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Procurement Policy and Supplier Behavior — OEM *vs.* ODM

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This paper has two purposes. The first one is to describe and contrast the cost-reducing efforts of original equipment manufacturing (OEM) and original design manufacturing (ODM) suppliers given a fixed, cost-plus contract. The result shows that the cost-reducing effort of the OEM supplier is in line with the assembler's requirement while the ODM supplier is able to keep some of the information rent and exerts less effort. The bargaining power of the ODM supplier is also stronger relative to that of the OEM supplier. It is consistent with the degree of information asymmetry residing in the contracting parties. The second purpose is to derive an optimal contract and procurement policy based on a simple institutional setting. The optimal cost-plus contract is obtained and its components deciphered. The drivers behind the supplier's cost-reducing effort are also studied.

Outsourcing is the strategic use of outside resources to perform activities traditionally handled by internal staff and resources.[1] It has been practiced for years, but the recent surge in excitement and growth is likely to result from changes in the competitive marketplace, which force the companies to take a hard look at their core competencies and to form a closer alliance with their suppliers to help reduce costs and improve services. Supply chain management, as part of the enterprise resource planning (ERP) paradigm, becomes critical for survival.[2]

The success of the Japanese auto makers has generated significant interest for researchers to look into many aspects of the Japanese style of management. On the operational side, important concepts in Japanese production systems such as the *kanban* system, zero inventory, and just-in-time have been formalized and heavily studied (*e.g.*, Monden 1983; Hall & Hall 1984). This development has also ignited research in analyzing the impact of setup cost reduction on production planning (*e.g.*, Porteus, 1985; Zangwill, 1987). When US manufacturers encountered difficulties in implementing *kanban* or just-in-time systems, researchers began to study the behavioral side of the Japanese system, especially corporate culture such as business groups and *keiretsu*, lifetime employment, and team work (*e.g.*, Hutchins, 1986; Abegglen & Stalk, 1985; Imai, 1986). However, when it comes to one of the building blocks of the Japanese auto industry, the suppliers, the incentive issues as applied to the relationship between the assembler and its suppliers receive little attention.

One major reason is that the data are difficult to come by. Researchers are not able to obtain the details of contract negotiations and the finalized version of the contract itself. Even if they are familiar with the operations, the research methodology used is based on case-by-case, descriptive field studies, which are difficult to generalize. Second, even written contracts sometimes are vague. Informal, implicit agreements constitute a large portion of these black-box elements. Third, most researchers in this area come from disciplines such as operations research, industrial engineering, management science, and organizational behavior, which usually regard such supplier relationship as being smooth, thereby assuming away the incentive problems. Economists are indeed interested in optimal incentive schemes. However, their derivations are usually done without taking into account what practice dictates, a criticism rightfully advanced by Arrow (1985).

Asanuma (1985a, 1989) has conducted extensive field studies in the Japanese auto industry.[3] Three sources of components were identified: (1) design supplied (DS), where the assembler provides the technical drawings and the supplier provides only the manufacturing capability; (2) design approved (DA), where the supplier provides both the manufacturing capability and technical know-how for the design approved by the assembler; and (3) off the shelf (OS) for standard components. In the realm of supply chain management, the assembler is most nterested in the first two sources, which will be called OEM (original equipment manufacturing) and ODM (original design manufacturing) in this paper for generality.

This paper describes and contrasts the cost-reducing efforts of the OEM and ODM suppliers given a fixed, cost-plus contract. Reducing and controlling operating costs is listed as the op reason companies outsource.[4] As the practice of target costing spreads rapidly, the assembler has every intention of "transmit[ting] the competitive reality faced by the firm to its suppliers" (Cooper & Slagmulder, 1997, p. 14). How the suppliers react to the assembler's demand and whether there is any difference among suppliers become interesting issues. In addition, this research derives an optimal contract and procurement policy based on a simple institutional setting in order to address the incentive issues involved in observed Japanese practice of adopting linear contracts (Asanuma, 1985a) in such relationships.

The remainder of the paper is organized as follows. The next section provides a literature review on related issues. This is followed by an analysis of the supplier behavior given a fixed, cost-plus contract, as well as the derivation of the optimal procurement policy. The last section concludes the paper.

LITERATURE REVIEW

Although target costing is usually classified as one form of market-based pricing,[5] its value as a cost-reducing tool cannot be overemphasized. Once set, "[t]*he target cost of a product can never be exceeded.*"[6] The firm then uses techniques such as value engineering and quality function deployment to modify design, material specification and production process to reduce costs while preserving the value as perceived by the customers. For outsourced components, the assembler transmits the market pressure to the supplier in the form of target price paid, which in turn becomes the supplier's target cost to meet.

Loeb and Surysekar (1998) studied whether and how payment ceilings should be set in cost-plus contracting. Their findings support the use of an overall payment ceiling to elicit the supplier's private (cost) information and to mitigate the moral hazard problem associated with cost-plus contracting. However, when target costing paradigm is adopted, as is done in this paper, both "whether" and "how" problems with respect to payment ceilings become moot at best. The ceiling is already determined by the market conditions.

