} Q_i,\ i \in \{1,2\}.$$

The solution to this problem is

$$a_i^* = [\Theta_i + \rho\Omega]^{-1} \Theta_i u,\ i \in \{1,2\}. \tag{5}$$

Substituting (5) into (4) yields the expression Π^P for the maximal profit under a product organization:

$$\Pi^P = \frac{1}{2} \sum_{i \in \{1,2\}} u^T \Theta_i [\Theta_i + \rho\Omega]^{-1} \Theta_i u. \tag{6}$$

II(iii). *Optimal Contracting: Functional Organization*

In a functional organization, the owner's maximization problem is

$$\max_{\{\alpha_i, v_i\}} \Pi = \sum_{i \in \{X,Y\}} \left\{ u^T R_i^T v_i - \frac{\rho}{2} \alpha_i^T \Omega \alpha_i - \frac{1}{2} v_i^T D v_i \right\}, \tag{7}$$

$$\text{subject to}: \quad R_i \alpha_i = D v_i,\ i \in \{X, Y\}. \tag{8}$$

Equation (8) is the system of incentive compatibility constraints for the function division managers, and it can be solved for the vector of efforts

$$v_i = D^{-1} R_i \alpha_i,\ i \in \{X, Y\}. \tag{9}$$

Substituting (9) into (7) yields the modified maximization problem

$$\max_{\{\alpha_i\}} \Pi = \sum_{i \in \{X,Y\}} \left\{ u^T \Lambda_i \alpha_i - \frac{\rho}{2} \alpha_i^T \Omega \alpha_i - \frac{1}{2} \alpha_i^T \Lambda_i \alpha_i \right\}, \tag{10}$$

where

$$\Lambda_i \equiv R_i^T D^{-1} R_i,\ i \in \{X, Y\}.$$

The optimal solution to this problem is

$$\alpha_i^* = [\Lambda_i + \rho\Omega]^{-1} \Lambda_i u,\ i \in \{X, Y\}. \tag{11}$$

Substituting (11) into (10), we get the expression Π^F for the maximal profit under a functional organization:

$$\Pi^F = \frac{1}{2} \sum_{i \in \{X,Y\}} u^T \Lambda_i \left[\Lambda_i + \rho\Omega\right]^{-1} \Lambda_i u. \tag{12}$$

Conditions (6) and (12) provide closed form expressions for the profits of the two organizational forms that differ only in that the matrix Θ_i appears in (6) and Λ_i appears in (12). Despite their simple structure, though, these expressions are difficult to compare directly because several economic forces are at work concurrently: (1) the fact that product-line profitability is easier to measure than functional area profit contribution; (2) possible asymmetries in marginal profitability across functions and products, which determines the relative incentive sensitivity of activities; (3) cross-product externalities; and (4) diseconomies of span. In Section 3, we consider the case in which there are no cross-product externalities ($\theta = \xi = 0$), all activities have the same marginal productivity ($\beta_1 = \beta_2 = \gamma_1 = \gamma_2$), and there are no diseconomies of span ($\delta = 0$). This analysis isolates the impact of (1) and highlights two important effects that lead to the dominance of the product organization. The section illustrates that symmetry is important to generating this dominance. Section 4, then, analyzes the impact of asymmetric marginal productivities. In Section 5, we allow $\delta > 0$ in order to isolate the effect of (4) and investigate other extensions to the model.

III. DOMINANCE OF THE PRODUCT ORGANIZATION

In order to derive our benchmark result, we initially assume complete symmetry; i.e., each of the four possible activities has the same coefficients in the profit and effort functions, $\beta_1 = \beta_2 = \gamma_1 = \gamma_2$. We also assume that there are no diseconomies of span, $\delta = 0$. Our first result is that under these conditions, the product-based organization dominates the functional organization.

Proposition 1. Suppose (i) cross-product externalities are symmetric, i.e. $\theta = \xi \leqslant 1$; *(ii) all activities have the same marginal profitability,* $\beta_1 = \beta_2 = \gamma_1 = \gamma_2$. *Then, as long as the correlation r of profit signals exceeds* -1 *and externalities are less than perfect, i.e.* $\theta = \xi < 1$, *the product-based organization yields strictly higher profits than the functional organization, i.e.,* $\Pi^P > \Pi^F$. *Moreover, in the absence of externalities, the relative performance of the functional organization compared to the product-based organization decreases as r increases. When* $r = -1$ *or* $\theta = \xi = 1$, *the two organizational forms yield equal profit.*

Proof: See appendix.

The intuition behind Proposition 1 stems directly from the fact that compensation can be tied to product-line profitability but not to functional area profit contributions. Let us first consider a situation without any cross-product externalities. Under the symmetry assumptions of proposition 1, the profit maximizing levels of efforts are themselves symmetric. In a functional organization, the desired symmetric effort levels can only be obtained by linking the pay of each manager to the performance of each of the two products, i.e., $\alpha_{X1}, \alpha_{Y1}, \alpha_{X2}$ and α_{Y2} must all be used. In a product organization, on the other hand, any desired symmetric level of efforts can be induced by tying a manager's reward to the performance of the division that he oversees; i.e., only a_{11} and a_{22} matter for achieving incentive compatibility. This means that the product organization will only tie the reward of a manager to the performance of the *other* product division if this makes it possible to further reduce the risk that he must bear: a_{12} and a_{21} are chosen to minimize the risk premium $\rho\sigma^2(a_{ii}^2 + 2ra_{ii}a_{ij} + a_{ij}^2)$ so that $a_{ij} = -ra_{ii}$. If $r = 0$, the product organization finds it optimal not to tie a manager's compensation to the profits of the other product line. This means that the product manager must only bear the risk premium associated with the product line that he controls while a functional manager is exposed to the risk associated with both product lines. In that special case, the cost of implementing given (symmetric) levels of efforts are exactly twice as high in the functional organization as in the product organization. If $r > 0$, the product manager's reward decreases with the performance of the other product line (i.e., a_{12} and a_{21} are negative), i.e., there is a sort of 'yardstick competition.' In fact, for the case of perfect correlation between the noise of each product line (i.e. $r = 1$), setting $a_{12} = -a_{11}$ provides full insurance to the agent, allowing the principal to achieve the first best. If $r < 0$, a manager's reward is tied positively to the profits of the product line that he does not control (i.e., a_{12} and a_{21} are positive). It is only in the extreme case where $r = -1$ that the two organizational forms perform equally well: with perfect negative correlation between the two profit measures, functional managers are also completely insured and both organizations achieve the first best.

These results are only superficially related to those of Maskin, Qian and Xu [2000]. They show that, when different measures of managerial performance become possible as the organizational structure is changed, the organization that measures performance with less 'variation' across its managers can perform better, because it is able to use yardstick competition more effectively. In our paper, the firm has at its disposition the *same* performance measures, whatever the organizational structure.

