A Double Moral Hazard Model of Organization Design

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We develop a theory of organization design in which the firm's structure is chosen by trading off ex post efficiency in the implementation of projects against ex ante efficiency in the selection of projects. Using our framework, we derive a novel set of empirical predictions regarding differences between firms with a functional structure and firms with a divisional structure. We examine how the overall profitability of the two structures is affected by various factors like size, complexity, and asymmetry in the importance of tasks and also explore the desirability of adopting a narrow business strategy.

1. Introduction

We develop a theory of organization structure in which the optimal structure is chosen to mitigate moral hazard problems in the selection and the implementation of projects. For the sake of concreteness, we

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refer to the organization as a "firm," although our results are equally relevant for other types of organizations, including the government, government agencies, and nonprofit organizations. Specifically, we consider the choice between a "divisional structure" and a "functional structure." Under the divisional structure, also known as the "M-form," the firm is organized as a collection of self-contained divisions, each of which has full responsibility over a subset of projects, and needs to perform all tasks associated with these projects (e.g., production, marketing, finance, human resources, R&D, etc.). Under a functional structure, also known as the "U-form," the firm is organized as a collection of functional departments, each of which specializes in one task and performs it on all projects that the firm undertakes. Therefore, under the functional structure, each project is executed by a team of agents who belong to different functional departments.[1]

To examine the advantages and disadvantages of the divisional and functional structures, we consider a firm that consists of a board of directors, a manager, and two agents (mid-level managers, business units, or simply employees). The manager's role is to select projects and recommend them to the board of directors. If the board accepts the manager's recommendation, the two agents perform tasks like production and marketing on each project. In this setting, the divisional structure corresponds to the case where each agent gets the full responsibility over a subset of projects and performs all tasks on these projects, whereas the functional structure corresponds to the case where each agent specializes in one task and performs it on all selected projects.

Our main premise is that the selection of projects by the manager is subject to a moral hazard problem: the manager may prefer to recommend expensive projects which he personally likes even if there are more profitable projects around. We examine the effect of organization structure on this managerial moral hazard problem, as well as on the agents' incentives when they implement the selected projects. We show that for a given set of selected projects, the divisional structure is more efficient *ex post* because it enables the firm to offer each agent an incentive contract that ties his compensation directly to his performance. By contrast, under the functional structure there is a moral hazard in teams problem (e.g., Alchian and Demsetz, 1972) because each project requires the joint effort of two agents. However, the *ex post* inefficiency of the functional structure may render expensive projects unprofitable and hence it may deter the manager from recommending them to the board

1. It should be emphasized that our theory applies equally well to any situation in which organizations can either assign the full responsibility over a set of projects to individual groups or alternatively require groups to cooperate with one another in the execution of projects.

of directors. Hence, the optimal organization structure is determined by trading-off its effect on the *ex ante* selection of projects and its effect on the *ex post* implementation of selected projects. Our theory then emphasizes the interaction between organizational structure and investment decisions. This interaction has received empirical support by several studies (e.g., Merchant, 1981; Pike, 1986; and especially Segelod, 1996), but as far as we know, has not been studied earlier by theoretical models.

Using our framework, we are able to derive a novel set of empirical predictions. Among other things, we show that relative to firms with the functional structure, firms with a divisional structure have less restrictive standards for project evaluation, they adopt more projects, their projects are more likely to succeed and have a higher variance of gross returns, and they pay a higher expected compensation to their agents. Moreover, we show that the functional structure is more likely to dominate the divisional structure when (i) expensive projects require a larger initial investment, (ii) conditional on success, projects yield a smaller return, and (iii) the firm's technology exhibits weak economies of scope and strong economics of scale. In addition, we examine how the overall profitability of the divisional and functional structures changes when firms grow and can adopt more projects, when projects become more complex and require more tasks, and when the tasks have asymmetric effects on the probability that projects will succeed. We also consider the possibility that the firm will adopt a narrow business strategy in order to mitigate managerial moral hazard in the selection of projects.

The study of organization designs was pioneered by Chandler (1962) who argued that as firms like DuPont, General Motors, Sears, and Standard Oil grew and adopted more diverse product lines, the difficulties in coordinating functions across product lines induced them to switch from the functional structure (U-form) to the divisional structure (M-form). Chandler concluded that a firm's structure follows its strategy which determines the number and type of its product lines. Our model shows that the interaction between strategy and structure can run both ways: holding fixed the firm's strategy which is determined by the manager's choice of projects, the divisional structure dominates the functional structure *ex post*. However, the functional structure may improve the manager's selection of projects *ex ante*. This suggests that both structure and strategy are determined simultaneously by more fundamental factors like technology (economies of scale and scope), the availability of efficient projects, and the profitability of successful projects.

Several papers have already examined the choice between the functional and the divisional structures. Like us, these papers consider a firm that produces two goods which require two tasks each. The divisional structure corresponds in this framework to the grouping of agents according to products, whereas the functional structure corresponds to the grouping of agents according to tasks. Our paper departs from these papers in many respects, the most important of which is that we endogenize the firm's choice of projects and study the tradeoff between *ex ante* efficiency in the selection of projects (which favors the functional structure) and *ex post* efficiency in the implementation of selected projects (which favors the divisional structure). In earlier papers, the firm's projects are given exogenously, and hence, unlike in our paper, the firm's structure does not affect its strategy (i.e., the choice of projects).

Aghion and Tirole (1995) consider a model in which the functional structure requires agents to specialize in specific tasks and hence economizes on the cost of training agents, but the divisional structure strengthens the agents' incentives to exert effort by generating better external signals about their talent.[2] They show that as managerial work overload increases, the divisional structure becomes more attractive relative to the functional structure since then, the manager relies more often on the agents' decisions and this improves their ability to signal talent to the external job market. In Rotemberg (1999), the firm can better control agents who perform the same task under the functional structure, but cross-task coordination is more efficient under the divisional structure. He shows that the divisional structure dominates the functional structure when the number of employees is sufficiently large. Qian et al. (2006) consider a model in which the divisional structure eliminates the need for costly cross-division communication to coordinate tasks, but the functional structure economizes on the cost of coordination by coordinating tasks on a company-wide basis. The divisional structure is particularly attractive in their model when there is a need for local experimentation of uncertain innovations involving several tasks; such experimentation is inefficient under the functional structure due to the need for costly communication among different divisions that engage in different tasks. In Maskin et al. (2000), the functional structure exploits economies of scale by grouping similar tasks in the same division, but the divisional structure provides better incentives because it promotes yardstick competition among similar divisions. Besanko et al. (2005) focus on the role of risk aversion: under the divisional structure, the compensation of agents depends only on their own (risky) performance, whereas under the functional structure it also depends on the (risky)

2. Although the functional structure in Aghion and Tirole (1995) also gives rise to a team problem, the agents in their model do not receive monetary incentives as in our model and are motivated instead by career concerns.

performance of other agents. Hence, agents must receive a larger risk premium under the functional structure in order to induce them to exert the same level of effort. This result may be reversed however if there are significant asymmetries in the contribution of the tasks to profits, or significant positive externalities across tasks. Corts (2007) considers a model with two possible configurations of tasks: "individual accountability" (which is akin to the divisional structure), where each agent is compensated on the basis of a single (noisy) performance measure that depends only on the agent's own effort, and "teams" (which is akin to the functional structure), where compensation is based on two (noisy) performance measures which depend on the agents' joint effort. Individual accountability has the advantage of compensating the risk-averse agents on the basis of only one noisy performance measure rather than two. The disadvantage of individual accountability is that the firm uses a single performance measure to evaluate the two tasks that each agent performs, whereas under teams it uses two performance measures.

In Harris and Raviv (2002), the comparison between the divisional and functional structures depends on the likelihood that various cross-task interactions will be realized, as well as on the CEO's cost of coordinating company-wide interactions between all tasks. For a wide range of parameters, both the functional and the divisional structures are dominated by either the matrix form whereby each task is coordinated by two different middle managers, or by a flat hierarchy whereby only the CEO may coordinate cross-task interactions. Mookherjee and Tsumagari (2001) also show that the matrix form can be optimal. The key disadvantage of the divisional structure in their model is that it does not allow one division to source cheap components from a rival division when the latter happens to be more efficient. Although the functional structure allows for this possibility, the resulting benefits accrue disproportionately to the division managers rather than the firm's owners. The matrix form overcomes both problems.

The rest of the paper is organized as follows. Section 2 describes the model. Section 3 characterizes the expected *ex post* profit of the firm under the divisional and functional structures, holding constant the set of selected projects. In Section 4, we endogenize the selection of projects and compare the overall profit of the firm under the two structures. In Section 5, we study how the optimal structure of the firm changes when it adopts more projects, when projects require more tasks, and when tasks have asymmetric effect on the probability of success. In Section 6, we consider the possibility that the firm will adopt a narrow business strategy and will specialize in only one type of project. Concluding remarks are in Section 7.

