Centralized versus Delegated Budgeting Process under Negative Externality

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1. Introduction

This paper derives the characteristics of the budget prepared under the condition that two departments within a firm interact with one another. There are several cases that a number of departments within a firm interact reciprocally; among them, the typical one is the relationship between manufacturing and marketing departments. This paper focuses on this relationship and also shows the result of comparing the budget prepared in a centralized firm with that in a delegated firm.

A firm is divided into several departments by functions and each of them interacts reciprocally. The operations performed by a department constraint others', and vice versa. For example, it often happens that a department that potentially attains good performance has to keep in line with other departments that are not as competent as the good department. This situation is referred to as externality, especially negative externality. If each department pursues its own interest under the situation where negative externality arises within a firm, the firm causes opportunity loss. Accordingly, headquarters has to not only establish the operational plans for each department, but also coordinate their plans to maximize firm-wide profit. This is one of the functions that budgeting is expected to accomplish, "coordination." This style of organization is called a functional organization. Or, since headquarters has authority to control every single task that each department performs, it is called a centralized organization.

However, as the various operations each department performs are complexly intertwined with one another, a centralized organization puts an extra load to coordinate such complicated operations on headquarters. To reduce the load, the firm turns out to be divided into several divisions by markets and the headquarters delegates a part of its authority to each division. As a result, it is freed from the load of coordination and able to develop firm-wide strategy. This style of organization is called a divisional organization. Or, since headquarters delegates its authority to each division, it is called a delegated

organization.

It is considered that a delegated style of organization is beneficial for large-scale complex firms (e.g. Anthony and Govindarajan, 2006). However, as stated in the next section, there are few previous studies that analyze the budgeting process in each style of organization under the condition where negative externality arises within a firm. The aim of this paper is to show whether a delegated organization can attain efficient resource allocation in the budgeting process affected by negative externality. This paper is organized as follows; section 2 refers to the related studies and shows the difference between this paper and them; section 3 exhibits the model; given a centralized firm, as benchmarks, section 4 shows the results in the cases of symmetric information and asymmetric information, respectively; section 5 describes the characteristics of the budget prepared by incentive compatible mechanisms; then, section 6 does that of the budget prepared in a delegated firm and compares the results derived in section 5 and 6; lastly, section 7 concludes this paper.

2. Related Studies

This paper relates to three groups of previous studies: delegation, coordination, and externality. Firstly, Melumad and Reichelstein (1987), Baiman and Rajan (1995), Harris and Raviv (1998), Baldenius (2003), and Dutta and Fan (2012) are referred to as the group of delegation. They analyze the situation that a principal delegates the authority to invest in a project to an agent, that is, they study the process of capital budgeting[1]. And, they show the condition that delegation is preferred to centralization.

As opposed to the above studies, Melumad, Mookherjee and Reichelstein (1992; 1995), and Mookherjee and Reichelstein (1997) deal with the process of operating budgeting. Furthermore, they apply a multi-agent model and study the significance of coordination in a hierarchical organization. Given the direct revelation mechanisms, a principal simultaneously contracts with every agent without any costs, that is, headquarters simultaneously can develop every single operational plan. However, in practice, headquarters obliges managers to develop their operational plans. These papers focus on this fact, analyze the situation that a principal delegates its authority to an agent (a manager) and obliges him to develop his and the other agent's (his subordinate's) operational plans, and show whether the delegated mechanisms in a hierarchical organization can attain the same outcome as the direct revelation mechanisms. To put it simply, they study hierarchical coordination.

On the other hand, Kanodia (1993) and Chen (2003) focus on the coordinating function

of budgeting stated in the introduction and study horizontal coordination between agents. Kanodia (1993) analyzes the process of operating budgeting in a centralized firm in which a principal has to coordinate the operations performed by a manufacturing and marketing department, and shows the following results: 1) the operations conducted by an efficient department are subject to the ability of an inefficient department because a principal levels out the operations conducted by each department, and 2) the budgeted volumes of each department are first-best when both departments are efficient, otherwise both of the departments' budgeted volumes are second-best. Chen (2003) analyze the process of capital budgeting in a centralized firm in which 1) a principal invests in the R&D department, 2) the productivity of the manufacturing department increases due to the investments in the R&D department, and 3) both departments are authorized to share the information on their operations.

Also, these two papers examine externality[2]. In Kanodia (1993), in the case that the efficiency of each department is not identical, since an efficient department is subject to the other inefficient department, negative externality happens. To the contrary, in Chen (2003), in the case that a principal invests in R&D department, since the productivity of manufacturing department increases, positive externality happens.

From the above argument, let us figure out the difference between this paper and the related studies. Firstly, it is explained the difference between capital budgeting and operating budgeting. In the process of operating budgeting, headquarters has to allocate resources to every single department that are supposed to operate for the coming year. When negative externality happens in the budgeting process, headquarters has to coordinate the operations each department performs to maximize firm-wide profit. On the other hand, in the process of capital budgeting, headquarters allocates resources to just the departments/divisions whose projects' yield rates are over a firm's hurdle rate. As it turned out, a firm is not influenced by negative externality. Accordingly, it can be said that the related studies on delegation in capital budgeting process and Chen (2003) do not study the influence of negative externality.