One interpretation of Proposition 1 is that the firm should organize around what it can measure well. This is an old theme of the accounting literature, and it is one aspect of the traditional critique of the U-form (Williamson [1975]). However, it is important to note that the economics underlying Proposition 1 differs from the traditional analysis of the drawbacks of the U-form. That analysis emphasizes that the unobservability of functional area profitability gives rise to an 'Alchian-Demsetz' type team problem (Holmstrom and Tirole [1989], pp. 67 and 124). While the handicap of the functional organization captured in Proposition 1 stems from the unobservability of functional area profit contributions, we emphasize that Proposition 1 *is not* driven by a team problem. The reason is the following. First, since the profit functions are linear and there are no cross-product externalities, there is no direct 'free rider' problem. Nor is there an 'induced' team problem stemming from the incentive scheme.[12] In our setup, the owner could (if she wanted to) make the agent's marginal compensation equal to his marginal cost of effort and recover this expense through the intercept of the linear compensation.

Proposition 1 can also be *interpreted* in terms of task specialization. To do so, let us relabel the model as follows. Rather than considering how the four tasks x_i, y_i should be allocated pairwise between two agents, let there be only two tasks T_1 and T_2 and two measures of performance $\pi_1(T_1)$ and $\pi_2(T_2)$. Task i is running 'product division i.' Each of the two agents is able to shoulder a load equivalent to a full task. The choice of organizational form can then be framed as whether each task should be split equally between the two agents, as in the functional organization, or whether each agent should be solely responsible for a single task, as in the product-based organization. Proposition 1 implies that task specialization is optimal. Viewed in this way, Proposition 1 is similar to the task-specialization result of Holmstrom and Milgrom [1991] who find that if two agents must allocate their effort between a continuum of tasks, it is never optimal for the two agents to be jointly responsible for any task. The key to their result as well as to ours is that there is a fixed cost of inducing an agent to exert effort on an additional task. However, the source of this fixed cost in the two papers is completely different. In Holmstrom and Milgrom, there is a continuum of tasks and, because the cost of effort is a function of the agent's total effort (i.e. $\delta = 1$), the marginal cost of expending effort on the shared task is positive at zero. In other words, our results hold even in the absence of diseconomies of span, while the Holmstrom and Milgrom result arises *because* of diseconomies of span. In our model, the fixed cost comes from the combination of two factors. Firstly as we have seen, 'sharing tasks' increases the risk premium demanded by the agents. Secondly, reinterpreting our model in terms of task specialization leads to a situation where we have discrete tasks and discrete sharing of tasks (i.e., tasks can only be split 'in halves'). This means that the weight attached to this additional risk premium is itself positive for all values

[12] By induced team problem, we mean the following. If $y = f(e_1, e_2)$ where y is output and e_i is agent i's effort, and if the marginal cost of each agent's effort is 1, then the owner of the firm would want to have $1 = f_{e_1} = f_{e_2}$. But, if the sharing rule is $s_1(y) = 1 - s_2(y)$, implementing this scheme is not possible.

of δ, despite the fact that, with $\delta = 0$, the marginal cost of effort at zero is itself zero.[13] In other words, the information structure of the firm itself, rather than the structure of the effort function, gives rise to a form of 'task specialization.'

We now consider the possibility that functional area effort on behalf of one product can have a beneficial effect on the profitability of the firm's other product. Further, assume that these are symmetric so that $\theta = \xi \in (0, 1)$. The main effect of such cross-product externalities is to weaken the advantage of the product-based organization. Indeed, this advantage disappears when the externalities become perfect, i.e., when $\theta = \xi = 1$. To see this, let us examine how the optimal implementation of a given level of effort is affected by the introduction of externalities. Consider first the case where $r > 0$ so that, in the product organization without externalities, the reward of a manager is tied negatively to the profits of the other division. With externalities, the manager's activities do affect both profit measures so that a negative value of a_{12} actually *decreases* the manager's incentives to expand effort. Indeed, in the extreme case where $r = 1$ and $\theta = \xi = 1$, setting $a_{12} = -a_{11}$, which was optimal without externalities, would provide absolutely no incentive to expand effort. To restore the incentives at minimum cost, the firm will increase both a_{11} and a_{12}, limiting its ability to 'insure' its agents.[14] If $r < 0$, the product organization would, in the absence of externalities, tie the reward of its managers positively to the profit of the other product line. If we introduce an externality, then the previous levels of a_{11} and a_{12} now provide excessive incentives. To implement the same given level of effort as before, it is optimal to reduce both a_{11} and a_{12}. This again limits the product organization's relative advantage in minimizing the risk borne by its managers.[15]

[13] It is worth noting that the discreteness of tasks is not itself the crucial difference between the two papers. With their assumed cost function (i.e., $\delta = 1$), Holmstrom and Milgrom's result would go through even if they had discrete symmetric tasks and task-sharing rules. On the other hand, with $\delta = 0$ and in the absence of our two effects, Itoh [1991] and [1992] has shown that the principal would actually prefer discrete tasks to be shared between agents, with an appropriate specification of the cost of effort.

[14] For given levels of effort, the cost of implementation comes from the risk borne by the agent, which takes the form $\rho\sigma^2(a_{11}^2 + 2ra_{11}a_{12} + a_{12}^2)$. The marginal cost of increasing a_{11} is $2a_{11} + 2ra_{12}$, while the cost of increasing a_{12} is $2ra_{11} + 2a_{12}$. Evaluated at $a_{12} = -ra_{11}$, which is an implementation condition without externalities, these marginal costs are respectively equal to $a_{11}(1 - r^2) \geqslant 0$ and 0 (since a_{12} was chosen to minimize the variance of the manager's earnings). Hence any increase in the power of incentives given to the manager must rely (in part at least) on an increase in a_{12}.

[15] The case of $r = 0$ is similar. Without externalities, we have $a_{12} = 0$. But with externalities, a_{12} *can* now affect incentives. Again, as a_{12} was optimally set equal to 0 in the situation without externalities, the marginal cost of increasing it is smaller than the marginal cost of using a_{11}. Hence, once externalities are introduced, given effort levels will be implemented by using a positive a_{12} and a lower value of a_{11} than without externalities.

IV. DOMINANCE OF THE FUNCTIONAL ORGANIZATION: ASYMMETRIES AND THE INCENTIVE FLEXIBILITY EFFECT

In the presence of asymmetries we show that another effect, the *incentive flexibility effect*, can favor the functional organization. This effect becomes strong enough to overturn the ranking that Proposition 1 establishes when asymmetries are 'large enough' in a sense we shall make precise below.

To begin our discussion, we note that a theme of the modern literature on strategic management is that firms can be fruitfully thought of as collections of value-creating activities, and that different activities may be more or less important in different economic environments (Porter [1985]). In consumer packaged goods companies, such as Procter & Gamble or Unilever, marketing and brand management activities are paramount, while in high tech firms, such as Hewlett Packard or 3M, R&D activity is paramount. When asymmetries are present across functions or products, the owner would wish to differentiate incentives for activities under the control of a manager. If the owner wished to differentiate incentives across products, for example, she could put different weights on the profits of products 1 and 2. If she wished to differentiate incentives across functions, she could tie compensation of one functional area general manager more closely to profit than the other. Both forms of differentiation are possible in the functional organization. For example, it would be possible in the functional organization to set large values for α_{X1} and α_{Y1} if product 1 were more important than product 2, and it would be equally possible to set large values for α_{X1} and α_{X2} if function X were more important than function Y. On the other hand, it is only possible to differentiate incentives across products in the product organization, as profits are *measured* per product and managerial responsibility is also *allocated* per product. As a result, there is a built-in advantage for the functional organization when certain types of asymmetries are present. This is expressed in the following principle.