2. The Model

Consider a firm that consists of a board of directors, a manager, and two agents (middle managers, business units, or simply employees). The manager's task is to screen projects and recommend them to the board of directors. The board of directors either approves the manager's selection or rejects it. If the board of directors approves the manager's selection, the two agents need to implement the selected projects. If the board rejects the manager's selection, the game ends and all agents get a payoff of 0.

2.1 Project Selection

Using his expertise, the manager selects projects from a large pool of potential projects. All projects yield a return R if they succeed and 0 if they fail. Projects differ only with respect to the required initial investment: L-type projects require a low initial investment which we normalize to 0, whereas H-type projects require a high initial investment equal to $I \in (0, R)$. We assume that the manager can always discover H-type projects, but can discover (at least two) L-type projects only with probability α; with probability $1 - \alpha$, the manager discovers only H-type projects.

A key assumption in our model is that the manager prefers H-type projects over L-type projects. As a result, he will recommend two H-type projects to the board of directors if he anticipates that they will approve his recommendation. Otherwise, the manager who prefers that the firm will adopt L-type projects than not adopt any projects, will recommend two L-type projects provided that he manages to discover them.[3] The manager's preference toward H-type projects could be due to several reasons. First, the manager may have "empire-building" preferences and may like to manage more expensive, "larger" projects. Second, it is possible that H-type projects enhance the manager's general human capital whereas L-type projects only contribute to his firm-specific human capital. Third, it may be the case that L-type projects are "traditional," whereas H-type projects are more "innovative" and involve "cutting edge" technologies that the manager likes. For instance, a founder of a biotechnology firm may prefer projects that bring him a greater recognition in the scientific community even if they are more costly for the firm. Fourth, if the manager is also an entrepreneur, then he might be personally involved with the development of H-type projects, and hence may resist replacing them with more profitable

3. The manager will never recommend one project of each type, because then the board of directors will realize that he conceals an additional L-type project.

L-type projects if they become available. Finally, the manager may prefer H-type projects because he can costlessly discover them but needs to exert costly effort in order to discover L-type projects.

We assume that the board of directors is a perfect agent of outside investors and is interested in maximizing the net expected profit of the firm. Hence, unlike the manager, the board of directors prefers L-type projects over H-type projects. To focus on the incentive role of organization design, we assume that monetary incentives alone (any equity stake the manager has plus wages and bonuses) are insufficient to induce the manager to recommend L-type projects. Given this assumption, the manager's wage will be constant and equal to his reservation wage, which we normalize to zero.

We also assume that when the manager recommends H-type projects, the board of directors cannot discern whether he failed to discover L-type projects, or whether he did discover them but chose to conceal this fact. Because the board is interested in maximizing the firm's expected profit, it will approve the manager's recommendation if the net expected value of the selected projects is positive. Consequently, we have a managerial moral hazard problem: the manager anticipates that the board of directors will approve H-type projects when they are profitable and hence he recommends them even if he discovers more profitable L-type projects. By contrast, the manager does not recommend H-type projects when their net expected value is negative, because he correctly anticipates that the board will reject his recommendation. Instead, the manager recommends L-type projects if he manages to discover them and does not recommend any projects otherwise.

2.2 Project Implementation

Once projects have been approved by the board of directors, the two agents need to perform two tasks on each project to enhance its chance to succeed. For concreteness, we refer to the two tasks as production (p) and marketing (m), but they could equally be engineering and product design, R&D and financing, or purchasing and sales. We assume that each of the two agents can perform at most two tasks. Because each project requires two tasks, the firm can at most adopt two projects. Given the efforts that the agents exert in task p, e_p, and task m, e_m, the probability that a project will succeed is

$$q(e_p, e_m) = e_p + e_m. \tag{1}$$

Below, we will make parameter restrictions that will ensure that in equilibrium, $q(e_p, e_m) \leq 1$ under both organizational structures.

2.3 The Organizational Structure

Given our setup, there are two ways to allocate the two projects and the two tasks between the two agents. One alternative is to assign each project to one agent and let him perform both tasks on his assigned project. We refer to this alternative as the "multidivisional structure," (i.e., the M-form) or "divisional structure" for short. Under this structure, the firm essentially has two divisions, each of which is fully responsible for one project. We assume that agent j's cost of implementing his project is

$$C^d(e_{pj}, e_{mj}) = \gamma e_{pj}^2 + \gamma e_{mj}^2 - \frac{\rho e_{pj} e_{mj}}{2}, \quad j = 1, 2, \tag{2}$$

where e_{pj} and e_{mj} are the efforts of agent j in production and in marketing, $\gamma \geq 1$, and $\rho \in (-1, 1)$ is a parameter that measures the complementarity between the two tasks. If $0 < \rho < 1$, there are economies of scope: performing one task lowers the cost of performing the other task (e.g., engaging in marketing allows the agents to learn about customers' needs and design the product more efficiently; alternatively, performing two different tasks increases the agents' satisfaction and lowers their disutility of effort). If $-1 < \rho < 0$, there are diseconomies of scope, so performing one task increases the cost of performing the other task.

A second alternative is the "Unitary functional structure," (i.e., the U-form), or "functional structure" for short. Here each agent specializes in one task and performs it on both projects. One can now think of the two agents as the "production department" and the "marketing department." The cost that agent i incurs when performing task i on projects 1 and 2 is

$$C^f(e_{i1}, e_{i2}) = \gamma e_{i1}^2 + \gamma e_{i2}^2 - \frac{\sigma e_{i1} e_{i2}}{2}, \quad i = p, m, \tag{3}$$

where e_{i1} and e_{i2} are the efforts of agent i in projects 1 and 2 and $\sigma \in (-1, 1)$ is a parameter that measures the degree of economies of scale if $0 < \sigma < 1$ or diseconomies of scale if $-1 < \sigma < 0$. Performing each task twice lowers the cost of effort if $\sigma > 0$, and increases it if $\sigma < 0$.

The two organizational structures are illustrated in Figure 1.

2.4 The Timing

First, the board of directors sets up the organizational structure of the firm. Then, the manager screens projects and recommends two of them to the board of directors. The board in turn either accepts the manager's recommendation or rejects it. In the latter case, no projects are implemented and all agents get a payoff of 0. If the board accepts the manager's recommendation, it signs incentive contracts with the two

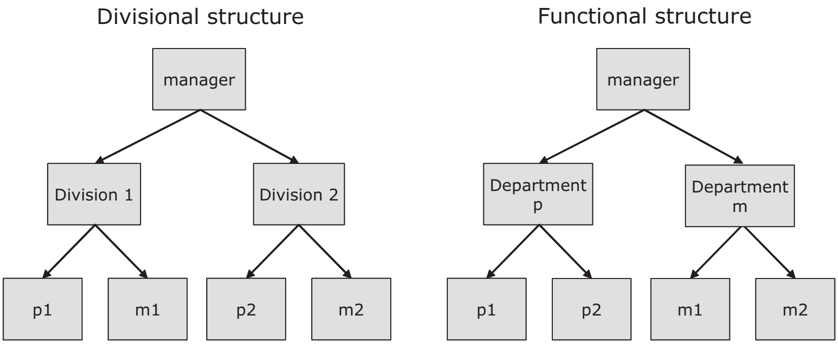

FIGURE 1. ILLUSTRATING THE DIVISIONAL AND THE FUNCTIONAL STRUCTURES

agents. Finally, the agents implement the selected projects and payoffs are realized.

Note that we assume that the board, not the manager, signs contracts with the agents. The logic behind this assumption is that after projects are selected, the manager's incentives are not fully aligned with those of the board. In particular, if the manager gets extra private benefits when projects succeed, then he may wish to maximize the probability of success rather than profits. Moreover, we assume that the board sets up the organizational structure *before* projects are selected, but signs contracts with the agents *after* projects are selected. This reflects the idea that organizational structure is a long-term decision whereas incentive contracts are a more short-term decision which is easier to modify. Hence, although the board can offer the agents contracts at the outset and design them so as to motivates the manager to select L-type, the board will have an incentive to renegotiate these contracts once the manager has recommended projects in order to ensure that the selected projects are implemented efficiently.

It is also worth noting that if the manager is averse to the firm's losses (say because his reputation is damaged in this case), then he will not select H-type projects when they are not profitable. In this case, the formal approval of projects by the board of directors is not needed in order to mitigate managerial moral hazard in the selection of projects.

3. The Expected ex post Profit of the Firm under the Two Organizational Structures

In this section, we compute the expected profit of the firm, gross of the cost of investment, under each structure, holding fixed the type of projects that the firm adopts. In the next section, we will also take the selection of projects into account and determine which organizational structure is more efficient overall.

3.1 The Divisional Structure

The salient feature of the divisional structure is that each project is assigned to one agent who gets the full responsibility for this project. Because there is no interaction between the two agents in this case, the board of directors can sign a contract with each agent separately.