Next, although Melumad, Mookherjee and Reichelstein (1992; 1995), and Mookherjee and Reichelstein (1997) analyze the process of operating budgeting, they also do not deal with the influence of negative externality. However, Melumad, Mookherjee and Reichelstein (1992) mentions the significance of coordination between agents in a delegated firm and are related to the analysis conducted in section 7.

Lastly, Kanodia (1993) uniquely studies the process of operating budgeting influenced

by negative externality. As this paper explores the process of operating budgeting in which negative externality happens, the setup of this paper is analogous to that of Kanodia (1993). However, Kanodia (1993) shows only the results in a centralized firm and does not mention the significance of delegation.

To sum up, there has been no study that analyzes the significance of delegated authority to prepare operating budget under the condition that negative externality may harm a firm. So, this paper aims to present whether a delegated firm can allocate resource in the process of operating budgeting more efficiently that a centralized firm.

3. Model

This paper models the situation that a risk-neutral headquarters (hereafter HQ) allocates a budget to two departments: manufacturing and marketing departments. Each department is presided over by a risk-neutral manager. As is often the case with budget preparation, firstly, HQ orders a marketing manager establish sales estimates for the coming year. Subsequently, based on the sales estimates, a manufacturing manager is ordered to submit production plans. Meanwhile, HQ refers to the sales estimates and the production plans submitted by each manager, and then decides a quantity of production, which is also called budgeted volume, to maximize firm-wide profit. Finally, based on the budgeted volume, HQ allocates a manufacturing and sales costs budget to the manufacturing and marketing departments, respectively. As described in the context of responsibility accounting (e.g. Demski, 1994, pp. 519–538), the marketing manager has responsibility to sell the quantity of products deduced from the budgeted volume and the each manager has responsibility to perform their operations within their budgets.

The main components of sales costs are advertising and sales promotion costs, or salary for the personnel of marketing department. Among them, advertising and sales promotion costs are classified as managed costs and salaries for marketing personnel are as committed costs, and generally HQ decides the amount of them in advance. This means that HQ can know the accurate amount of them before preparing a budget. Moreover, they are fixed costs that are not varied with sales volume. Hence, these sales costs are stable in a range of almost same amount period by period not until extraordinary events, such as selling new products or integrating current branches, happen. This paper ignores these kinds of extraordinary events and assumes that the sales costs that marketing department requires to execute its operation are fixed at C where $C > 0$. Also, for simplicity, this paper ignores

variable sales costs[3].

However, this paper assumes that HQ cannot know the expected quantity of products the marketing department will sell for the coming year within C. This means that the expected sales quantity is the private information of the marketing departments. Furthermore, there are two types of the marketing department on the expected sales quantity: good and bad type. Let the expected sales quantity denote v, and that of the good type (resp. the bad type) denotes v_g (resp. v_b), where $0 < v_b < v_g$. Namely, the good type sells out more products than the bad type within the same amount of sales costs. The marketing manager privately observes its own type before submitting its sales estimate for coming year.

In addition, this paper assumes that HQ cannot know the marginal cost and it is the private information of the manufacturing department. In analogy with the marketing department, there are two types of the manufacturing department on the marginal cost: good and bad type. Let the marginal cost denote θ, and that of the good type and (resp. the bad type) denotes θ_g (resp. θ_b), where $0 < \theta_g < \theta_b$. Namely, the cost function is linear and the good type produces more outputs than the bad type within the same amount of production costs. The manufacturing manager privately observes its own type before submitting its marginal costs for coming year. For simplicity, this paper ignores fixed manufacturing costs.

HQ orders each department to report its private information, $v_i (i = \{g, b\})$ and $\theta_j (j = \{g, b\})$, and based on the reports submitted by each department, decides the quantity of production q to maximize its firm-wide profit. Let the revenue function denote $S(q)$ and it satisfies the following conditions: $S(\cdot)' > 0$, $S(\cdot)'' \leq 0$ and $S(0) = 0$. HQ can observe $S(\cdot)$ before preparing the budget. For computational ease, this paper assumes $S'(v_g) = \theta_g$ and $S'(v_b) = \theta_b$, which means that the derived quantity of production is globally optimal when the types of both departments are identical.

Let the combination of each department's type denote $\{v_i, \theta_j\}$. The quantity of production is decided as q_g in the case of $\{v_g, \theta_g\}$, or q_b in the case of $\{v_b, \theta_b\}$. From the assumption on the revenue function and the marginal cost, it is derived that $0 < q_b < q_g$. Moreover, this paper assumes that all of the products the manufacturing department produces in a period are immediately sold by the marketing department within the period. Besides, since HQ pursues the maximization of its firm-wide profit, the quantity of production is q_b in the cases of $\{v_g, \theta_b\}$ and $\{v_b, \theta_g\}$. In other words, when the one department is a good type and the other one is a bad type, the good type is subject to the bad type, as it were, is affected by negative externality caused from the bad type, and the quantity of

production is set at the optimal output level of the bad type. Through such a process, the quantity of product $q_k(k=\{g, b\})$ is decided and each item of general budgets: a sales budget, a sales costs budget, and a manufacturing costs budget is authorized as $S(q_k)$, C, and $\theta_j q_k$, respectively.