Laffont and Tirole (1986) considered a static (one-period) control problem where a regulated firm with private information about its own efficiency parameter decides what level of effort to put into the production process. The regulator (*e.g.*, the government agency) has a prior belief of the firm's "type" and observes the actual cost of production. They are able to derive an optimal scheme which is linear in ex post cost. See Holmstrom and Milgrom (1987) for similar results.

In Laffont and Tirole (1988), the authors preserved most of the basic structure of their 1986 paper, including the efficiency parameter, but extended it to a dynamic (two-period) framework. This paper formalizes the concept of "ratchet effect"[7] by allowing the regulator not to "commit himself not to use in the second period the information conveyed by the firm's first-period performance."

The problem with the use of the efficiency parameter to identify the type of the firm is that when there are more than two periods, as the models in this paper adopt, it becomes difficult to update the regulator's belief reasonably well unless an appropriate equilibrium concept is invoked, such as a sequential equilibrium (Kreps & Wilson, 1982), an exercise not tried here. Instead, the efficiency parameter is replaced by a random variable that represents the unpredictable production environment (*e.g.*, how likely the machinery will break down or the yield rate of the output) against which the supplier exerts effort to tame the cost of production. The realization of this random variable is observable only by the supplier before she makes an effort decision but the assembler has some preliminary information about it (*i.e.*, knows its probability distribution).

Another problem with Laffont and Tirole (1988) is that although a two-period model provides sharper focus and tractability, it simply cannot capture the long-term relation between the assembler and his suppliers. The multi-period models presented in this paper thus subsume the two-period one and eventually are extended to infinite horizon.

The cost structure used in this paper is similar to that of McAfee and McMillan (1986) with two differences. First, it is indexed by time in a multi-period setting; second, the target cost at period t replaces the intrinsic cost that is observable only by the supplier. They also compare an incentive contract with cost-plus and fixed-price contracts[8] in a bidding situation and conclude that the incentive contract performs better. Since their model is essentially one-period,[9] target cost plays no role except in the trivial case where average cost is calculated from previous periods. Kawasaki and McMillan (1987) used their results to empirically examine the parameters of the incentive contract in the context of subcontracting in Japanese manufacturing industries.[10] It is tempting to use the incentive contract because of strong empirical implications. But as Asanuma (1985a) points out, the contracts between the assembler and his suppliers are basically cost-plus. So the efficiency issue of the incentive contract will be put aside for future studies

As to the ratchet effect, Weitzman (1980) provides an early treatment on this topic. He models a no-commitment situation by explicitly formulating target output as a function of the agent's previous performance, as is done in this paper. But he treats the parameters of the target as random variables. Instead, this paper leaves these parameters fixed, as is determined in the negotiation process before mass production begins, so the bargaining power of the parties to the contract can be examined.

Recent development in the literature casts the issue of specific investment (or reliance investment in contract law jargon), such as the cost-reducing effort in this paper, in the realm of incomplete contracts and renegotiation (*e.g.*, Chung, 1991; Hart & Moore, 1988; Reichelstein, 1992). Gietzmann and Larsen (1998) analyzed how cooperation between the assembler and the supplier can be achieved via a careful design of the governance procedures in an incomplete contract setting. Since the parameters of the contract considered in the model are assumed fixed *ex ante*, such complexity is avoided.

SUPPLIER BEHAVIOR GIVEN FIXED CONTRACT

In this section, the supplier 's cost-reducing behavior given a fixed, cost-plus contract will be extracted. The model considered has two pairs of players: the assembler will be matched with the OEM and the ODM suppliers, respectively. They are all assumed to be risk neutral in order to focus on incentive issues. The assembler signs contracts with the two types of suppliers following the contractual scheme in Figure 1.

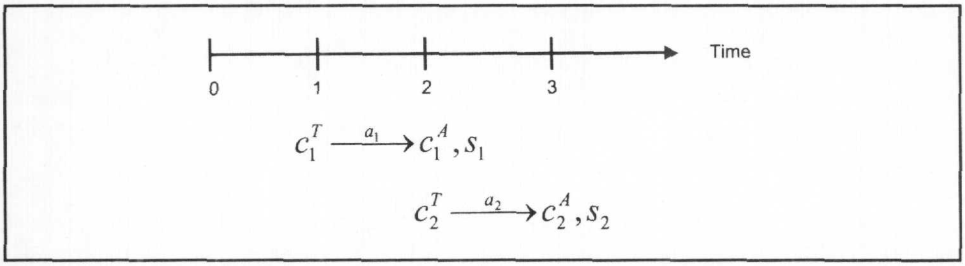

Figure 1. Contractual Scheme.