We assume that the efforts of the two agents when they implement projects are nonverifiable. Hence, the firm can condition the agents' compensation only on whether their respective projects succeed or not. Moreover, we assume that the agents are wealth-constrained, so their compensation cannot be negative.[4] Consequently, the firm will offer agent j $(j = 1, 2)$ compensation of W_j if project j succeeds, and 0 otherwise. The contract offered to agent j is characterized by the solution to the following problem:

$$\max_{\{e_{pi}, e_{mi}, W_i\}} \quad q_1(e_{p1}, e_{m1})(R - W_1) + q_2(e_{p2}, e_{m2})(R - W_2)$$
$$s.t. \quad e_{pi}, e_{mi} \in \arg\max_{\hat{e}_{pi}, \hat{e}_{mi}} q_i(\hat{e}_{pi}, \hat{e}_{mi}) W_i - C^d(\hat{e}_{pi}, \hat{e}_{mi}), \quad i = 1, 2,$$
$$q_i(e_{pi}, e_{mi}) W_i - C^d(e_{pi}, e_{mi}) \geq 0, \quad i = 1, 2. \tag{4}$$

Solving this problem, the optimal contracts are such that

$$W_j^d = \frac{R}{2}, \quad j = 1, 2. \tag{5}$$

At the optimum, the participation constraints of the two agents are nonbinding,[5] and the probability that project j succeeds is:

$$q_j^d = \frac{2R}{4\gamma - \rho}, \quad j = 1, 2. \tag{6}$$

Because $\gamma \geq 1 > \rho$, $q_j^d > 0$. To ensure that $q_j^d < 1$ for all $\rho \in (-1, 1)$, we assume that $\gamma > \frac{2R+\rho}{4}$, that is γ is sufficiently large relative to R.

Noting that the expected *ex post* profit from project j is $q_i(e_{pi}, e_{mi})(R - W_i)$ and using (5) and (6), the expected profit per project,

4. Alternatively, we can assume that the agents become infinitely risk-averse if their monetary payoff is negative. Either way, the assumption that agents cannot get a negative monetary payoff does not affect our qualitative results—see the discussion in Section 3.3.

5. Given e_{pj}^d, e_{mj}^d, and W_j^d, the expected payoff of agent j is $\frac{R^2}{2(4\gamma-\rho)} > 0$.

gross of the cost of investment, under the divisional structure is

$$\pi^d = \frac{R^2}{4\gamma - \rho}. \tag{7}$$

Equation (7) implies that π^d increases with ρ, so the firm is more profitable *ex post* if there are stronger economies of scope. The reason is that economies of scope lower the agents' costs of effort, so a smaller compensation is needed to induce them to exert the same level of effort.

3.2 The Functional Structure

Under the functional structure, each agent specializes in one task and performs it on both projects. Hence, each project requires the joint effort of the two agents.

As before, the agents' compensation cannot be negative and can depend only on the success or failure of the two projects. Using W_{ij} to denote the compensation of agent i $(i = p, m)$ if project j $(j = 1, 2)$ succeeds, the contracts offered to the two agents are chosen to solve the following problem:

$$\begin{aligned}
\max_{\{e_{ij}, W_{ij}\}} \quad & q_1(e_{p1}, e_{m1})(R - W_{p1} - W_{m1}) + q_2(e_{p2}, e_{m2})(R - W_{p2} - W_{m2}) \\
s.t. \quad & e_{p1}, e_{p2} \in \arg\max_{\hat{e}_{p1}, \hat{e}_{p2}} q_1(\hat{e}_{p1}, e_{m1})W_{p1} + q_2(\hat{e}_{p2}, e_{m2})W_{p2} \\
& \quad - C^f(\hat{e}_{p1}, \hat{e}_{p2}) \\
& e_{m1}, e_{m2} \in \arg\max_{\hat{e}_{m1}, \hat{e}_{m2}} q_1(e_{p1}, \hat{e}_{m1})W_{m1} + q_2(e_{p2}, \hat{e}_{m2})W_{m2} \\
& \quad - C^f(\hat{e}_{m1}, \hat{e}_{m2}) \\
& q_1(e_{p1}, e_{m1})W_{p1} + q_2(e_{p2}, e_{m2})W_{p2} - C^f(e_{p1}, e_{p2}) \geq 0 \\
& q_1(e_{p1}, e_{m1})W_{m1} + q_2(e_{p2}, e_{m2})W_{m2} - C^f(e_{m1}, e_{m2}) \geq 0.
\end{aligned} \tag{8}$$

The resulting optimal contracts are such that

$$W_{p1} + W_{m1} = W_{p2} + W_{m2} = \frac{R}{2}. \tag{9}$$

At the optimum, the participation constraints of the two agents are nonbinding,[6] and the probability that project j succeeds is

$$q_j^f = \frac{R}{4\gamma - \sigma}, \quad j = 1, 2. \tag{10}$$

6. Given e_{pj}^f, e_{mj}^f, and W_j^f, the expected payoff of agent j is $\frac{3R^2}{8(4\gamma - \sigma)} > 0$.

Because $\gamma \geq 1 > \sigma$, $q_j^f > 0$. To ensure that $q_j^f < 1$ for all $\sigma \in (-1, 1)$, we require that $\gamma > \frac{R+\sigma}{4}$.

Using (9) and (10), the expected profit per-project, gross of the cost of investment, under the functional structure is

$$\pi^f = \frac{R^2}{2(4\gamma - \sigma)}. \tag{11}$$

Equation (11) implies that π^f increases with σ so economies of scale make the firm more profitable. The reason is that scale economies lower the agents' cost of effort, so a smaller compensation is needed to induce them to exert the same level of effort.

3.3 Comparing the Expected ex post Profits under the Divisional and Functional Structures

Using equations (7) and (11), we establish the following result:

Lemma 1: $\pi^d > \pi^f$ *for all* $\rho \in (-1, 1)$ *and all* $\sigma \in (-1, 1)$.

Lemma 1 implies that holding fixed the type of projects that the firm adopts, the divisional structure is more profitable *ex post* than the functional structure. The intuition is that under the functional structure, the agents' compensation depends on their joint effort, so there is a "moral hazard in teams" problem: agents have an incentive to free-ride on one another's effort. Under the divisional structure, there is no such problem because the success of each project depends on the effort of only one agent. Equations (7) and (11) show that *ex post*, the advantage of the divisional structure over the functional structure increases with ρ (economies of scope) and decreases with σ (economies of scale).

It should be noted that our assumption that the agents are wealth constrained rules out contracts with a negative fixed payment. With these kind of contracts, the firm can solve the agents' moral hazard problem by paying them R in case of a success and set the negative fixed payment equal to the expected value of the firm. That is, the firm can be effectively "sold to the agents." However, although these contracts achieve a first-best solution to the agents' problem under the divisional structure as each agent becomes the sole owner of one project, they fail to achieve a first-best solution under the functional structure because then each project is jointly owned by two agents, so there is still a teams problem. Hence, Lemma 1 continues to hold.

Because Lemma 1 abstracts from the cost of investment and from the manager's selection of projects, it does not fully answer the question which structure is more efficient overall. In the next section, we address this question.

4. The Optimal Organizational Structure under Managerial Moral Hazard

To examine the effect of organization structure on the manager's *ex ante* selection of projects, recall that when the manager recommends two (costly) H-type projects, the board of directors cannot tell whether this is because he failed to discover L-type projects or because he did discover them but chose to conceal this fact. The board of directors will therefore approve H-type projects under structure s ($s = d, f$) if and only if the required initial investment I is such that $I \leq \pi^s$. Because we normalized the cost of L-type projects to 0, the board will always accept the manager's recommendation to adopt L-type projects.

Anticipating the board's behavior, the manager, who prefers H-type projects over L-type projects, will recommend costly H-type projects if and only if $I \leq \pi^s$; the firm's per-project profit in this case is $\pi^s - I$. If $I > \pi^s$, the manager, who prefers that the firm will adopt L-type projects rather than not adopt any projects, will recommend L-type projects if he succeeds to discover them and will not recommend any projects otherwise (his recommendation will be rejected anyway). The firm in this case overcomes the managerial moral hazard problem in projects selection. Because the manager discovers L-type projects only with probability α, the resulting expected per-project profit of the firm is $\alpha\pi^s$.

The discussion implies the following result:

Proposition 1: *The optimal organizational structure of the firm is as follows:*

(i) If $I < \pi^f$, the firm will choose the ex post efficient divisional structure and will end up adopting two H-type projects with probability 1.

(ii) If $\pi^f \leq I \leq \pi^d$, the firm will choose the ex post efficient divisional structure if $\alpha < \hat{\alpha} \equiv \min\{\frac{\pi^d - I}{\pi^f}, 1\}$, and will choose the ex post inefficient functional structure if $\alpha > \hat{\alpha}$. Because only the functional structure overcomes the managerial moral hazard problem in projects selection, the firm will end up adopting two H-type projects with probability 1 under the divisional structure, and two L-type projects with probability α under the divisional structure.

(iii) If $I > \pi^d$, the firm will choose the ex post efficient divisional structure and will end up adopting two L-type projects with probability α if $I > \pi^d$.