The sales budget $S(q_k)$ represents the performance target of the marketing department and the manufacturing costs budget $\theta_j q_k$ does that of the manufacturing one. At the end of a period, each department's performance metrics: sales quantity and manufacturing costs are realized. In the case that their realized performance is over their budget, HQ pays them bonus, or in the case that the former is under the latter, HQ issues them penalty. Based on the above setting, the sequence of events is as follows;

1. Each department privately observes their type.
2. HQ sets up budgeting mechanisms.
3. Each department reports their types to HQ.
4. HQ decides the quantity of production and allocates their budgets to each department.
5. Each department operates in accordance with their budgets.
6. Each department's performance is realized and bonuses are paid or penalties are issued based on their realized performances.

Now, the probability of each type is explained. The probability of a good type of each department is $\Pr(v_g)=\Pr(\theta_g)=p$, and that of a bad type is $\Pr(v_b)=\Pr(\theta_b)=1-p$. And each of the joint probability is as follows: $\Pr(v_g, \theta_g)=p_{gg}$, $\Pr(v_g, \theta_b)=p_{gb}$, $\Pr(v_b, \theta_g)=p_{bg}$, and $\Pr(v_b, \theta_b)=p_{bb}$. This paper assumes that the type of each department is independent and the probability structure is common knowledge.

Lastly, the payoff of each player is presented. The payoff of HQ is the firm-wide profit $S(q_k)-\theta_j q_k-C$. As sated above, the payoff of each department is a bonus in the case that realized performance is over performance target, or a penalty in the case that the former is under the latter. Without loss of generality, this paper ignores their fixed salaries, their payoffs are positive in the case that they are paid their bonus or they are negative in the case that they are issued their penalties.

Incidentally, it must be noticed that, in the case of $\{v_g, \theta_b\}$, even though the marketing department can sell the quantity of products equal to v_g, the quantity of production set at v_b. Accordingly, since the marketing department can sell products at the unit sales costs of $\dfrac{C}{v_g}$,

the necessity amount of sales costs should turn out to be $\dfrac{C}{v_g}q_b$. Unfortunately, HQ cannot fine-tune the total amount of sales costs budget C in proportion as the quantity of production. Eventually, HQ cannot help but allocate C to the marketing department no matter what type the marketing department is. Consequently, in this case, the marketing department can obtain the payoff $C\left(1-\dfrac{q_b}{v_g}\right)>0$. Similarly, in the case that HQ allocates a manufacturing costs budget to the manufacturing department more than necessity amount of manufacturing costs, the difference between them turns out to be the payoff of the manufacturing department. Generally, the difference between allocated budgets and necessity amount of costs is called budgetary slack. Namely, each department can benefit the budgetary slack in addition to their bonuses.

4. Benchmark

This section clarifies the expected payoff of HQ in the case of symmetric information first. In this case, HQ can observe the type of each department as well as each manager before preparing budgets. As a result, HQ can set the quantity at the optimum level. Let the optimum quantity denote $q_k^*(k=\{g, b\})$ and it is decided as follows,

$$q = \begin{cases} q_g^*, & if \quad \{v_g, \theta_g\} \\ q_b^*, & otherwise. \end{cases} \tag{1}$$

Therefore, in the case of symmetric information (first best), the expected payoff of HQ (expected firm-wide profit) Π^{fb} is as follows.

$$\Pi^{fb} = p_{gg}[S(q_g^*)-\theta_g q_g^*]+p_{bg}[S(q_b^*)-\theta_g q_b^*]+(1-p)[S(q_b^*)-\theta_b q_b^*]-C \tag{2}$$

Even if HQ can observe their types, in the case of $\{v_g, \theta_b\}$, it has to leave the budgetary slack $C\left(1-\dfrac{q_b^*}{q_g^*}\right)$ to the marketing department as noted in section 3. On the contrary, in the case of $\{v_b, \theta_g\}$, it can benefit the reduced manufacturing costs $\Delta\theta q_b^*$ where $\Delta\theta=\theta_b-\theta_g$.

Next, the expected payoff of HQ in the case of asymmetric information is presented. Following generally practiced budgeting processes, the marketing department is a leader and the manufacturing department is a follower. Hence, let us examine the reporting strategy of the manufacturing department first.

After recognizing the type of the marketing department, the manufacturing

department reports its type to HQ. Accordingly, its reporting strategy is $\{\theta_g v_g, \theta_g v_b, \theta_b v_g, \theta_b v_b\}$. As for the good type, its payoff is 0 if it reports $\theta_g v_i$ and the payoff is $\Delta\theta q_b$ if it reports $\theta_b v_i$. And, as for the bad type, its payoff is $-\Delta\theta q_k$ if it reports $\theta_g v_i$ and the payoff is 0 if it reports $\theta_b v_i$. As a result, the manufacturing department always prefers to report $\theta_b v_i$ no matter what type it is.

Meanwhile, since the marketing department reports its type without knowing the type of the manufacturing department, its reporting strategy is $\{v_g, v_b\}$. However, it can infer that the manufacturing department always reports $\theta_b v_i$ and HQ sets the quantity of production at q_b no matter what type it reports. As a consequence, it always reports v_b for pursuing its budgetary slack.