Incentive Flexibility Principle: Asymmetries that lead to different first-best levels of efforts for activities relating to the same product improve the relative performance of the functional organization.

Let us explicitly consider two types of asymmetry that favors the functional organization. Suppose first that one function is dominant, so that $\beta_1 = \beta_2 \equiv \beta > \gamma \equiv \gamma_1 = \gamma_2$. That is, function X is unambiguously more important for organizational success than function Y. Figure 3 shows *effort supply functions* for activities x_i and y_i for this case. The effort supply function shows the effort provided by a manager as a function of the slope of the manager's incentive contract. If function X has a higher marginal profitability than function Y, then the effort supply function for x_i will be flatter than the effort supply function for y_i; i.e., function X is more *incentive sensitive* than function Y.

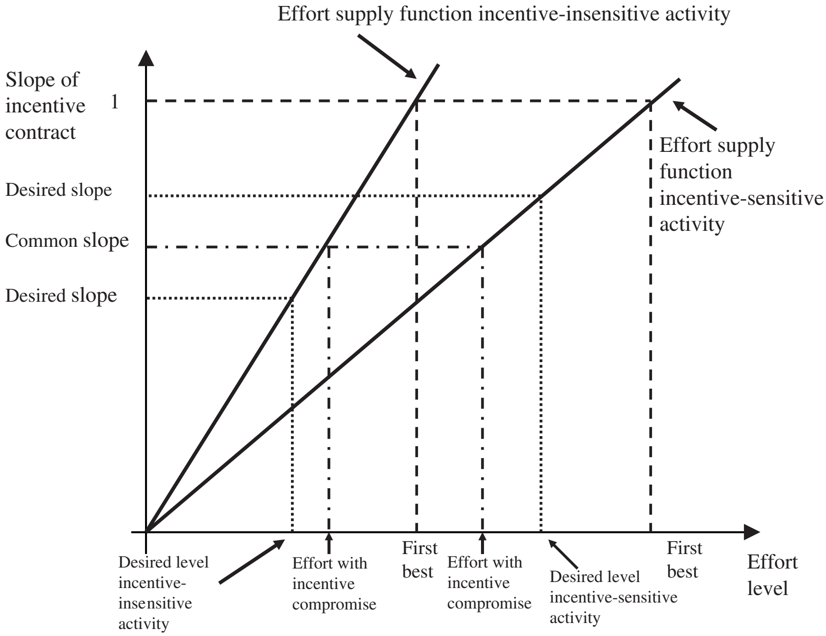

Figure 3
Effort supply function incentive-insensitive activity

In the absence of risk-aversion, the first-best solution would give managers incentive contracts of slope 1, making them the residual claimants. This solution is not optimal with risk-averse managers, but it illustrates that the induced effort level would be greater for the more incentive sensitive activity. With risk aversion, the desired effort levels are smaller for each activity, and if the owner could do so, she would choose a larger contract slope for the more incentive sensitive activity, as shown in Figure 3.[16]

In the dominant function case, a functional organization groups activities according to their incentive sensitivity, so that the owner can indeed give function X and function Y activities different contract slopes. However, in the product-based organization, the same contract slope applies to both activities, as shown in Figure 3, so the owner is forced to make an *incentive compromise*, which works to reduce her expected profitability.[17]

[16] This is analogous to third-degree price discrimination in which a monopolist prefers to charge a lower price to consumers with more elastic demands.
[17] See Proposition A1 in the Appendix for a formal analysis of the effect of a dominant function on the relative performance of the functionial and product organizations.

Another illustration of the incentive flexibility principle is a situation where there are privileged product/function pairs. This is especially likely to occur in diversified conglomerates, where, for example, the success of some product lines might depend heavily on R&D, while the success of others might rest mostly on marketing or manufacturing efficiency.[18] For example, suppose that function X is especially important for product 1, while function Y is especially important for product 2, i.e., $\beta_1 = \gamma_2 > \beta_2 = \gamma_1$. The owner would like to induce high levels of x_1 and y_2 and relatively low levels of x_2 and y_1. As in the case of a dominant function, such asymmetric effort levels cannot be induced in a product-based organization. They can, however, be obtained with a functional form by putting a higher weight on $\tilde{\pi}_1$ than on $\tilde{\pi}_2$ in the compensation scheme of the manager of function X and setting a lower weight on $\tilde{\pi}_1$ than on $\tilde{\pi}_2$ in the contract of the manager of function Y. Hence, like the presence of a dominant function, this asymmetry improves the relative performance of the functional form.[19]

Our analysis should be contrasted with the traditional intuition that a functional organization (U-form) allows the firm to exploit economies of scale within particular functions better than a product-based (M-form) organization does (Holmstrom and Tirole [1989], p. 125). With linear profit functions, there are no economies of scale in functional activities in our model, so the traditional intuition does not apply. What happens instead is that by allowing for differentiated incentives across functions, the functional organization channels large amounts of managerial effort into the functional activity that is especially important to the firm's success and lesser amounts of effort into the activity that is not as important. This results in a more efficient pattern of effort across functional areas than what arises in a product-based organization. That is, when there is a dominant function, a functional organization can improve the specialization of managerial incentives and effort within the firm.

While asymmetries in the marginal productivities of the four activities can indeed improve the *relative* performance of the functional organization, whether they can actually make it more profitable than the product-based organization is less obvious. The following proposition shows that, under some conditions, functional asymmetries can indeed effect such a reversal.

Proposition 2. Assume that externalities are not complete and the profits of the two product lines are not perfectly inversely correlated ($\theta < 1$ and $r > -1$). There is a critical level of the externality parameter, defined as $\theta_c \in [0, 1]$, such that for all $\theta > \theta_c$, one can always find a degree of functional asymmetry beyond

[18] For example, until the late 1990's, Corning sold both medical instruments and cookware. While innovation was probably important for both product lines, marketing was probably *relatively* more important for the cookware line.

[19] See the Appendix, under Propostion A1, for a formal statement and proof.

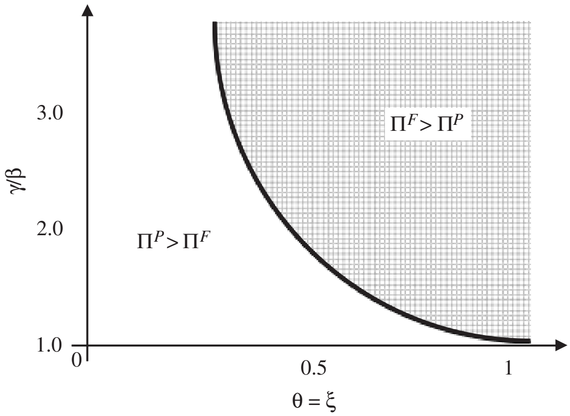

Figure 4
Relative profitability of functional and product-based organizations with functional area asymmetries

which the functional form is more profitable than the product form. If the correlation between the profits of the two product lines is sufficiently negative and $\rho\sigma^2$ is large enough, then there exists a degree of functional asymmetry beyond which a functional organization is more profitable than a product-based organization, even in the absence of externalities.