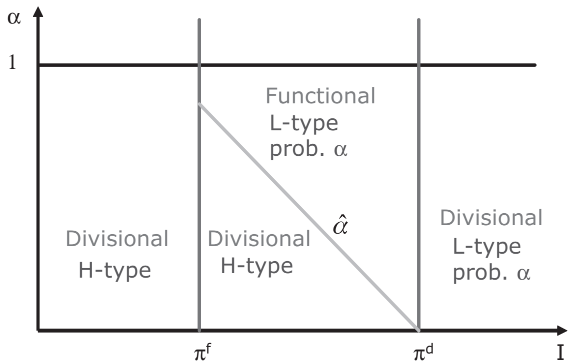

FIGURE 2. COMPARING THE DIVISIONAL AND THE FUNCTIONAL STRUCTURES

Proof.

(i) Because $I < \pi^f < \pi^d$, the manager will recommend two H-type projects under both structures anticipating correctly that the board of directors will accept his recommendation. Because organizational structure does not affect the manager's choice, the firm will choose the *ex post* efficient divisional structure.

(ii) Now the manager recommends H-type projects under the divisional structure but L-type projects under the functional structure. Because the probability of discovering L-type projects is α, the expected per-project profit under the functional structure is $\alpha\pi^f$. Under the divisional structure, the expected per-project profit is $\pi^d - I$. The result follows by comparing $\alpha\pi^f$ and $\pi^d - I$.

(iii) Because $I > \pi^d > \pi^f$, the manager recommends L-type projects under both structure because he anticipates that the board of directors will reject H-type projects. As in (i), organization structure does not affect the selection of projects, so the firm will choose the *ex post* efficient divisional structure. □

Proposition 1 is illustrated in Figure 2 that shows for each pair of I and α which organization structure dominates and which kind of projects the firm will end up adopting (the figure is illustrated under the assumption that $\rho \leq \sigma$ which ensures that $\hat{\alpha} < 1$ for all I).

The interesting range of parameters is $\pi^f \leq I \leq \pi^d$, where the firm faces a tradeoff between *ex ante* efficiency in the selection of projects which favors the functional structure and *ex post* efficiency in the implementation of selected projects which favors the divisional structure. Focusing on this range of parameters, there are several interesting implications which are worth discussing. First, the firm adopts the *ex post* inefficient functional structure provided that the likelihood of discovering L-type projects, α, is above some threshold $\hat{\alpha}$. This threshold falls with the cost of H-type projects, I, implying that the functional structure (which mitigates the managerial moral hazard problem) becomes optimal for a larger set of parameters. Intuitively, when I is large, the managerial moral hazard problem in projects' selection becomes more costly, so the firm is more inclined to mitigate it by adopting the *ex post* inefficient functional structure. Interestingly, Segelod (2002) describes the resource allocation systems in six different Swedish industries and finds that pharmaceutical companies, which have very large investments in R&D (approximately 15–20% of sales revenues), "often have a functional or semi-functional structure, viz. they have one unit for R&D, one for production, and one for marketing" (p. 64). By contrast, Swedish engineering companies and forest groups, which have smaller rates of investment, are mostly divisionalized.

Second, using equations (7) and (11), it follows that $\frac{\partial\hat{\alpha}}{\partial R} = \frac{2I}{R\pi^f} > 0$. Hence, an increase in R shifts $\hat{\alpha}$ upward and thereby expands the set of parameters for which the divisional structure is optimal. Intuitively, an increase in R increases the importance of *ex post* considerations which favor the *ex post* efficient divisional structure.

Third, using equations (7) and (11) again, reveals that $\hat{\alpha}$ shifts upward when σ decreases and when ρ increases. Hence, even when the managerial moral hazard problem is taken into account, economies of scale and diseconomies of scope favor the functional structure, whereas diseconomies of scale and economies of scope favor the divisional structure.

We summarize these observations in the following proposition.

Proposition 2: *Suppose that $\pi^f \leq I \leq \pi^d$. Then, all else equal, the functional structure becomes optimal for a wider set of parameters as I increases (H-type projects are more costly), as R decreases (conditional on being successful, projects are less profitable), as ρ decreases (there are weaker economies of scope), and as σ increases (there are stronger economics of scale).*

We now proceed by conducting the following thought experiment. Suppose that we take a sample of firms and divide it into two subsamples: one with firms that have a divisional structure and one with firms that have a functional structure. Then, on the basis of Proposition 1, what kind of differences should we expect to see between the two subsamples?

To address this question, we begin by fixing the values of R, α, and γ and assuming that the variation in organizational structures across firms is due to differences in I. Now, recall first that the board of directors always approves L-type projects, but approves H-type projects under structure $s = f, d$ only when $I \leq \pi^s$. Because $\pi^f < \pi^d$, this implies that the board of directors uses a more restrictive standard for project approval under the functional structure. Second, note that under the functional structure, the firm ends up adopting projects only with probability α, but under the divisional structure it adopts projects with probability 1 if $I \leq \pi^d$ and with probability α when $I > \pi^d$. If we assume that each firm has access to $2n$ projects and has $2n$ agents, where n is a large positive integer, then this finding implies that firms with a divisional structure should have more projects than firms with a functional structure. Third, because $\gamma \geq 1$, $\rho > -1$, and $\sigma < 1$, equations (6) and (10) imply that $q^d > q^f$, so projects are more likely to succeed under the divisional structure. Fourth, recall that the agents receive monetary compensation only when projects are adopted and succeed. Using equations (5), (6), (9), and (10), the expected compensation of the agents is equal to π^d if $\pi^d > I$ and $\alpha\pi^d$ if $\pi^d < I$ under the divisional structure, and is equal to $\alpha\pi^f$ under the functional structure. Because Lemma 1 implies that $\pi^f < \pi^d$, the expected compensation is lower under the functional structure.

Proposition 3: *Consider a sample of firms which differ with respect to I (the cost of H-type projects) and possibly ρ and σ. Then, firms with a divisional structure have less restrictive standards for project evaluation and adopt more projects than firms with a functional structure, their projects are more likely to succeed, and they pay a higher expected compensation to their agents.*

Next, we fix the values of I, α, γ, ρ, and σ and assume that for each firm, the value of R is drawn from some distribution function $h(R)$ on the support $[0, \overline{R}]$. Recall from Proposition 1 that the functional structure is optimal if and only if $\pi^f \leq I \leq \pi^d$ and $\alpha > \frac{\pi^d - I}{\pi^f}$. Using (7) and (11), these conditions are jointly satisfied if and only if $z_0 \leq R \leq z_1$, where $z_0 \equiv \sqrt{(4\gamma - \rho)I}$ and $z_1 \equiv \min\{\sqrt{\frac{I}{\frac{1}{(4\gamma-\rho)} - \frac{\alpha}{2(4\gamma-\sigma)}}}, \sqrt{2(4\gamma - \sigma)I}\}$. When these inequalities fail, that is, $R < z_0$ or $R > z_1$, the divisional structure is optimal. It is therefore clear that the variance of the gross returns of the implemented projects, represented by R, is larger under the divisional structure than under the functional structure.

Using equation (11) and assuming for simplicity that $z_1 < \overline{R}$, the expected net return per project, conditional on the functional structure being optimal, is given by

$$E\pi^f = \frac{\int_{z_0}^{z_1} \frac{\alpha R^2}{2(4\gamma - \sigma)} h(R)dR}{H(z_1) - H(z_0)}. \tag{12}$$

This expression reflects the fact that under functional structure, the firm adopts L-type projects with probability α whenever $z_0 \leq R \leq z_1$. Likewise, using equation (7), the expected net return per project, conditional on the divisional structure being optimal, is given by

$$E\pi^d = \frac{\displaystyle\int_0^{z_0} \frac{\alpha R^2}{4\gamma - \rho} h(R) dR + \int_{z_1}^{\overline{R}} \left[\frac{R^2}{4\gamma - \rho} - I\right] h(R) dR}{1 - (H(z_1) - H(z_0))}. \tag{13}$$

Here, the firm adopts L-type projects with probability α whenever $R \leq z_0$, but adopts two H-type projects with probability 1 whenever $R \geq z_1$. In general, the relationship between $E\pi^f$ and $E\pi^d$ is ambiguous. For example, suppose that $\sigma = \rho = 0$ (no economies of scale or scope), $\gamma = 1$, $I = 4$, $h(R)$ is uniform, and $\overline{R} = 6$. Then $E\pi^f > E\pi^d$ for $\alpha > 0.212$ and $E\pi^f < E\pi^d$ for $\alpha > 0.212$. The finding that either organizational structure can be more profitable is consistent with Mahajan et al. (1988) who review empirical studies on the relationship between profitability and the adoption of the divisional structure (M-form) and find mixed evidence: some studies find that the divisional structure has a positive effect on profitability (e.g., Armour and Teece, 1978; Teece, 1981), whereas others find either no effect (Cable and Yosuki, 1985), or even a negative effect (Cable and Dirrheimer, 1983).