Therefore, in the case of asymmetric information, the expected payoff of HQ Π^{as} is as follows.

$$\Pi^{as} = [S(q_b^*) - \theta_b q_b^*] - C \tag{3}$$

From the equation (2) and (3), $\Pi^{as} < \Pi^{fb}$. Namely, HQ lose its expected payoff due to the asymmetric information

The budgetary slacks that each good type department obtains are $\Delta\theta q_b^*$ and $C\left(1 - \dfrac{q_b^*}{q_g^*}\right)$, respectively.

5. Budget Prepared by Incentive Compatible Mechanisms

In the case of asymmetric information, the quantity of production is nothing but q_b^*. To avoid the opportunity loss caused from the decreased production, HQ sets up the incentive compatible mechanisms that induce both departments to report their private information truly. In the following analysis, it is assumed that both departments prefer the reporting strategy HQ prefers when they see their payoffs to be indifferent.

To induce the manufacturing department to report its private information truly, HQ allocates a manufacturing costs budget $\theta_g q_k + \Delta\theta q_b$ to the manufacturing department that reports $\theta_g v_i$. That is, HQ has to leave budgetary slack $\Delta\theta q_b$ to the manufacturing department.

However, from the analysis of the last section, regardless of the manufacturing department's reports, the marketing department reports v_b. To induce the marketing department to reports its private information truly, HQ has to leave the sales budgetary slack $C\left(1 - \dfrac{q_b}{v_g}\right)$ to the marketing department that reports v_g.

Thus, HQ solves the following optimization problem.

$$\max_{\{q_g, q_b\}} p_{gg}\left[S(q_g)-\theta_g q_g-\Delta\theta q_b-C\left(1-\frac{q_b}{v_g}\right)\right]+p_{gb}\left[S(q_b)-\theta_b q_b-C\left(1-\frac{q_b}{v_g}\right)\right]$$

$$+p_{bg}[S(q_b)-\theta_g q_b-\Delta\theta q_b]+p_{bb}[S(q_b)-\theta_b q_b]-C$$

subject to $\qquad \theta_j q_k \geq 0 \quad j, k = \{g, b\}$

$\qquad\qquad\qquad C \geq 0$

Let the optimum quantity of production derived by the incentive compatible mechanisms denote q_k^{ic} and the solution to the above problem is as follows.

Lemma 1. *The quantity of production* q_g^{ic} *or* q_b^{ic} *satisfies the following condition, respectively.*

$$S'(q_g^{ic}) = \theta_g \tag{4}$$

$$S'(q_b^{ic}) = \theta_b + (1-p_{gg})^{-1}\left[p_{gg}\Delta\theta - p\frac{C}{v_g}\right] \tag{5}$$

The equation (4) and (5) indicate the condition to set q_g^{ic} and q_b^{ic}, respectively. As shown in the equation (1), only in the case that both departments are good types, the quantity is set at q_g^{ic}, and otherwise, it is set at q_b^{ic}. From the equation (4), the quantity of production when the both departments are good types is first best, $q_g^{ic}=q_g^*$. This is identical with the typical result of adverse selection (e.g. Laffont and Martimort, 2002). However, as opposed to the typical result, the quantity of production when at least either department is a bad type is always distorted downwardly. Especially, in the case that the marketing department is a good type and the manufacturing department is a bad type, it cannot be said so and the following result is derived.

Proposition 1. *In the case that the marketing department is a good type and the manufacturing department is a bad type, the quantity of production is strictly more than the optimum level,* $q_b^{ic}>q_b^*$ *when* $p_{gg}\Delta\theta<p\dfrac{C}{v_g}$.

Proof. It is obvious from the equation (5).

When $p_{gg}\Delta\theta > p\dfrac{C}{v_g}$, the quantity of production that HQ orders the manufacturing department is strictly less than the optimum level, $q_b^{ic} < q_b^*$. This is also identical with the typical result of adverse selection (e.g. op. cit.). In addition, when $p_{gg}\Delta\theta = p\dfrac{C}{v_g}$, the quantity of production is equal to the optimum level, $q_b^{ic} = q_b^*$. This is analogous to the slack contract stated in Antle and Eppen (1985). In sum, the quantity that a principal orders a bad type agent is weakly less that the optimum level.

As opposed to the above general notion, the firm has the possibility that the bad type's quantity of production is strictly more than the optimum level even though negative externality affects a firm's production. Proposition 1 points out that.

Let us consider intuitively the reason of proposition 1. In the case that the marketing department is a good type and the manufacturing department is a bad type, HQ sets the quantity of production at q_b despite the fact that the marketing department can sell the quantity of q_g. However, when $p_{gg}\Delta\theta < p\dfrac{C}{v_g}$, the manufacturing costs are not so high that the firm had better manufacture more products to avoid the opportunity loss that it should have sold more products. That is why, the quantity of production q_b^{ic} exceeds the optimum level q_b^* and approaches q_g when the manufacturing costs are not so high, concretely $\theta_b < \theta_g + \dfrac{p}{p_{gg}}\dfrac{C}{v_g}$.