Proof: See appendix.

The intuition behind Proposition 2 is straightforward. It simply says that functional asymmetries can reverse the ranking of the two organizational forms when their relative performances under symmetric conditions are already close enough. As we know from Proposition 1, this occurs when r is small and/or externalities are large. Figure 4 displays a representative set of numerical calculations showing how the relative profitability of the two organizational forms varies with the level of (symmetric) externalities and the degree of functional dominance, $\frac{\gamma}{\beta}$.[20]

An implication of Proposition 2 is that if the firm has a strong competence in a particular functional area and there are functional area externalities across product lines, a functional organization may be desirable. Phrased in the language of strategic management, our model suggests that a firm should organize around its 'core competencies,' even when it is hard to measure the

[20] The parameter values for this example are $\rho\sigma^2 = 2$, $\delta = r = 0$, $\beta_1 = \beta_2 = 1$. Taking $\theta = 1/2$ for example, one can check that, with $\gamma = 3$, we have $\Pi^F = 19.62 > \Pi^P = 19.4$. Using $r = -3/4$, one can also check that the functional form can be more profitable even in the absence of externalities. Using $r = -3/4$, $\theta = 0$, $\delta = 0$, $\rho\sigma^2 = 2$ and $\beta_1 = \beta_2 = 1$, one gets that for $\gamma = 3$, $\Pi^F = 16.19 > \Pi^P = 16.16$. Differences become larger as γ is increased beyond 3.

profit contribution of those competencies. The managerial logic of this is that when a firm has a core competence that resides in a function, then to maximize the impact of the competence on the firm's success, senior executives responsible for that function should receive higher powered incentives than senior executives responsible for other functions. Organizing the firm along product lines gets in the way of providing differentiated incentives, which then implies that the firm will fail to exploit its competence as fully as it could.[21]

As functional dominance with symmetric externalities can make the functional organization more profitable than the product organization, one might also wonder whether significantly *asymmetric* externalities, in themselves, could also reverse the ranking of the two organizational forms. The presence of an externality only in X affects the relative performance of the organizational forms in two ways. First, it makes it desirable to implement a greater level of effort in X than in Y. This creates an asymmetry of the same type as our 'dominant function' case and, hence, favors the functional organization due to the incentive flexibility effect. Secondly, it becomes optimal for the product organization to link the compensation of its managers to the performance of both divisions and thus reduces the 'Proposition 1' advantages of the product-based organization. Both effects lead to a better relative performance of the functional form. We suppose, then, that only *one* of the two functions generates significant cross-product externalities. In other words, we set ξ equal to zero so that externalities occur only within functional area X. To isolate the effect of this asymmetry, we assume that the marginal productivity coefficients are perfectly symmetric, i.e., $\beta_1 = \beta_2 = \gamma_1 = \gamma_2$. We show that, indeed, for large enough values of θ, a functional organization leads to higher expected profits than a product-based organization.

Proposition 3. Suppose the marginal productivity coefficients are perfectly symmetric, $\beta_1 = \beta_2 = \gamma_1 = \gamma_2$ and there are no diseconomies of span, $\delta = 0$. If only one of the two functions generates cross-product externalities, $\theta > 0, \xi = 0$, and this externality is sufficiently large, the functional organization is more profitable than the product-based organization, i.e., $\Pi^F > \Pi^P$.

Proof: See appendix.

We could not obtain analytical results for the case of privileged product/functions pairs. Numerical calculations show that, as in the case of functional asymmetries, one can find parameter values for which the functional organization is more profitable than the product-based

[21] For an application of the logic of Proposition 4 to IBM, see our working paper.

organization, even though there are no cross-product externalities.[22] However, the effect of externalities is rather different. On the one hand, as we have seen, larger externalities minimize the disadvantage from having to tie an agent's reward to both measures of profit. This favours the functional organization. On the other hand, greater externalities effectively reduce the degree of privileged product/function pair asymmetry: as θ increases, the effect of any activity on the two measures of profit becomes more similar. Numerical calculations suggest that this severely limits the range of parameters for which this type of asymmetry can make the functional organization more profitable than the product-based organization.[23]

V. EXTENSIONS TO THE MODEL

Our results have been obtained in the simplest possible model, where contracts were linear and the noise terms of each profit measure were normally distributed. *Given our assumed constant absolute risk aversion (CARA) utility function and the normality of the error terms*, the linearity of contracts is not an issue: As shown by Milgrom and Holmstrom [1987]—and Laffont and Martimort [2002] in a multi-tasking setting—linear contracts are in fact optimal. Without normality, however, non-linear contracts may well improve on linear contracts. Still, there does not seem to be any reason to believe that this would affect our analysis significantly. Even with non-linear contracts, inducing the correct level of effort only requires that the compensation of a product manager be tied to the profits of her own division, while the reward of a functional manager must still be tied to the profits of both divisions. The product organization's ability to induce the same (symmetric) levels of efforts, while imposing less risk on its managers, should therefore still remain. The incentive flexibility effect would also survive as no amount of non-linearity would allow a product-based firm to induce efforts in any proportion other than $\frac{\beta_i}{\gamma_i}$. Of course, the precise *magnitude* of these effects would likely change under non-linear contracts. This means not only that the range of parameters for which the functional form dominates would be different but that one cannot *a priori* even be completely certain that such dominance would always be possible.

V(i). *Diseconomies of Span*

Up to now, we have not discussed the precise shape of the cost of effort function. When $\delta = 0$, managers exhibit a preference for 'task variety' in the sense that the marginal cost of effort for any single task only increases with the amount of effort expanded on that task. When $\delta > 0$, the marginal cost of

[22] For example $\theta = \delta = 0$, $\beta = 1$, $\rho\sigma^2 = 10$, $r = -0.9$ and $\gamma > 7$.

[23] For $r = 0$, for example, extensive simulations show that, irrespective of the asymmetry, $\Pi^P > \Pi^F \forall \theta < 1$.

effort for any task increases with the total amount of effort that the manager spends across all the tasks that she supervises. This gives rise to two additional effects. The first is an *effort disparity effect*. This effect arises because for given effort vectors, z_i or v_i, the difference in total effort cost $\sum_{i\in\{1,2\}} \Delta_i - \sum_{i\in\{X,Y\}} \Delta_i$ between a product organization and a functional organization is equal to $\delta(x_1 - y_2)(y_1 - x_2)$. This implies that when there is a dominant product, effort costs tend to be higher in a product organization, while if there is a dominant function, effort costs tend to be higher in a functional organization. This effect, then, moderates the impact of the incentive flexibility effect discussed earlier. However, as Proposition 2 has been shown to hold for all values of $\delta \in [0, 1]$, we know that one can still find parameter ranges for which the functional asymmetries are large enough to ensure that the functional organization is more profitable than the product organization. The second effect is the well known *multi-task effort allocation problem*. As δ increases, a manager has a tendency to devote large amounts of effort to the product (or function) with the higher marginal profitability. For $\delta \to 1$, this tendency becomes extreme, and the manager devotes no effort to the activity with the lower marginal profitability. This effect makes it difficult to induce effort supply under both organizational forms, and thus has no clear cut impact on the *relative profitability* of the two organizations. Hence, in contrast to the earlier work of Holmstrom and Milgrom [1991], where the specialization result derives from diseconomies of span, our basic results do not.