Proposition 4: *Consider a sample of firms which differ only with respect to the value of R which is drawn for each firm from the interval* $[0, \overline{R}]$. *Then, firms with a divisional structure may or may not have higher expected net returns than firms with a functional structure, but their projects have a smaller variance of gross returns.*

The main insight in this section is that the *ex post* inefficient functional structure can mitigate the manager's incentive to recommend H-type projects.[7] A natural question to ask at this point is whether the firm can induce the manager to select L-type projects by other means. Although we assume that monetary incentives alone are insufficient for that purpose, the board of directors may still be able to induce the manager to select L-type projects by threatening to fire him if he recommends H-type projects. However, if the manager is needed in order to complete the projects that he selected (say because he has some inalienable human capital which is essential for the execution of projects), then firing him would hurt the firm's performance and

7. Note that if the manager is also the founder of the firm, then he may wish to set up the functional structure himself in order to credibly commit to outside investors that he will not select inefficient projects.

may be worse than adopting a functional structure. Alternatively, the firm could hire two managers to screen projects and use yardstick competition to induce them to recommend L-type projects when they manage to discover them. The drawback of this scheme is that the firm would have to compensate two managers instead of just one. Another possibility is that the board of directors will commit the firm to focus on L-type projects by imposing a technological constraint on its ability to implement H-type projects. We consider this possibility in Section 6. One more possibility is to distort the agents' compensation in order to ensure that the profit of each project will be below I.[8] However, as we discussed earlier, such a scheme may not be credible because the board of directors will have an incentive to renegotiate the agents' contracts once the manager has recommended H-type projects in order to ensure that the selected projects are implemented efficiently. Anticipating this incentive, the manager will not be deterred from recommending H-type projects.

5. Extensions

In this section, we use our model to shed light on how the profitability of the two organizational structures changes when the firm grows and can adopt more projects, or when projects become more complex and require more tasks, or when the tasks have asymmetric effects on the probability that projects will succeed.

5.1 The Firm can Adopt $2n$ Projects

To examine the effect of size on organization structure, suppose that for some exogenous reason, each agent can complete $2n$ tasks, where n is a positive integer. Given this assumption, now the firm can adopt $2n$ projects: under the divisional structure, it will assign n projects to each agent who will then perform tasks p and m on these n projects. Under the functional structure, each agent will specialize in one task and will perform it on all $2n$ projects. To simplify matters, we will assume that with probability α the manager discovers at least $2n$ L-type projects and with probability $1 - \alpha$ he discovers only H-type projects. As before, this assumption ensures that all the projects that the firm adopts are of the same type.

8. The firm can in fact make the excessive compensation conditional on the adoption of H-type projects. The advantage of this alternative scheme is that it renders H-type projects unprofitable and hence deters the manager from recommending them to the board of directors, without requiring the firm to pay excessive compensation when L-type projects are adopted.

Let $N_1 = \{1, \ldots, n\}$ and $N_2 = \{n+1, \ldots, 2n\}$ be the sets of projects assigned to agents 1 and 2 under the divisional structure. Agent *j*'s resulting cost of effort becomes

$$C_j^d = \gamma \sum_{\ell \in N_j} \left(e_{p\ell}^2 + e_{m\ell}^2\right) - \frac{\rho}{2} \sum_{\ell \in N_j} e_{p\ell} e_{m\ell} \\ -\frac{\sigma}{2} \sum_{\ell \in N_j} \sum_{\ell' \in N_j \setminus \ell} \left(\frac{e_{p\ell} e_{p\ell'} + e_{m\ell} e_{m\ell'}}{2}\right), \quad j = 1, 2. \tag{14}$$

Note that because each agent needs to perform tasks p and m on $n > 1$ projects, C_j^d is affected not only by economies of scope as before but also by economies of scale.

Under the functional structure, each agent specializes in one task and preforms it on all $2n$ projects. Consequently, agent *i*'s cost of effort is given by

$$C_i^f = \gamma \sum_{\ell=1}^{2n} e_{i\ell}^2 - \frac{\sigma}{4} \sum_{\ell=1}^{2n} \sum_{\ell'=1, \ell' \neq \ell}^{2n} \left(\frac{e_{i\ell} e_{i\ell'}}{2}\right), \quad i = p, m. \tag{15}$$

To ensure that the cost functions are nonnegative for all values of ρ and σ, we assume that $n < \frac{4\gamma+1}{2}$.

When $n = 1$, N_1 and N_2 are singletons, so C_j^d and C_i^f coincide with the cost function in equations (2) and (3). Hence equations (14) and (15) generalize the cost functions in equations (2) and (3) to the case where $n > 1$.

Assuming that the firm adopts n identical projects, it is straightforward to verify that the expected *ex post* profit per-project under the divisional structure is given by

$$\pi^d(n) = \frac{R^2}{4\gamma - \rho - (n-1)\sigma}, \tag{16}$$

whereas under the functional structure, it is given by

$$\pi^f(n) = \frac{R^2}{2(4\gamma - (2n-1)\sigma)}. \tag{17}$$

The assumption that $n < \frac{4\gamma+1}{2}$ ensures that the denominators of (16) and (17) are positive. When $n = 1$, $\pi^d(n)$ and $\pi^f(n)$ coincide with the expressions in (7) and (11). Hence, equations (16) and (17) generalize the previous analysis to the case where $n > 1$. Notice that $\pi^d(n)$ increases with both ρ and σ, whereas $\pi^f(n)$ increases with σ.

Proposition 5: *An increase in n has the following effects:*

(i) *It raises both $\pi^d(n)$ and $\pi^f(n)$ and thereby makes the managerial moral hazard problem more severe if $\sigma > 0$ (there are economies of scale) but less severe if $\sigma < 0$ (there are diseconomies of scale).*
(ii) *It widens the gap between $\pi^d(n)$ and $\pi^f(n)$ and thereby the range of parameters for which organizational structure can solve the managerial moral hazard problem if and only if $\sigma(\frac{\rho}{n} - \sigma) > 0$ and shrinks it otherwise.*
(iii) *It makes the functional structure more ex post profitable than the divisional structure if and only if $\sigma > \frac{4\gamma+\rho}{3n-1}$.*
(iv) *Conditional on the functional structure solving the managerial moral hazard problem whereas the divisional structure not, that is, $\pi^f(n) < I < \pi^d(n)$, it raises (lowers) $\hat{\alpha}$ and thereby favors the divisional (functional) structure if $\sigma > 0$ ($\sigma < 0$).*

Proof.

(i)–(ii) Equations (16) and (17) imply that $\frac{\partial \pi^d(n)}{\partial n} = \frac{\sigma(\pi^d(n))^2}{R^2}$ and $\frac{\partial \pi^f(n)}{\partial n} = \frac{\sigma(2\pi^f(n))^2}{R^2}$, so $\frac{\partial \pi^d(n)}{\partial n}$ and $\frac{\partial \pi^f(n)}{\partial n}$ have the same sign as σ. Moreover,

$$\frac{\partial(\pi^d(n) - \pi^f(n))}{\partial n} = \frac{2n\sigma\left(\dfrac{\rho}{n} - \sigma\right)\pi^d(n)\pi^f(n)(\pi^d(n) + 2\pi^f(n))}{R^4}, \tag{18}$$

which is positive if and only if $\sigma(\frac{\rho}{n} - \sigma) > 0$.

(iii) Using equations (16) and (17) again, it follows that

$$\pi^d(n) > \pi^f(n) \quad \Leftrightarrow \quad \sigma < \frac{4\gamma + \rho}{3n - 1}. \tag{19}$$

(iv) Assuming that $\pi^f(n) < I < \pi^d(n)$, and restricting attention to cases where $\hat{\alpha} = \min\{\frac{\pi^d(n)-I}{\pi^f(n)}, 1\} < 1$, it follows that

$$\frac{\partial \hat{\alpha}}{\partial n} = \frac{\overbrace{\dfrac{\sigma(\pi^d(n))^2}{R^2}}^{\frac{\partial \pi^d(n)}{\partial n}}\pi^f(n) - \overbrace{\dfrac{\sigma(2\pi^f(n))^2}{R^2}}^{\frac{\partial \pi^f(n)}{\partial n}}(\pi^d(n) - I)}{(\pi^f(n))^2}$$
$$= \frac{\sigma}{R^2}\left[\frac{(\pi^d(n))^2 - 4\pi^f(n)(\pi^d(n) - I)}{\pi^f(n)}\right]. \tag{20}$$

Because $\pi^f(n) < I$, the square bracketed term is positive:

$$\frac{(\pi^d(n))^2 - 4\pi^f(n)(\pi^d(n) - I)}{\pi^f(n)} > \frac{(\pi^d(n))^2 - 4\pi^f(n)(\pi^d(n) - \pi^f(n))}{\pi^f(n)}$$
$$= \frac{(\pi^d(n) - 2\pi^f(n))^2}{\pi^f(n)} > 0. \tag{21}$$

Hence, the sign of $\frac{\partial\hat{\alpha}}{\partial n}$ equals the sign of σ. □

Intuitively, an increase in n means that economies/diseconomies of scale play a more significant role under both structures. As a result, projects become more profitable if $\sigma > 0$ (there are economies of scale) and less profitable if $\sigma < 0$ (there are diseconomies of scale). Although an increase in n affects both structures, it affects the functional structure to a larger extent because each agent performs each task n times under the divisional structure but $2n$ times under the functional structure. Consequently, when $\sigma > 0$, an increase in n may make the functional structure more *ex post* efficient than the divisional structure. To illustrate, suppose that $\sigma = 1$, $\rho = 0$, and $\gamma = 5$. Then, $\pi^d(n) \geq \pi^f(n)$ if $n \leq 7$ and $\pi^d(n) < \pi^f(n)$ when $n = 8, 9, 10$ (n cannot exceed 10 because by assumption, $n < \frac{4\gamma+1}{2} = 10.5$).