6. Delegated Budgeting Process

This section examines whether the firm improves its expected profit by making its structure a divisional/delegated organization. In this delegated firm setting, the firm integrates the marketing and manufacturing departments into one division, assigns either of their managers to the division manager, and delegates the authority to coordinate between the marketing and manufacturing departments within the division and to decide the quantity of production to the division manager. Instead, the division manager takes responsibility to realize the division profit that is assigned by HQ as explained by management accounting textbooks (e.g. Demski, 1994). By delegating the authority, HQ is freed from the burdens associated with the coordination between the marketing and manufacturing departments in a functional/centralized firm setting.

In the following analysis, it is assumed that the expected sales quantity and the marginal costs are the division manager's private information, that is, they are common knowledge within the division. Also, this paper assumes that the division has no ex ante resources for its operation, and the division manager is risk-neutral.

Before the budgeting process, HQ offers the division manager the following type

Table 1. Allocation Rules based on the Manager's Report

Manager's Report	Assigned Target	Allocated Resources
$\{v_g, \theta_g\}$	$S(q_g)-\theta_g q_g-C$	$\theta_g q_g$
$\{v_g, \theta_b\}$	$S(q_b)-\theta_b q_b-C$	$\theta_b q_b$
$\{v_b, \theta_g\}$	$S(q_b)-\theta_g q_b-C$	$\theta_g q_b$
$\{v_b, \theta_b\}$	$S(q_b)-\theta_b q_b-C$	$\theta_b q_b$

incentive scheme.

$$\alpha+\beta\{[S(q_k)-\theta_j q_k-C]^A-[S(q_k)-\theta_j q_k-C]^T\} \geq \underline{U}, \ j, k = \{g, b\} \tag{6}$$

The inequality (6) is a typical form of incentive scheme (e.g. Kaplan and Atkinson, 1998). α and β represent fixed salary and a bonus coefficient, respectively. $\underline{U}$ represents the division manager's reservation utility lest he/she leaves the firm. In fact, they do not play an important role in the following analysis. For notational ease, this paper assumes $\alpha=0$, $\beta=1$, and $\underline{U}=0$

Let us explain the terms in the curly brackets. The expression in the first square brackets $[S(q_k)-\theta_j q_k-C]^A$ represents the actual division profit that the division realizes at the end of a period and that in the second ones $[S(q_k)-\theta_j q_k-C]^T$ does the target division profit that HQ assigns to the division at the beginning of a period. To motivate the division manager to attain the target profit, HQ pays a bonus based on the difference between the actual and target profit $[S(q_k)-\theta_j q_k-C]^A-[S(q_k)-\theta_j q_k-C]^T$. If the division manager realizes $[S(q_k)-\theta_j q_k-C]^A-[S(q_k)-\theta_j q_k-C]^T>0$, the division manager is paid a bonus. In contrast, if $[S(q_k)-\theta_j q_k-C]^A-[S(q_k)-\theta_j q_k-C]^T<0$, the division manager is penalized.

However, if the division manager notices that it is impossible to attain the target profit at the beginning of a period, the division manager leaves the firm and the firm-wide cannot be realized. That is why, HQ has to set the target profit at the beginning of a period as follows.

$$[S(q_k)-\theta_j q_k-C]^A-[S(q_k)-\theta_j q_k-C]^T \geq 0 \tag{7}$$

Similarly, the inequality (7) represents the individual rationality constraints.

In the delegated firm setting, the division manager reports both pieces of the private information $\{v_i, \theta_j\}(i, j=\{g, b\})$ to HQ. Based on the report, HQ assigns its target profit and allocates the resources to attain it to the division. The same way as in the centralized firm

setting explained in section 3, HQ decides the division's target and resources as shown in the following table.

In the case of $\{v_g, \theta_b\}$ and $\{v_b, \theta_g\}$, it is suboptimal that the division produces the quantity of production q_g. Accordingly, if the manager reports $\{v_g, \theta_b\}$ (resp. $\{v_b, \theta_g\}$), HQ assigns the target $S(q_b) - \theta_b q_b - C$ (resp. $S(q_b) - \theta_g q_b - C$), and allocates the resources $\theta_b q_b$ (resp. $\theta_g q_b$) lest the division manager sets the quantity of production at q_g.

Meanwhile, HQ considers the following incentive compatibility constraints to induce the division manager to report its private information truly.

$$[S(q_k) - \theta_j q_k - C]^A - [S(q_k) - \theta_j q_k - C]^T \geq [S(q_k) - \theta_j q_k - C]^A - [S(q_k) - \theta_{j'} q_k - C]^T \quad (8)$$

$$[S(q_k) - \theta_j q_k - C]^A - [S(q_k) - \theta_j q_k - C]^T \geq [S(q_k) - \theta_j q_k - C]^A - [S(q_{k'}) - \theta_j q_k - C]^T \quad (9)$$

$$[S(q_k) - \theta_j q_k - C]^A - [S(q_k) - \theta_j q_k - C]^T \geq [S(q_k) - \theta_j q_k - C]^A - [S(q_{k'}) - \theta_{j'} q_k - C]^T \quad (10)$$

$$j \neq j', \quad k \neq k', \quad j, j', k, k' = \{g, b\}$$

There are three kinds of incentive compatibility constraints. The inequality (8), (9) and (10) mean that HQ induces the division manager to report the true manufacturing costs, the true quantity of production, and both of them, respectively.