On the other hand, as we are going to see below, the precise shape of the cost of effort function does matter when the product-based organization and the functional form are compared to other possible types of organizations.

V(ii). *Generalists versus Specialists*

We have so far assumed that the firm had to hire (only) two managers and that these managers were specialists in the sense that it was not possible to find agents who could perform all four tasks productively. We now drop this last assumption but still keep the number of managers at two. In our model, there are in fact circumstances in which the owner would want to have both managers do everything. To see why, consider the special case where there is complete symmetry, there are no cross-product externalities ($\theta = \xi = 0$) and $r = 0$ so that the slopes of the product managers' compensation schedules in a product organization can be set independently of each other. It is straightforward to show that under these conditions, an organization of two generalists is more profitable than a product organization in which division heads are product specialists. The reason for this is that, for any given levels of *total* effort devoted to a task, a generalist only exerts half the effort of the corresponding specialist on any given task. This lowers the cost of implementing effort through two channels. Firstly, as the disutility of effort is quadratic in every task-specific effort level, the total direct cost of effort is less: implementing total effort levels of $x_1 = x_2 = y_1 = y_2 \equiv x$ involves a total cost of effort equal to $(1 + 3\delta)x^2$ with two generalists and a total cost of effort equal to $2(\frac{1}{2})[x^2 + 2\delta x^2 + x^2] = 2x^2(1 + \delta)$ with specialists. For all values of δ smaller than 1, the cost of effort is smaller with generalists. Secondly, as each generalist must only be induced to exert half the effort level of a specialist on any task, generalists are given lower-power incentives than specialists, reducing their exposure to risk.[24] This second effect holds for all values of δ. Hence diseconomies of span weaken but do not eliminate the relative advantage of hiring 'generalists.'

On the other hand, using generalists combines the disadvantages of both the product and functional forms. Like the functional organization, an organization relying on generalist managers must tie each manager's reward to both measures of profit in order to induce the desired levels of effort for all four activities. As we have shown in Proposition 1, this tends to lead to higher implementation costs than for the product form. Moreover, because each manager controls both functional activities relating to a given product, the generalist organization suffers from the same lack of flexibility as the product organization. In particular, any asymmetries between functions would force it into an 'incentive compromise' and would favour the functional form.

V(iii). *Disaggregated Organization*

We now keep our assumption that managers are 'specialists,' but allow the firm to assign responsibility for each of the product-function effort choice to a different agent. In this structure, the firm would consist of four agents, one with responsibility for x_1, one with responsibility for y_1, and so forth. As this structure disaggregates responsibility for decision making, we refer to it as the 'disaggregated organization.' An obvious advantage of the disaggregated organization is that, by eliminating multi-tasking, it reduces the cost of implementing given levels of efforts when there are diseconomies of span (i.e. $\delta > 0$).

Let us first assume, as we have in the main part of the paper, that the reservation utility of each agent is standardized to zero. In this case, the disaggregated organization dominates the functional form: for all $\delta > 0$: it offers the same flexibility at a lower cost. However, the disaggregate organization is not necessarily more profitable than the product form. This is because, like the functional organization, it entails creating separate

[24] Define the contract terms that implement the given levels of effort of specialists in the product organization as $a_{11} = a_{22} \equiv a$. Therefore, for $r = 0$, the risk premium that must be paid to each of the two managers is $\frac{\rho\sigma^2}{2}(a^2 + a^2) = \rho\sigma^2 a^2$. To implement the same total levels of effort with generalists, each manager's compensation must receive a proportion $\frac{a}{2}$ of the profits of each product division. Hence each manager must receive a risk premium equal to $\frac{\rho\sigma^2}{2}[(\frac{a}{2})^2 + (\frac{a}{2})^2 + (\frac{a}{2})^2 + (\frac{a}{2})^2] = \frac{\rho\sigma^2}{2}a^2$. The cost of risk borne by generalists remains smaller than for specialists as long as $r < 1$, i.e., as long as the 'cost of risk' function remains convex.

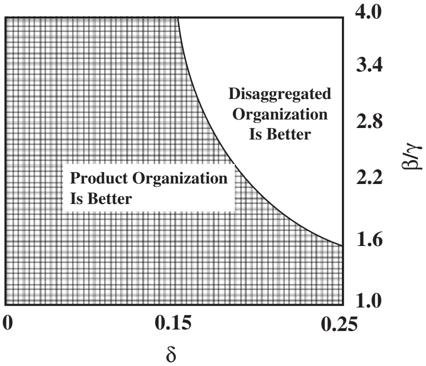

Figure 5
Comparison between product organization and disaggregated organization

incentives for the implementation of each task, while the product organization can use the same incentive to ensure that the two tasks relating to the same product are carried out. Hence, with perfect symmetry and $\delta = 0$, the product organization is more profitable than the disaggregated organization.[25] It is only as δ increases and there is significant functional asymmetry that the disaggregated organization begins to dominate the product organization. Numerical calculations give us an idea of the range of parameters for which the disaggregate organization does better than the product form. Representative calculations are summarized in Figure 5.

Of course, setting the reserve utility of agents equal to zero is nothing more than a convenient standardization. In practice, agents are likely to obtain positive utility from their outside options and must therefore be compensated for giving them up. This creates a fixed cost of hiring additional agents. This is clearly a disadvantage of the disaggregated organization and can easily make it less attractive than either the product or the functional organization.

VI. SUMMARY AND CONCLUSION

This paper has studied the choice among organizational forms in an environment in which agents must be motivated through incentive contracts to undertake multiple tasks on behalf of products. Two organizational forms are studied: a functional organization and a product-based organiza-

[25] With symmetry and no externalities, the expected profits of the functional organization, the product organization and the disaggregated organization are, respectively

$$\Pi^F = \frac{2\beta^4}{\beta^2+\rho\sigma^2(1+\delta)^2(1+r)}, \Pi^P = \frac{4\beta^4}{2\beta^2+\rho\sigma^2(1+\delta)^2(1-r^2)} \text{ and } \Pi^D = \frac{2\beta^2}{\beta^2+\rho\sigma^2(1+r)}$$

so that, for $\delta \geqslant 0$ but not too large, we have $\Pi^P > \Pi^D \geqslant \Pi^F$.

tion. In a functional organization, the firm is divided into functional divisions, and a division manager has responsibility for a single function's activities on behalf of all products. In a product-based organization, the firm is organized into product divisions, and a division manager has responsibility for all functional activities on behalf of a single product.