If we restrict attention to cases in which the divisional structure remains *ex post* efficient, and assume moreover that organization structure can solve the managerial moral hazard problem (i.e., $\pi^f(n) < I < \pi^d(n)$), then an increase in n favors the divisional structure by expanding the range of parameters for which it is more efficient overall if $\sigma > 0$, and favors the functional divisional structure if $\sigma < 0$.

5.2 Each Project Requires $2k$ Tasks

We now wish to examine how the optimal structure of the firm is affected by the complexity of the projects that it adopts. To this end, we identify complexity with the number of tasks that projects require and will assume that each project requires $2k$ tasks, where k is a positive integer (with two projects and $2k$ tasks, the firm as a whole needs to perform $4k$ tasks). In order to maintain the feature that the firm has the capacity to adopt exactly two projects, we will also assume that there are $2k$ agents, who as before, can perform two tasks each. To ensure that the probability that projects succeed does not increase simply due to the increase in k, we divide the sum of the efforts by k:

$$q\,(e_1, \ldots, e_{2k}) = \sum_{j=1}^{2k} \frac{e_j}{k}. \tag{22}$$

This modification ensures that if each agent exerts the same effort as in Section 3, then the likelihood of success will be exactly as in Section 3. Consequently, an increase in k will affect matters only through its effect on the agents' incentives.

Under the divisional structure, the firm will establish two divisions and will assign each division the full responsibility over one project. However, unlike in Section 3, now there are $k > 1$ agents in each division, each of whom performs two different tasks on the same project. Naturally then, we now have a moral hazard in teams problem even under the divisional structure.

Using A_i and B_i to denote the tasks assigned to agent i, we can write the cost of effort of each agent i under the divisional structure as

$$C^d(e_{iA_i}, e_{iB_i}) = \gamma e_{iA_i}^2 + \gamma e_{iB_i}^2 - \frac{\rho e_{iA_i} e_{iB_i}}{2}, \quad i = 1, \ldots, k.$$

Note that as in Section 2, the cost of effort under the divisional structure is affected by economies/diseconomies of scope because each agent performs two different tasks.

Because the two projects are completely independent, we can characterize the optimal contracts by considering the firm's problem vis-à-vis one division (the problem vis-à-vis the other division is completely identical). The contracts that the firm offers the k agents who work in the division are characterized by the solution to the following problem:

$$\begin{aligned} \max_{\{e_{iA_i}, e_{iB_i}, W_i\}} \quad & \sum_{j=1}^{k} \frac{(e_{iA_i} + e_{iB_i})}{k} \left(R - \sum_{i=1}^{k} W_i \right) \\ s.t. \quad & e_{iA_i}, e_{iB_i} \in \arg\max_{\hat{e}_{iA_i}, \hat{e}_{iB_i}} \left(\frac{\hat{e}_{iA_i} + \hat{e}_{iB_i}}{k} + \sum_{j \neq i}^{k} \frac{(e_{jA_i} + e_{jB_i})}{k} \right) W_i \\ & \qquad - C^d(\hat{e}_{iA_i}, \hat{e}_{iB_i}), \quad i = 1, \ldots, k, \\ & \left(\sum_{i=1}^{k} \frac{(e_{iA_i} + e_{iB_i})}{k} \right) W_i - C^d(e_{iA_i}, e_{iB_i}) \geq 0, \quad i = 1, \ldots, k, \end{aligned} \tag{23}$$

where $\sum_{i=1}^{k} \frac{(e_{iA_i} + e_{iB_i})}{k}$ is the probability that the project that was assigned to the division succeeds.

Solving this problem reveals that under a divisional structure, the expected *ex post* per-project profit (gross of the cost of investment) is

$$\pi^d(k) = \frac{\pi^d}{k^2}, \tag{24}$$

where π^d is given by equation (7). Note that $\pi^d(k)$ falls with k. The reason for this is that an increase in k makes the moral hazard in teams problem more severe because the success of each project depends on the joint effort of more agents.

Under the functional structure, each of the $2k$ agents specializes in a single task and performs it on the two projects that the firm adopts. The situation then is exactly as in Section 2, except that there are now $2k$ agents and $2k$ tasks instead of just 2 agents and 2 tasks. In particular, the cost that agent i incurs when performing task i on projects 1 and 2 is still given by equation (3).

Using W_{ij} to denote the compensation of agent i $(i = 1, \ldots, 2k)$ if project j $(j = 1, 2)$ succeeds, and noting that the probability that project j succeeds is $\sum_{i=1}^{2k} \frac{e_{ij}}{k}$, the contracts offered to the $2k$ agents are characterized by the solution to the following problem:

$$\begin{aligned}
&\max_{\{e_{ij}, W_{ij}\}} \quad \sum_{i=1}^{2k} \frac{e_{i1}}{k}\left(R - \sum_{i=1}^{2k} W_{i1}\right) + \sum_{i=1}^{2k} \frac{e_{i2}}{k}\left(R - \sum_{i=1}^{2k} W_{i2}\right) \\
&s.t. \quad e_{i1}, e_{i2} \in \arg\max_{\hat{e}_{i1}, \hat{e}_{i2}} \left(\frac{\hat{e}_{i1}}{k} + \sum_{j \neq i}^{2k} \frac{e_{j1}}{k}\right) W_{i1} + \left(\frac{\hat{e}_{i2}}{k} + \sum_{j \neq i}^{2k} \frac{e_{j2}}{k}\right) W_{i2} \\
&\qquad - C^f(\hat{e}_{i1}, \hat{e}_{i2}), \quad i = 1, \ldots, 2k, \\
&\qquad \left(\sum_{i=1}^{2k} \frac{e_{i1}}{k}\right) W_{i1} + \left(\sum_{i=1}^{2k} \frac{e_{i2}}{k}\right) W_{i2} - C^f\left(e_{i1}, e_{i2}\right), \quad i = 1, \ldots, 2k.
\end{aligned} \tag{25}$$

Solving this problem reveals that under the functional structure, the expected *ex post* profit per project (gross of the cost of investment) is

$$\pi^f(k) = \frac{\pi^f}{k^2}, \tag{26}$$

where π^f is given by equation (11). The intuition why $\pi^f(k)$ falls with k is that an increase in k means that each project requires the joint effort of more agents and hence the moral hazard in teams problem becomes more severe.

Proposition 6: *An increase in k has the following effects:*

(i) It lowers both $\pi^d(k)$ and $\pi^f(k)$ and thereby alleviates the managerial moral hazard problem.

(ii) It shrinks the gap between $\pi^d(k)$ and $\pi^f(k)$ and thereby the range of parameters for which organization structure can solve the managerial moral hazard problem.

(iii) Conditional on the functional structure solving the managerial moral hazard problem whereas the divisional structure not, that is, $\pi^d(k) \leq I \leq \pi^f(k)$, it lowers $\hat{\alpha}$ and thereby favors the functional structure.

Proof. Parts (i) and (ii) are obvious. Part (iii) follows by noting that when $\hat{\alpha} < 1$, $\hat{\alpha}$ is given by $\frac{\pi^d(k)-I}{\pi^f(k)} = \frac{\pi^d - k^2 I}{\pi^f}$. □

Parts (ii) and (iii) of Proposition 6 imply that an increase in k has a mixed effect on the range of parameters for which the functional structure is optimal. On the one hand, it shrinks the range of parameters for which the functional structure can mitigate managerial moral hazard. On the other hand, conditional on being in this range, an increase in k makes the functional structure optimal for a larger set of parameters. The reason for this is that both $\pi^d(k)$ and $\pi^f(k)$ decrease in k so the firm gives less weight to *ex post* considerations which favor the *ex post* efficient divisional structure, and more weight to *ex ante* considerations which favor the functional structure.

5.3 Asymmetric Tasks

In this subsection, we examine the effect of cross-task asymmetries on the optimal structure of the firm. To this end, we relax the assumption that the two tasks have the same effect on the probability that projects will succeed and assume instead that this probability is given by

$$q(e_p, e_m) = \frac{2(e_p + he_m)}{1+h}, \quad h \geq 1. \tag{27}$$

That is, we now assume (without a loss of generality) that task m has a bigger influence on the likelihood of success than task p. The rest of the model remains as in Section 2; in particular, the agents' costs of implementing projects are still given by equations (2) and (3). Note that when the agents' efforts are as in Section 3, the likelihood of success and the payoffs are as in Section 3. Hence, the assumption that $h > 1$ affects matters only through its effect on the agents' incentives.