In addition, HQ has to allocate the positive amount of resources. That is, HQ considers the following resource feasibility constraints[4].

$$\theta_g q_g \geq 0 \tag{11}$$

$$\theta_g q_b \geq 0 \tag{12}$$

$$\theta_b q_b \geq 0 \tag{13}$$

Although there are several constraints in the delegated firm setting, HQ has to consider only the constraints as stated in the following lemma.

Lemma 2. The binding constraints in the delegated firm setting are as follows.

· $[S(q_g) - \theta_g q_g - C^g]^A - [S(q_g) - \theta_g q_g - C^g]^T = \Delta\theta q_b + C\left(1 - \dfrac{q_b}{v_g}\right)$

· $[S(q_b) - \theta_b q_b - C^g]^A - [S(q_b) - \theta_b q_b - C^g]^T = C\left(1 - \dfrac{q_b}{v_g}\right)$

· $[S(q_b) - \theta_g q_b - C^b]^A - [S(q_b) - \theta_g q_b - C^b]^T = \Delta\theta q_b$

· $[S(q_b) - \theta_b q_b - C^b]^A - [S(q_b) - \theta_b q_b - C^b]^T = 0$

Proof. See the appendix.

The payoff of HQ is the firm-wide profit expected in the budgeting process. The expected firm-wide profit is identical with the stochastically aggregated target profit that HQ assigns to the division. Obviously, HQ intends to maximize it. Accordingly, the objective function is as follows.

$$\max_{\{q_g, q_b\}} p_{gg}[S(q_g)-\theta_g q_g-C^g]^T + p_{gb}[S(q_b)-\theta_b q_b-C^g]^T + p_{bg}[S(q_b)-\theta_g q_b-C^b]^T$$
$$+ p_{bb}[S(q_b)-\theta_b q_b-C^b]^T$$

Substituting the binding constraints shown in lemma 2 into the above objective function, the newly objective function is as follows.

$$\max_{\{q_g, q_b\}} p_{gg}\left\{[S(q_g)-\theta_g q_g-C^g]^A-\Delta\theta q_b+C\left(1-\frac{q_b}{v_g}\right)\right\}$$
$$+ p_{gb}\left\{[S(q_b)-\theta_b q_b-C^g]^A-C\left(1-\frac{q_b}{v_g}\right)\right\}$$
$$+ p_{bg}\{[S(q_b)-\theta_g q_b-C^b]^A-\Delta\theta q_b\} + p_{bb}\{[S(q_b)-\theta_b q_b-C^b]^A\}$$

In effect, HQ's objective function in the delegated firm setting is identical with that in the centralized firm setting as described in the last section. As a result, the solutions of the above problem are as same as those in lemma 1. Thus, the following result is derived.

Proposition 2. The efficiency of resource allocation in a budgeting process does not change depending on the structure of a firm, whether a centralized or delegated firm.

The above result does not intend to deny the advantage of a delegated firm. Rather, it means that HQ can attain the similar level efficiency of resource allocation as in a centralized firm despite the fact that HQ does not directly coordinate between departments within a firm. Moreover, in a delegated firm, HQ is freed from the burdens associated with the coordination. Therefore, the following deduction is derived.

Corollary. Firms have potential benefit resulting from forming their structure in delegated

style.

Generally speaking, divisional/delegated style organization has benefit to relieve information loads on top management in functional/centralized organization. The main result of this paper is analogous to the generally accepted ideas on delegated organization. However, it should be noticed that firms do not obtain the benefit stemming from delegated style organization until the proper incentive scheme is offered. The reason why HQ can allocate resources in delegated budgeting process as efficient as in centralized one is because HQ offers the division manager the allocation rules shown in Table 1. Without them, the firm had potential risk that the division would produce the quantity of production q_g when the manufacturing department is a good type and the manufacturing department is a bad type. Even though firms reform their organization in delegated style, they do not always obtain the benefit stemming from the reorganization into delegated organization.

7. Conclusion

This paper examines the budgeting process involving negative externality between departments within a firm. Typical budgeting process starts from sales estimates presented by marketing departments. Then, based on the sales estimates, manufacturing and other operational plans are developed. At this particular stage, negative externality sometimes happens. Especially, if it is expected that manufacturing costs are so high that producing the quantity of production equivalent to estimated volume of sales is irrational, headquarters has to set the quantity of production less than the estimated volume of sales to maximize firm-wide profit. This is a kind of negative externality. However, by doing so, firms avoid to exhibit greater loss. This is a kind of function that budgeting is expected to accomplish: coordination.

Under asymmetric information, when at lease either of marketing or manufacturing department is a bad type, the quantity of production assigned to manufacturing department is downwardly distorted than optimal level. However, when the above type of negative externality happens and manufacturing costs are not expected to be extremely high, the quantity of production is not downwardly distorted and turns out to be more than optimal level. This is also the benefit stemming from the coordinating function of budgeting.