Because our model abstracts from important issues, such as the number of levels in the organization's hierarchy and the degree to which decision making authority is centralized or decentralized, it does not provide a complete theory of endogenous organizational structure. Our objective instead has been to identify economic forces that systematically favor organizing along a product dimension versus a functional dimension in settings in which incentive contracting plays a significant role in a firm's internal structure. In particular, the model identifies four distinct forces that shape the relative profitability of functional and product-based organizations:

1) *Noisiness of performance measures*: Measuring a product line's contribution to profitability is generally easier than measuring a functional area's contribution to profitability. This effect favors a product organization because it allows the owner to offer incentive contracts with better risk-bearing properties than can be offered in a functional organization.
2) *Disparities in the marginal profitability of functional areas*: Situations in which a particular function is more important to organizational success generally favors the functional organization. The functional organization allows the firm to better apply the incentive sensitivity principle: with a fixed number of agents it is better to group activities with similar degrees of incentive sensitivity together.
3) *Cross-product externalities*: Situations in which there are cross-product externalities within a function favors a functional organization. This is because function managers automatically internalize these externalities in decision making whereas product managers must be given incentives to do so through the compensation scheme, which then erodes the risk-bearing advantages of the product organization.
4) *Diseconomies of span of control*: Diseconomies of span generally favor the functional organization when one product is significantly more important to firm profitability than the other and favors the product organization when one function is significantly more important than the other.

While the role of cross-product externalities has already been discussed in the literature about the U-form and the M-form, we believe that the other three factors have not been analyzed before. Moreover, the complex interactions between cross-product externalities and various types of asymmetries have not been examined previously.

These forces should be useful beyond the confine of the 'U-form versus M-form debate.' In particular, our 'incentive flexibility principle' can help explain the existence of many hybrid organizations. For example, consider again our basic model with the following asymmetries. Activities x_1 and y_1 are equally important for the firm; their marginal impacts on total profits are lower than the marginal impact of x_2 but higher than the marginal effect of y_2. In that case, an organization grouping x_1 and y_2 under the same manager but assigning x_2 and y_2 to two other managers would avoid incentive intensity compromises and might therefore be optimal.

It is our hope that this paper illustrates how multi-task agency theory can fruitfully shed light on the economics of a firm's organizational strategy. In future work, we hope to continue this line of research by showing how changes in the scope of a firm's activities (e.g., adding additional products or entering additional geographic markets) affect its choice of organizational structure. Baron and Besanko [2001] provide some insights into the relationship between firm scope and organizational structure, but their model does not study functional organizations, nor does it consider the roles of noisy observables and hidden action which are key parts of this paper. We would also like to endogenize not only the organizing dimension, but also the number of levels in the firm's hierarchy and the allocation of decision authority in the organization.

APPENDIX[26]

Proof of Proposition 1. For simplicity, let us set $\beta_1 = \beta_2 = \gamma_1 = \gamma_2 = 1$

Using expressions (5) and (11), plugging back into the expected profit functions and taking limits for $\theta \to \xi$,[27] we have

$$\Pi^P = \frac{2(1+\theta)^2}{1 + \frac{\rho\sigma^2(1-r^2)(1+\delta)^2}{2(\theta^2 - 2\theta r + 1)}},$$

and

$$\Pi^F = \frac{2(1+\theta)^2}{1 + \rho\sigma^2 \frac{(1+\delta)^2(1+r)}{(1+\theta)^2}}$$

so that

$$\Pi^P \geqslant \Pi^F \text{ iff } \frac{1-r^2}{2(\theta^2 - 2\theta r + 1)} \leqslant \frac{1+r}{(1+\theta)^2}.$$

[26] The proofs of the propositions rely on the solutions to (5)–(6) and (11)–(12), which are expressed in matrix form. Because the scalar solutions to (6) and (12) are extremely complicated, we omit them for brevity. They are, however, available from the authors upon request.

[27] Taking $\lim_{\theta\to\xi}\Pi^P$ requires numerous applications of L'Hospital's rule.

For $r = -1$ the two sides of the inequality are equal to zero so that $\Pi^P = \Pi^F$. For $\theta = 1$ (but $r > -1$), the inequality becomes $\frac{1-r}{4(1-r)} \leqslant \frac{1}{4}$, which also holds with equality, implying $\Pi^P = \Pi^F$. For $r > -1$ and $\theta < 1$, the inequality is equivalent to

$$\begin{aligned}
&\frac{1-r}{2(\theta^2 - 2\theta r + 1)} \leqslant \frac{1}{(1+\theta)^2} \Longleftrightarrow \\
&0 \leqslant (1+r)\theta^2 - 2\theta(1+r) + 1 + r \Longleftrightarrow \\
&0 \leqslant (\theta - 1)^2,
\end{aligned}$$

which holds as a strict inequality for $\theta < 1$.

Finally, for $\theta = 0$, we have

$$\frac{\Pi^P}{\Pi^F} = \frac{2[1 + \rho\sigma^2(1+r)(1+\delta)^2]}{2 + \rho\sigma^2(1-r^2)(1+\delta)^2}.$$

Defining

$$K \equiv \rho\sigma^2(1+\delta)^2, \frac{\Pi^P}{\Pi^F} = \frac{2[1 + K(1+r)]}{2 + K(1-r^2)}$$

so that the sign of

$$\frac{d(\Pi^P/\Pi^F)}{dr}$$

is the same as the sign of

$$\begin{aligned}
&[2 + K(1-r^2)]K - [1 + K(1+r)][-2rK] \\
&\quad = K[2 + K(1-r^2) + 2r(1 + K(1+r))]
\end{aligned}$$

which is positive iff $2(1+r) + K(1+r) > 0$, which must hold for all $r > -1$. Hence $\frac{d(\Pi^P/\Pi^F)}{dr} > 0 \; \forall r > -1$.

Asymmetries in Productivities: Proposition A1

To isolate the pure effect of asymmetries in productivities we neutralize the two effects that made the product organization more profitable than the functional organization in Proposition 1. This is done by assuming that $r = 0$ (so that the product organization cannot use the a_{ij} coefficients to further reduce the risk borne by the agent) and by requiring that the product organization manager is twice as risk-averse as a functional manager, i.e., $\rho_p = 2\rho$ and $\rho_f = \rho$ (neutralizing the fact that the functional manager must 'bear two risks'). We can then state:

Proposition A1. Suppose there are no cross-product externalities, $\theta = \xi = 0$, there are no diseconomies of span, $\delta = 0$ and $\beta_1 = \beta_2 \equiv \beta > \gamma \equiv \gamma_1 = \gamma_2$ or *$\beta_1 = \gamma_2 \equiv \beta \neq \beta_2 = \gamma_1 \equiv \gamma$. Then compensating for the effects underlying Proposition 1, the profitability of the product-based organization relative to the functional organization, $\frac{\Pi^P}{\Pi^F}$, decreases as one function X becomes increasingly dominant, i.e., as $\frac{\beta}{\gamma}$ increases above 1.*

Proof: Solving expressions (6) and (12) we get

$$\Pi^P = \frac{(\beta^2+\gamma^2)^2}{\beta^2+\gamma^2+\rho_p\sigma^2(1-r^2)} \text{ and}$$

$$\Pi^F = \frac{\beta^4}{\beta^2+\rho\sigma^2(1+r)} + \frac{\gamma^4}{\gamma^2+\rho\sigma^2(1+r)}$$

if $\beta_1 = \beta_2 \equiv \beta > \gamma \equiv \gamma_1 = \gamma_2$ and

(13) $$\Pi^P = \frac{(\beta^2+\gamma^2)^2}{\beta^2+\gamma^2+\rho_P\sigma^2(1-r^2)}. \quad (A.1)$$

(14) $$\Pi^F = \frac{\beta^2[\beta^2(\gamma^2+\rho\sigma^2)-r\gamma^2\rho\sigma^2]+\gamma^2[\gamma^2(\beta^2+\rho\sigma^2)-r\beta^2\rho\sigma^2]}{(\beta^2+\rho\sigma^2)(\gamma^2+\rho\sigma^2)-r^2\rho^2\sigma^4}. \quad (A.2)$$

if $\beta_1 = \gamma_2 \equiv \beta \neq \beta_2 = \gamma_1 \equiv \gamma$.
Setting $r = 0$ and $\rho_p = 2\rho$ in these four expression we get

(15) $$\Pi^P = \frac{(\beta^2+\gamma^2)^2}{(\beta^2+\gamma^2)+2\rho\sigma^2}. \quad (A.3)$$

(16) $$\Pi^F = \frac{\beta^4}{\beta^2+\rho\sigma^2} + \frac{\gamma^4}{\gamma^2+\rho\sigma^2}. \quad (A.4)$$

for both cases.