Assuming that the firm adopts two identical projects, the expected *ex post* per-project profit under the divisional structure is given by:

$$\pi^d(h) = \frac{4(2\gamma(1+h^2) + h\rho)}{(1+h)^2(4\gamma + \rho)}\pi^d, \tag{28}$$

where π^d is given by (7).

Under the functional structure, one agent specializes in task p and the other specializes in task m. However because $h > 1$, it is more efficient for the firm to pay agent m an extra dollar at the expense of agent p as the former has a bigger influence on the probability of success. Consequently, at the optimum the firm will set $W_{p1} = W_{p2} = 0$, and will effectively shut down department p. The more productive department m will then perform task m on both projects.[9] The resulting expected *ex post* per-project profit is

$$\pi^f(h) = 2\left(\frac{h}{1+h}\right)^2 \pi^f, \tag{29}$$

where π^f is given by (11).

It is easy to check that $\pi^d(1) = \pi^d$ and $\pi^f(1) = \pi^f$, and that both $\pi^d(h)$ and $\pi^f(h)$ are increasing with h. Hence, under both structures, the expected *ex post* profits increase with the degree of asymmetry between the two tasks. As a result, the managerial moral hazard problem becomes more severe under both structures because the manager is tempted to recommend costly H-type projects for a larger set of values of I. Under the functional structure, $\pi^f(h)$ is increasing with h because the firm only operates the m department whose marginal productivity is increasing with h. Under the divisional structure, an increase in h induces each agent to shift effort from task p to the more productive task m although the agents do not quit task p altogether because their cost of effort is quadratic. The reason why $\pi^d(h)$ increases with h is that shifting effort from task m to task p has a first order effect on the probability of success but only a second order effect on the cost of effort.

Proposition 7: *An increase in h has the following effects:*

(i) It raises both $\pi^d(h)$ and $\pi^f(h)$ and thereby makes the managerial moral hazard problem more severe.
(ii) It widens the gap between $\pi^d(h)$ and $\pi^f(h)$ and thereby the range of parameters for which organization structure can solve the managerial moral hazard problem if $h > \hat{h}$ and shrinks it if $h > \hat{h}$, where

$$\hat{h} \equiv 1 + \frac{4\gamma + \rho}{4\gamma - \rho - 2\sigma}. \tag{30}$$

The divisional structure though remains ex post more efficient than the functional structure for all $h > 1$.

9. Obviously, the result that the firm will only operate department m is an artifact of the assumption that m and p are perfect substitutes. Otherwise, then the firm might use both at the optimum, although it would still substitute p for m. The main insight though does not depend on whether m and p are perfect or imperfect substitutes.

(iii) *Conditional on the functional structure solving the managerial moral hazard problem whereas the divisional structure not, that is,* $\pi^f(h) < I < \pi^d(h)$*, it raises (lowers)* $\hat{\alpha}$ *and thereby favors the divisional (functional) structure if* $I > I(h)$ $(I < I(h))$*, where*

$$I(h) \equiv \frac{2\,(4\gamma + h\rho)\,\pi^d}{(1+h)\,(4\gamma+\rho)}. \tag{31}$$

Proof.

(i)–(ii) Differentiating equations (28) and (29) reveals that $\pi^d(h)$ and $\pi^f(h)$ are increasing with h. Using the same equations again,

$$\frac{\partial(\pi^d(h) - \pi^f(h))}{\partial h} = \frac{2R^2(4\gamma - \rho - 2\sigma)(h - \hat{h})}{(1+h)^3(4\gamma+\rho)(4\gamma-\sigma)}. \tag{32}$$

Because $\gamma > 1$ and $\rho, \sigma < 1$, $\frac{\partial(\pi^d(h)-\pi^f(h))}{\partial h}$ has the same sign as $h - \hat{h}$. To prove that $\pi^d(h) > \pi^f(h)$ for all $h > 1$, note that

$$\pi^d(h) - \pi^f(h) = \frac{R^2\left(\overbrace{(8\gamma(2\gamma-\sigma)+\rho^2)h^2 + 4\rho(4\gamma-\sigma)h + 8\gamma(4\gamma-\sigma)}^{J(h)}\right)}{(1+h)^2(4\gamma+\rho)(4\gamma-\rho)(4\gamma-\sigma)}. \tag{33}$$

The sign of $\pi^d(h) - \pi^f(h)$ depends on the sign of $J(h)$ which is convex in h and $J'(1) = 2(4\gamma+\rho)(4\gamma+\rho-2\sigma) > 0$. Hence, $J(h)$ is increasing for all $h > 1$, implying that $J(h) > J(1) = (4\gamma + \rho)(12\gamma + \rho - 4\sigma) > 0$.

(iii) Assuming that $\pi^f(h) < I < \pi^d(h)$, and restricting attention to cases where $\hat{\alpha} = \min\{\frac{\pi^d(h)-I}{\pi^f(h)}, 1\} < 1$, it follows that

$$\frac{\partial\hat{\alpha}}{\partial h} = \frac{(1+h)\,(4\gamma+\rho)\,I - 2\,(4\gamma+h\rho)\,\pi^d}{h^3\,(4\gamma+\rho)\,\pi^f}$$
$$= \frac{(1+h)\,(4\gamma+\rho)}{h^3\,(4\gamma+\rho)\,\pi^f}\left(I - \overbrace{\frac{2\,(4\gamma+h\rho)\,\pi^d}{(1+h)\,(4\gamma+\rho)}}^{I(h)}\right), \tag{34}$$

where $I'(h) < 0$ and $I(1) = \pi^d$. □

Proposition 7 shows that an increase in cross-task asymmetries may favor either organizational structure, depending on the size of h

and the size of I. In particular, an increase in h favors the functional structure by expanding the gap between $\pi^d(h)$ and $\pi^f(h)$ if h is large and by lowering $\hat{\alpha}$ if I is small. When h is small and I is large, an increase in h favors the divisional structure by shrinking the gap between $\pi^d(h)$ and $\pi^f(h)$ and by increasing $\hat{\alpha}$. In a related paper, Besanko et al. (2005) show that cross-task asymmetries improve the relative performance of the functional structure. In their model this happens because cross-task asymmetries make it possible to tie the compensation of one functional department more closely to profit than the other; under the divisional structure, such differentiation of incentives across tasks is not possible. In our model by contrast, the increase in cross-task asymmetries improves the *ex post* performance of both organization structures, but at the same time, it aggravates the managerial moral hazard problem in the selection of projects.

6. Narrow Business Strategies (NBS)

Another mechanism that might be used to induce the manager to make a better selection of projects is to adopt an NBS. Rotemberg and Saloner (1994) show that an NBS may allow the firm to induce its employees to exert more effort in generating profitable ideas. The reason is that ideas are noncontractible, so the firm can reward its employees for generating ideas only when their ideas are actually implemented. When the firm is broad, the employees anticipate that the firm may not implement their valuable ideas either because it prefers to implement imported ideas from other activities, or because it is financially constrained and can only implement a limited number of ideas. Either way, employees may be reluctant to exert effort in generating ideas. An NBS has the advantage of committing the firm not to supplant the valuable ideas of one employee with the ideas of another employee.

In our case, an NBS commits the firm to focus exclusively on L-type projects and hence solves the managerial moral hazard problem. One way of implementing such NBS is to set a high hurdle rate for project selection. The problem with this policy however is that if the manager recommends H-type projects after all and these projects are profitable, the firm will find it hard to reject his recommendation. Thus, we prefer to think about an NBS as a technological constraint (rather than a policy) that the firm imposes on its ability to implement H-type projects.

To examine the optimal organization structure when the firm can also adopt an NBS, we will modify our basic setup slightly and assume that with probability μ, H-type projects require an initial investments I_1

and with probability $1-\mu$ they require an initial investment I_2, where $I_1 < \pi^f < I_2 < \pi^d$. As before, L-type projects do not require an initial investment. When $I = I_1$, there is a managerial moral hazard problem under both structures. When $I = I_2$, the problem arises only under the divisional structure because the manager correctly anticipates that under the functional structure, the board of directors will reject H-type projects.

If the firm adopts an NBS and focuses exclusively on L-type projects, then it will adopt the *ex post* efficient divisional structure and will implement L-type projects with probability α. With probability $1-\alpha$, the firm does not implement any projects. Because L-type projects do not require an initial investment, the expected per-project profit is

$$O^N = \mu\alpha\pi^d + (1-\mu)\alpha\pi^d = \alpha\pi^d. \tag{35}$$

The advantage of NBS is that the firm only focuses on L-type projects which do not require an initial investment and it implements them efficiently. The drawback of NBS is that with probability $1-\alpha$, the firm forgoes H-type projects even if they are profitable.