In addition, this paper compares the results derived in a centralized and delegated firm settings. It is derived that the both results are identical and the efficiency of resource

allocation in budgeting process does not depend on firms' structure. In budgeting process, headquarters has a heavy information load to coordinate various operations within a firm. By contrast, in a delegated firm, headquarters is freed from the load. Moreover, a firm can attain similar level of efficiency as a centralized firm without coordinating departments. This means that the delegated organization has potential benefit to relieve headquarters from the burdens associated with the coordination in budgeting process. However, it should be noticed that a firm cannot always obtain this kind of benefit after forming its structure in delegated style. To obtain the similar level efficiency as a centralized firm in a delegated firm, headquarters has to offer proper incentive schemes and/or resource allocation rules.

Appendix—Proof of Lemma 2—

Let us clarify the binding incentive compatibility constraints in each manager's report: $\{v_g, \theta_g\}$, $\{v_g, \theta_b\}$, $\{v_b, \theta_g\}$, and $\{v_b, \theta_b\}$.

i) Case of $\{v_g, \theta_g\}$

If the division manager reports $\{v_g, \theta_g\}$, the incentive compatibility constraints that HQ should consider are as follows.

$$[S(q_g) - \theta_g q_g - C]^A - [S(q_g) - \theta_g q_g - C]^T \geq [S(q_b) - \theta_g q_b - C]^A - [S(q_b) - \theta_b q_b - C]^T \quad (14)$$

$$[S(q_g) - \theta_g q_g - C]^A - [S(q_g) - \theta_g q_g - C]^T \geq [S(q_b) - \theta_g q_b - C]^A - [S(q_b) - \theta_g q_b - C]^T \quad (15)$$

$$[S(q_g) - \theta_g q_g - C]^A - [S(q_g) - \theta_g q_g - C]^T \geq [S(q_b) - \theta_g q_b - C]^A - [S(q_b) - \theta_b q_b - C]^T \quad (16)$$

The inequality (14) means that HQ prevents the division manager from reporting $\{v_g, \theta_b\}$. The inequality (14) is simplified as follows.

$$[S(q_g) - \theta_g q_g - C]^A - [S(q_g) - \theta_g q_g - C]^T \geq \Delta\theta q_b \quad (17)$$

The inequality (15) means that HQ prevents the division manager from reporting $\{v_b, \theta_g\}$. It should be noticed on the right-hand side of the inequality (15). If the manager reports $\{v_b, \theta_g\}$, the quantity of production is set at q_b. If so, the division can sell the products at the cost of $\dfrac{C}{v_g} q_b$. However, HQ cannot fine-tune the fixed marketing costs and HQ has no choice but to allocate C to the division. Namely, the division can obtain the budgetary slack $C\left(1 - \dfrac{q_b}{v_g}\right)$. In sum, the inequality (15) is simplified as follows.

$$[S(q_g) - \theta_g q_g - C]^A - [S(q_g) - \theta_g q_g - C]^T \geq C\left(1 - \frac{q_b}{v_g}\right) \quad (18)$$

The inequality (16) is the mixture of the inequalities (14) and (15). As a result, the inequality (16) turns out to be as follows.

$$[S(q_g)-\theta_g q_g-C]^A-[S(q_g)-\theta_g q_g-C]^T \geq \Delta\theta q_b+C\left(1-\frac{q_b}{v_g}\right) \tag{19}$$

Therefore, in equilibrium, the inequality (19) is binding and satisfied as follows.

$$[S(q_g)-\theta_g q_g-C]^A-[S(q_g)-\theta_g q_g-C]^T = \Delta\theta q_b+C\left(1-\frac{q_b}{v_g}\right) \tag{20}$$

ii) Case of $\{v_g, \theta_b\}$

If the division manager reports $\{v_g, \theta_b\}$, the considerable incentive compatibility constraints are as follows.

$$[S(q_b)-\theta_b q_b-C]^A-[S(q_b)-\theta_b q_b-C]^T \geq [S(q_g)-\theta_b q_g-C]^A-[S(q_g)-\theta_g q_g-C]^T \tag{21}$$

$$[S(q_b)-\theta_b q_b-C]^A-[S(q_b)-\theta_b q_b-C]^T \geq [S(q_b)-\theta_b q_b-C]^A-[S(q_b)-\theta_b q_b-C]^T \tag{22}$$

$$[S(q_b)-\theta_b q_b-C]^A-[S(q_b)-\theta_b q_b-C]^T \geq [S(q_b)-\theta_b q_b-C]^A-[S(q_b)-\theta_g q_b-C]^T \tag{23}$$

Like the inequalities (14), (15), and (16), the inequality (21), (22), and (23) means that HQ prevents the division manager from reporting $\{v_g, \theta_g\}$, $\{v_b, \theta_b\}$, and $\{v_b, \theta_g\}$, respectively. The inequalities (21) and (23) are simplified as follows.

$$[S(q_b)-\theta_b q_b-C]^A-[S(q_b)-\theta_b q_b-C]^T \geq -\Delta\theta q_g$$

$$[S(q_b)-\theta_b q_b-C]^A-[S(q_b)-\theta_b q_b-C]^T \geq -\Delta\theta q_b$$

Since the right-hand sides in the above two inequalities are strictly negative, they are satisfied with strict inequality sign and negligible.