Define $Z \equiv \frac{\Pi^P}{\Pi^F}$ and consider a mean-preserving increase in the asymmetry. We have

$$\frac{\partial Z}{\partial \beta} - \frac{\partial Z}{\partial \gamma} = 2(\gamma-\beta)(\beta^2+\gamma^2)\gamma\beta\rho\sigma^2\frac{A}{\Delta}$$

where

$$\Delta \equiv (\beta^2+\gamma^2+\rho\sigma^2)^2(\beta^4\gamma^2+\beta^4\rho\sigma^2+\gamma^4\beta^2+\gamma^4\rho\sigma^2)^2 > 0.$$

and

$$\begin{aligned} A \equiv\ & \beta^6\rho\sigma^2 + 2\beta^5\gamma\rho\sigma^2 + \gamma^3\beta^5 + 3\beta^4\gamma^2\rho\sigma^2 + 3\beta^4\rho^2\sigma^4 \\ & + 7\beta^3\gamma\rho^2\sigma^4 + 8\beta^3\gamma^3\rho\sigma^2 + \gamma^5\beta^3 + 2\beta^2\rho^3\sigma^6 + 6\beta^2\gamma^2\rho^2\sigma^4 \\ & + 3\beta^2\gamma^4\rho\sigma^2 + 2\beta\gamma^5\rho\sigma^2 + 4\beta\gamma\rho^3\sigma^6 + 7\beta\gamma^3\rho^2\sigma^4 \\ & + 3\gamma^4\rho^2\sigma^4 + \gamma^6\rho\sigma^2 + 2\gamma^2\rho^3\sigma^6 \\ & > 0. \end{aligned}$$

Hence

$$\left(\frac{\partial Z}{\partial \beta} - \frac{\partial Z}{\partial \gamma}\right) \lesseqgtr 0 \text{ as } \beta \gtreqless \gamma,$$

so that a mean preserving increase in asymmetry decreases Z.

Proof of Proposition 2: Define

$$B \equiv \frac{\rho\sigma^2(1+\delta)^2(1+r)}{(1+\theta)^2} \text{ and } A \equiv \frac{\rho\sigma^2(1+\delta)^2(1-r^2)}{1+\theta^2-2r\theta}$$

so that $A - 2B < 0\ \forall\theta < 1, r > -1$. We have

$$\Pi^F = \frac{\beta^4(1+\theta)^2}{\beta^2+B} + \frac{\gamma^4(1+\theta)^2}{\gamma^2+B} \text{ and } \Pi^P = \frac{(\beta^2+\gamma^2)^2(1+\theta)^2}{\beta^2+\gamma^2+A}$$

Setting $\Pi^F = \Pi^P$ and simplifying yields $\beta^4\gamma^2 A + \beta^4 AB + \beta^2\gamma^4 A + \gamma^4 AB = B^2(\beta^4+\gamma^4) + 2\beta^2\gamma^2(B+\beta^2+\gamma^2)$.

What we are trying to determine is whether, keeping β fixed, one can find values of γ that are different enough from β to ensure that $\Pi^F > \Pi^P$. To keep computations as simple as possible we set $\beta = 1$. Defining $z \equiv \gamma^2 \geqslant 0$ we have $\Pi^F - \Pi^P = z^2[(A-2B) + B(A-B)] + z[(A-2B) - 2B^2] + [A-B]B$, which is a second-degree polynomial in z. Define this polynomial as $P(z)$. The sign of $P(z)$ is the same as the sign of $[(A-2B)+B(A-B)]$, except for values of z lying between the roots of $P(z)$. The discriminant of the equation $P(z) = 0$ is $D = [A-2B][(A-2B) - 4AB - 4AB^2]$. As $A - 2B < 0$, $(A-2B) - 4AB - 4AB^2$ is also negative so that D is positive. Therefore the roots of the second degree equation $P(z) = 0$ are:

$$z_1 = \frac{2B^2 - (A-2B) + \sqrt{D}}{2[(A-2B)+B(A-B)]} \text{ and } z_2 = \frac{2B^2 - (A-2B) - \sqrt{D}}{2[(A-2B)+B(A-B)]}.$$

The numerator of z_1 is clearly positive. Straightforward computations show that the numerator of z_2 is also positive. This means that both roots always have the same sign determined by the sign of their denominator. Suppose first that $(A-2B) + B(A-B) < 0$. Since both roots are negative $P(z)$ is always of the same sign as $(A-2B) + B(A-B)$, which we assumed negative. Hence we must always have $\Pi^F < \Pi^P$. In other words, one can never find a functional asymmetry that is sufficient to reverse the profit ranking obtained in Proposition 1. Now suppose that $(A-2B) + B(A-B) > 0$ so that both roots are positive. Hence, $P(z)$ has the same sign as $(A-2B) + B(A-B)$ except for values of z between z_2 and z_1, i.e. $\Pi^F > \Pi^P$ iff $z > z_1$ or $z < z_2$. With $(A-2B) + B(A-B) > 0$ it is also straightforward to show that $z_2 < \beta^2 \equiv 1 < z_1$. Starting from $z = 1 = \gamma$ then, one can increase γ (and thus z) up to a point ($z \geqslant z_1$) where the functional asymmetry is large enough to ensure the dominance of the functional organization. A similar result can be obtained by decreasing γ up to a point where $z \leqslant z_2$. Hence a necessary and sufficient condition for the existence of positive values of z for which the functional form is more profitable than the product form is that $(A-2B) + B(A-B) > 0$. We must then determine under what conditions this inequality is satisfied.