If the firm does not adopt an NBS, then it needs to choose between the divisional and the functional structures. Under the divisional structure, the firm always adopts H-type projects, so its expected per-project profit is

$$\begin{aligned} O^d &= \mu(\pi^d - I_1) + (1-\mu)(\pi^d - I_2) \\ &= \pi^d - (\mu I_1 + (1-\mu)I_2). \end{aligned} \tag{36}$$

Compared with an NBS, the divisional structure enables the firm to implement projects with probability 1 (under an NBS it implements projects only with probability α). The disadvantage is that the firm adopts costly H-type projects.

Under a functional structure, the firm implements H-type projects for sure when $I = I_1$, but when $I = I_2$, it implements only L-type projects, which are available with probability α. Hence, the firm's expected per-project profit is

$$\begin{aligned} O^f &= \mu(\pi^f - I_1) + (1-\mu)\alpha\pi^f \\ &= (\alpha + \mu(1-\alpha))\pi^f - \mu I_1. \end{aligned} \tag{37}$$

The functional structure then mitigates managerial moral hazard only when the cost of investment is I_2. With probability μ, the cost of investment is I_1 and the functional structure fails to solve the managerial moral hazard problem. The firm then implements H-type projects which require an initial investment I_1. Equation (37) also shows that although the functional structure mitigates the managerial moral hazard problem with probability $1 - \mu$, it does poorly with respect to the agents' moral hazard problem: the *ex post* per-project profit is π^f rather than π^d. Moreover, under the functional structure, the firm forgoes H-type projects when $I = I_2$, so the overall probability that it implements projects is $\alpha + \mu(1 - \alpha)$. This probability exceeds α which is the probability that the firm implements projects under NBS, but so long as $\mu < 1$, it is below 1 which is the probability that the firm implements projects under the divisional structure. We summarize the discussion in the following proposition.

Proposition 8: *Comparing NBS with the divisional and functional structures absent NBS reveals the following:*

(i) NBS deals best with managerial moral hazard, followed by the functional structure which deals with the problem only with probability $1 - \mu$. *The divisional structure fails to mitigate managerial moral hazard. NBS is particularly attractive when* α *is close to* 1, *whereas the divisional structure is particularly attractive when* α *is close to* 0.

(ii) NBS and the divisional structure deal well with the agents' moral hazard problem and are therefore ex post efficient, whereas the functional form deals poorly with the agents' moral hazard problem and is ex post inefficient.

(iii) Under the divisional structure, the likelihood that the firm implements projects is 1, *whereas under the functional structure it is* $\alpha + \mu(1 - \alpha)$, *and under NBS, it is merely* α.

To illustrate Proposition 8, suppose that $I_1 = 0.1,\ I_2 = 0.75,\ R = 2,\ \gamma = 1,\ \rho = -0.8$, and $\sigma = 1$. Then equations (7) and (11) imply that $\pi^f = 2/3$ and $\pi^d = 5/6$. Substituting these numbers in equations (35), (36), and (37), we can present the optimal organizational structure in the following figure for each pair of μ and α.

Figure 3 shows that an NBS is optimal when α is large. Intuitively, under NBS, the firm implements L-type projects efficiently so its profitability is especially large when the probability of discovering L-type projects is large. By contrast, the divisional structure, under which the firm only implements H-type projects, is particularly attractive when α is small and when μ, which is the likelihood that H-type projects require a small investment, is high. When α and μ are intermediate, the functional structure, which deals with the managerial moral hazard problem at least partly, is optimal. Note that an increase in μ has an ambiguous effect on the optimality of the functional structure, because it makes the firm more susceptible to managerial moral hazard but at the same time it also makes it more likely to implement an H-type project for sure (this happens when $I = I_1$) rather than implement an L-type project with probability α (if $I = I_2$).

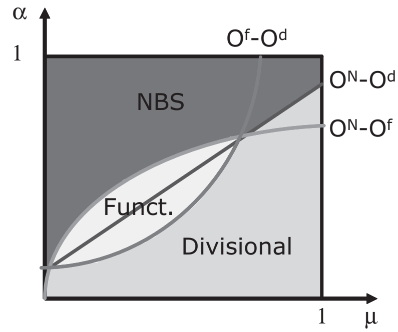

FIGURE 3. COMPARING NBS WITH THE DIVISIONAL AND FUNCTIONAL STRUCTURES ABSENT NBS

7. Conclusion

In this paper, we advance the idea that organizational structure may align the incentive of managers with those of shareholders. Our main insight is that organizational structures which appear to maximize firm value *ex post*, may not be optimal once managerial incentives are taken into account: in many cases it is optimal to put in place an organizational structure that appears to be *ex post* inefficient in order to restrict the management's ability to manipulate investment decisions in the direction it likes.

The idea that a firm may wish to commit itself to an *ex post* inefficient structure in order to enhance *ex ante* efficiency is reminiscent of the idea that firms may issue debt which may lead to costly financial distress *ex post* in order to boost the incentives of their managers *ex ante* (see, e.g., Grossman and Hart, 1982), and the idea that moral hazard in monitoring activity may prevent the refinancing of projects *ex post* but may improve projects' selection *ex ante* (Dewatripont and Maskin, 1995). We show that the *ex post* inefficiency of the functional structure could actually induce the firm's management to improve its selection of projects *ex ante*. Overall then, the functional structure is likely to be optimal when the managerial moral hazard problem in the selection of projects is sufficiently severe and the cost of expensive projects that the management likes is sufficiently high. Otherwise, the firm is better off implementing expensive projects efficiently under the divisional structure.

Our model shows that the organizational structure of the firm may affect its selection of projects and its strategy. This implies that structure does not follow strategy as Chandler (1962) has argued. Rather, strategy and structure are jointly determined by more fundamental variables like the firm's technology (economies of scale and scope), the availability of efficient projects, and the profitability of successful projects.

References

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

Alchian, A. and H. Demsetz, 1972, "Production, Information Costs, and Economic Organization," *American Economic Review*, 62, 777–795.

Armour, H. and D. Teece, 1978, "Organizational Structure and Economic Performance: A Test of the M-Form Hypothesis," *Bell Journal of Economics*, 9, 106–122.

Besanko, D., P. Régibeau, and K. Rockett, 2005, "A Multi-Task Principal-Agent Approach to Organizational Form," *Journal of Industrial Economics*, 53(4), 437–467.

Cable, J. and M. Dirrheimer, 1983, "Hierarchies and Markets An Empirical Test of the Multidivisional Hypothesis in West Germany," *International Journal of Industrial Organization*, 1(1), 43–62.

—— and H. Yosuki, 1985, "International Organization, Business Groups and Corporate Performance: An Empirical Test of the Multidivisional Hypothesis in Japan," *International Journal of Industrial Organization*, 3, 401–420.

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

Corts, K., 2007, "Teams versus Individual Accountability: Solving Multitask Problems through Job Design," *Rand Journal of Economics*, 38(2), 467–479.

Dewatripont, M. and E. Maskin, 1995, "Credit and Efficiency in Centralized and Decentralized Economies," *The Review of Economic Studies*, 62(4), 541–555.

Grossman, S. and O. Hart, 1982, "Corporate Financial Structure and Managerial Incentives," In J. McCall, ed. *The Economics of Information and Uncertainty*, Chicago: University of Chicago Press.

Harris, M. and A. Raviv, 2002, "Organizational Design," *Management Science*, 48(7), 852–865.

Mahajan, V., S. Sharma, and R. Bettis, 1988, "The Adoption of the M-Form Organizational Structure: A Test of Imitation Hypothesis," *Management Science*, 34(10), 1188–1201.

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

Merchant, K., 1981, "The Design of the Corporate Budgeting System: Influences on Managerial Behavior and Performance," *The Accounting Review*, 56(4), 813–829.

Mookherjee, D. and M. Tsumagari, 2001, "Delegated Management and Contract Intermediation," Mimeo. Available at http://econ.bu.edu/dilipm/wkpap.htm/delman.pdf.

Pike, R., 1986, "The Design of Capital Budgeting Processes and the Corporate Context," *Managerial and Decision Economics*, 7(3), 187–195.

Qian, Y., G. Roland, and C. Xu, 2006, "Coordination and Experimentation in M-form and U-form Organizations," *Journal of Political Economy*, 114(2), 336–402.

Rotemberg, J., 1999, "Process- Versus Function-Based Hierarchies," *Journal of Economics and Management Strategy*, 8, 453–487.

—— and G. Saloner, 1994, "Benefits of Narrow Business Strategies," *American Economic Review*, 84, 1330–1349.

Segelod, E., 1996, *Resource Allocation in Divisionalized Groups: A Study of Investment Manuals and Corporate Level Means of Control*, Ashgate Publishing Company.

——, 2002, "Resource Allocation in a Few Industries: Determinants and Trends," *International Journal of Production Economics*, 77, 63–70.

Teece, D.J., 1981, "Internal Organization and Economic Performance: An Empirical Analysis of the Profitability of Principle Firms," *Journal of Industrial Economics*, 30, 173–199.