Applying the same logic as the inequality (15) to the remaining inequality, the inequality (22) is simplified and binding as follows.

$$[S(q_b)-\theta_b q_b-C]^A-[S(q_b)-\theta_b q_b-C]^T = C\left(1-\frac{q_b}{v_g}\right) \tag{24}$$

iii) Case of $\{v_b, \theta_g\}$

If the division manager reports $\{v_b, \theta_g\}$, HQ has to consider the following incentive compatibility constraints.

$$[S(q_b)-\theta_g q_b-C]^A-[S(q_b)-\theta_g q_b-C]^T \geq [S(q_b)-\theta_g q_b-C]^A-[S(q_b)-\theta_b q_b-C]^T \tag{25}$$

$$[S(q_b)-\theta_g q_b-C]^A-[S(q_b)-\theta_g q_b-C]^T \geq [S(q_b)-\theta_g q_b-C]^A-[S(q_g)-\theta_g q_g-C]^T \tag{26}$$

$$[S(q_b)-\theta_g q_b-C]^A-[S(q_b)-\theta_g q_b-C]^T \geq [S(q_b)-\theta_g q_b-C]^A-[S(q_b)-\theta_b q_b-C]^T \quad (27)$$

By offering the division manager incentives as expressed in the inequality (25), (26), and (27), HQ can prevent the division manager to report $\{v_b, \theta_b\}$, $\{v_g, \theta_g\}$, and $\{v_g, \theta_b\}$, respectively. By the allocation rules in Table 1., the incentive compatibility constraints to prevent the division manager from reporting $\{v_b, \theta_b\}$ and $\{v_g, \theta_b\}$, the inequalities (25) and (27), are identical and simplified as follows.

$$[S(q_b)-\theta_g q_b-C]^A-[S(q_b)-\theta_g q_b-C]^T \geq \Delta\theta q_b \quad (28)$$

By the assumption of the revenue function, the right-hand side of the inequality (26) is strictly negative. That is to say, the inequality (26) is satisfied with a strict sign of inequality and this incentive compatibility constraint is negligible. Hence, the incentive compatibility constraint expressed as the inequality (28) is binding as follows.

$$[S(q_b)-\theta_g q_b-C]^A-[S(q_b)-\theta_g q_b-C]^T = \Delta\theta q_b \quad (29)$$

iv) Case of $\{v_b, \theta_b\}$

If the division manager reports $\{v_b, \theta_b\}$, the considerable incentive compatibility constraints to prevent the division manager from reporting $\{v_b, \theta_g\}$, $\{v_g, \theta_b\}$, and $\{v_g, \theta_g\}$ are as follows.

$$[S(q_b)-\theta_b q_b-C]^A-[S(q_b)-\theta_b q_b-C]^T \geq [S(q_b)-\theta_b q_b-C]^A-[S(q_b)-\theta_g q_b-C]^T \quad (30)$$
$$[S(q_b)-\theta_b q_b-C]^A-[S(q_b)-\theta_b q_b-C]^T \geq [S(q_b)-\theta_b q_b-C]^A-[S(q_b)-\theta_b q_b-C]^T \quad (31)$$
$$[S(q_b)-\theta_b q_b-C]^A-[S(q_b)-\theta_b q_b-C]^T \geq [S(q_b)-\theta_b q_b-C]^A-[S(q_g)-\theta_g q_g-C]^T \quad (32)$$

Since the right-hand sides of the inequalities (30) and (31) are strictly negative, they are negligible. The right-hand side of the inequality (32) is equal to zero and this incentive compatibility constraint is binding as follows.

$$[S(q_b)-\theta_b q_b-C]^A-[S(q_b)-\theta_b q_b-C]^T = 0 \quad (33)$$

From the above arguments, the binding incentive compatibility constraints are the equations (20), (24), (29), and (33). They are also the individual rationality constraints in

each case and it can be said that all of them are satisfied. Thus, the considerable constraints are them.

<div align="right">Q. E. D.</div>

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Notes ─────────

1) Arya, Glover and Young (1995), Bernardo, Cai and Luo (2004), and Baldenius, Dutta and Reichelstein (2007) also study the process of capital budgeting. However, they apply a multi-agent model and show the optimal method to allocate resources to agents. In short, they deal with competition and/or coordination between agents rather that delegation.

2) Zhang (2003), and Hughes, Zhang and Xie (2005) are referred to as the studies on externality. It is considered that when tasks which agents perform are independent (resp. complement), each agent is performed separately (resp. aggregately) (e.g. Milgrom and Roberts, 1992). Based on the generally accepted notion, they apply a multi-task model and show the optimal performance evaluation method.

3) Typical variable sales costs are bailing and/or distribution costs. These costs are paid to external contractors and HQ can figure out the amount of them. Accordingly, they are not recognized as private information of a marketing department. Also, they are justproportionate to the quantity of sales. Consequently, they do not take an important role in deriving the analytical result in this paper.

4) In the case of $\{v_g, \theta_b\}$, HQ does not allocate the resources equivalent to $\theta_b q_g$. Hence, the constraint $\theta_b q_g \geq 0$ is negligible.

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