Consider the inequality $(A-2B) - B(A-B) > 0$. Substituting the values of A and B and defining $M \equiv \rho\sigma^2(1+\delta)^2$ we get that $(A-2B) + B(A-B) > 0$ iff $\theta^2 - 2\theta + 11 < \frac{M}{(1+\theta)^2}(-r\theta^2 + 2\theta - r)$. This is equivalent to $Q(\theta) \equiv \theta^4 - 2\theta^2 + 1 + M\ (r\theta^2 - 2\theta + r) < 0$. We have $Q'(\theta) = 4\theta(\theta^2 - 1) + 2M(r\theta - 1) < 0$. Moreover $Q(\theta = 1) = 2M(r-1)\theta \leqslant 0$ and $Q(\theta = 0) = 1 + Mr$. Hence, if $r > -\frac{1}{M}$ then $Q(\theta = 0) > 0$ and there is a single value of θ, defined as $\theta_c \in\ ]0, 1[$ such that $(A-2B) + B(A-B) > 0$ iff $\theta > \theta_c$. Hence, for all $\theta > \theta_c$, one can always find a value of γ that is different enough from β that the

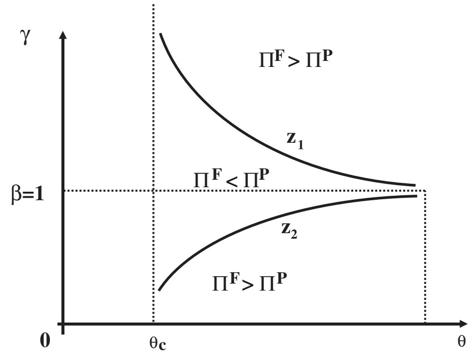

Figure 6
Functional asymmetries

functional organization is more profitable than the product-based organization. This situation is represented in Figure 6. If $r \leqslant -\frac{1}{M}$ then $Q(\theta = 0) \leqslant 0$ so that $(A - 2B) + B(A - B) > 0\ \forall \theta \in [0, 1[$. This means that the functional form is preferred even in the absence of externalities. Hence, provided that $\frac{1}{M} < 1$ there are values or r such that $\forall \theta \in [0, 1]$one can find values of γ different enough from β so that $\Pi^F > \Pi^P$.

Proof of Proposition 3

Let us set $\delta = r = \xi = 0$ and $\beta_1 = \beta_2 = \gamma_1 = \gamma_2 \equiv \beta$. Define $X \equiv \frac{\rho\sigma^2}{\beta^2}$. Solving (6) and (12)

$$\Pi^F = \frac{\beta^2}{1 + X} + \frac{\beta^2(1 + \theta)^4}{(1 + \theta)^2 + X}$$

$$\begin{aligned}\Pi^P = {} & \frac{\beta^2}{(\theta^2 + X(2 + \theta^2) + X^2)^2}[\theta^6(1 + X)^2 + 2(1 + X)^2\theta^5 \\ & + (1 + X)(X^2 + 4X + 2)\theta^4 + 2X(1 + X)(X + 4)\theta^2(1 + \theta) \\ & + 4X^2(2 + X)(1 + \theta)],\end{aligned}$$

so that $\Pi^F > \Pi^P$if and only if

$$\begin{aligned}P(\theta) \equiv {} & X^2[X(X + 2) + (1 + X)\theta^2][2(1 + X)\theta^3 \\ & + (3 + 4X)\theta^2 - 2\theta - 1(1 + X)]. > 0\end{aligned}$$

Hence for all $X > 0$, $P(\theta) > 0 \Longleftrightarrow Z(\theta) \equiv 2(1 + X)\theta^3 + (3 + 4X)\theta^2 - 2\theta - 2(1 + X) > 0$. We have $Z(\theta = 0) = -2(1 + X + \theta) < 0$ and $Z(\theta = 1) = 4X + 1 > 0$. As $Z'(\theta) = 6(1 + X)\theta^2 + 2(3 + 4X)\theta$, we can show that Z is decreasing in θ at $\theta = 0$ but is increasing in θ at $\theta = 1$: $Z'(\theta = 0) = -2 < 0$ and $Z'(\theta = 1) = 10 + 14X > 0$. However, one can also show that Z is strictly convex for $\theta \in [0, 1]$ as $Z''(\theta) = 12(1 + X)\theta + 2(3 + 4X) > 0$. Hence there exists a unique value of θ, defined as $\theta_c \in]0, 1[$ such that $\Pi^F > \Pi^P \forall \theta \in]\theta_c, 1]$ and $\Pi^P \geqslant \Pi^F \forall \theta \in [0, \theta_c]$.

REFERENCES

Aghion, P. and Tirole, J., 1995, 'Some Implications of Growth for Organizational Form and Ownership Structure,' *European Economic Review*, 39, 440–455.

Baker, George, 1992, 'Incentive Contracts and Performance Measurement,' *Journal of Political Economy*, 100, 598–614.

Baron, D. and Besanko, D., 2001, 'Strategy, Organization, and Incentives: Global Corporate Banking at Citibank,' *Industrial and Corporate Change*, 10, 1–36.

Brock, G. W., 1975, *The U.S. Computer Industry: A Case Study in Market Power*, Ballinger, Massachusetts.

Buchanan, D., 1994, 'Principles and Practices in Work Design,' in Sisson, K. (ed.), *Personnel Management; A Comprehensive Guide to Theory and Practice in Britain*, Blackwell, Publishers, Oxford.

Burton, R. M. and Obel, B., 1988, 'Opportunism, Incentives, and the M-Form Hypothesis: A Laboratory Study,' *Journal of Economic Behavior and Organization*, 99–119.

Carroll, P., 1993, *Big Blues: The Unmaking of IBM*, Crown Publishers, New York.

Chandler, Alfred, 1962, *Strategy and Structure: Chapters in the History of the American Industrial Enterprise*, MIT Press, Cambridge, MA.

Corts, K., 2005, 'Teams vs. Individual Accountability,' working paper, University of Toronto.

Hackman, J. R. and Lawler, E. E., 1971, 'Employee Reactions to Job Characteristics,' *Journal of Applied Psychology*, 55, 259–286.

Hackman, J. R. and Oldham, G. R., 1976, 'Motivation through the Design of Work: A Test of Theory,' *Organizational Behaviour and Human Performance*, 16, 250–279.

Holmstrom, B. and Milgrom, P., 1987, 'Aggregation and Linearity in the Provision of Intertemporal Incentives,' *Econometrica*, 55, 303–328.

Holmstrom, B. and Milgrom, P., 1991, 'Multitask Principal-Agent Analyses: Incentive Contracts, Asset Ownership, and Job Design,' *Journal of Law, Economics and Organization*, spring, 24–52.

Holmstrom, B. and Tirole, J., 1989, 'The Theory of the Firm,' in R. Schmalensee and R. Willig (eds), *Handbook of Industrial Organization*, North Holland, Amsterdam, 61–133.

Itoh, Hideshi, 1991, 'Incentives to Help in Multi-Agent Situations,' *Econometrica*, 59, 611–636.

Itoh, Hideshi, 1992, 'Cooperation in Hierarchical Organizations: An Incentive Perspective,' *Journal of Law Economics and Organization*, 8(2), 321–345.

Laffont, J. J. and Martimort, D., 2002, *The Theory of Incentives*, Princeton University Press.

Maskin, E.; Qian, Y. and Xu, C., 2000, 'Incentives, Information and Organizational Form,' *Review of Economic Studies*, 67, 359–378.

Porter, M., 1985, *Competitive Advantage*, Free Press, New York.

Tirole, J., 1989, *The Theory of Industrial Organization*, MIT Press.

Williamson, O., 1975, *Markets and Hierarchies: Analysis and Antitrust Implications*, Free Press, New York.