During time 0, a negotiation is initiated by the assembler to determine the parameters of the target costs (c_t^T) and the incentive payments (s_t) to be used for all future periods (t = 1, 2, ..., T). At the beginning of each period t, the assembler and the supplier will compare the previous period 's actual cost (c_t^A) with the target cost, settle the payment, and determine the current period 's target cost. During each period t, the supplier will then contribute her effort (a_t) to reduce cost as postulated by the target cost.

The target cost at time t is indirectly determined by

$$c_{t-1}^T - c_t^T = \delta + \lambda(c_{t-1}^T - c_{t-1}^A), \qquad (1)$$

where $\delta > 0$ is the fixed cost-reducing goal over the length of the contract and represents how much the cost should be reduced in period t if last period 's target cost were exactly met. $\lambda \in [0,1]$ is the adjustment parameter. Both δ and λ are determined ex ante at time 0. This formula has the supplier 's continuous improvement effort built into the contract. (1) can be rewritten (1) as

$$c_t^T = \lambda c_{t-1}^A + (1-\lambda)c_{t-1}^T - \delta . \tag{2}$$

It is easy to see that period t 's target cost can be expressed as a weighted average of period t-1 's actual and target costs, less a fixed cost-reducing goal. Given c_0^A and c_0^T as initial values, (2) can be further rewritten as

$$c_j^T = c_0^T(1-\lambda)^j + \sum_{t=0}^{j-1}(\lambda c_t^A - \delta)(1-\lambda)^{j-t-1} .$$

The actual cost at time t, c_t^A , can be denoted as

$$c_t^A = c_t^T + w_t - a_t \tag{3}$$

and is observable ex post to the contracting parties. w_t is an *i.i.d.* random variable at time t, representing unpredictable cost fluctuations whose realization is observed only by the ODM supplier during the manufacturing process, but the assembler has a prior belief of w_t, $f(w_t)$, defined over the interval $[\overline{w}, \underline{w}]$, a fixed support. As to that of the OEM supplier, it is assumed that there is no information asymmetry and the assembler is able to observe its realization with certainty. a_t represents the extent to which actual costs are reduced as a result of the supplier 's effort. It can also be interpreted as the relation-specific investment made by the supplier.

With a cost-plus contract, it can be assumed that the gross and net payments from the assembler to the supplier are, respectively,

$$g_t = s_t + c_t^A$$

and

$$s_t = k + \alpha(c_t^T - c_t^A) ,$$

where $k > 0$ is the gross profit margin and $\alpha \in [0,1]$ the reward parameter. k and α are determined ex ante. This format is in spirit similar to Laffont and Tirole 's (1986) result: a contract linear in ex post cost.

The supplier 's utility function, in monetary terms, is

$$u_t = s_t - H_t(a_t) ,$$

where $H_t(a_t)$ is the supplier 's cost of effort. It is assumed to be increasing and convex (i.e., $H_t^{'} > 0$ and $H_t^{''} > 0$). A common discount factor is assumed for all parties: γ .

The assembler 's problem with respect to the OEM supplier can be described as follows:

$$\min_{\{a_t, s_t\}_{t=1}^T} \sum_{t=1}^{T} \gamma^{t-1} g_t \tag{A-OEM}$$

$$\text{s.t. } u_t \geq 0, \forall t .$$

The assembler wants to minimize his total discounted payment over T periods subject to the OEM supplier receiving at least a reservation level of utility (normalized to zero). Since this problem of perfect information is a stationary one, the assembler is in effect solving, for each period,

$$\min_{\{a,s\}} g$$

$$\text{s.t. } u \geq 0 .$$

Proposition 1

Without information asymmetry, the optimal contract between the assembler and the OEM supplier can be characterized by

$$u = 0$$

and

$$H'(a^{OEM}) = \alpha = 1 .$$

In this problem, the OEM supplier will receive only her reservation utility and exert a level of effort that is Pareto efficient because of symmetry of information.

Next, consider the assembler 's problem when he faces an ODM supplier:

$$\min_{\{a_t, s_t\}_{t=1}^{T}} \sum_{t=1}^{T} \gamma^{t-1} \int_{\underline{w}}^{\overline{w}} g_t f(w_t) dw_t \qquad \text{(A-ODM)}$$

$$\text{s.t. } u_t \geq 0, \forall t \text{ and } \{a_t\}_{t=1}^{T} \text{ maximizes } V = \sum_{t=1}^{T} \gamma^{t-1} u_t .$$

The revelation principle does not apply here in the absence of commitment.[11] Moreover, the assembler is not concerned about the ODM supplier 's report on w_t any more than her cost-reducing effort. So the assembler will minimize his total expected discounted payments subject to the ODM supplier 's individual rationality and incentive compatibility constraints.

Given the passive target-setting role of the assembler, a set of optimal decision rules $\{a_t^{ODM}\}$ for the ODM supplier can be found by solving her decision problem alone. The optimal solution can be described in the following proposition.

Proposition 2

The optimal contract between the assembler and the ODM supplier can be characterized by

$$H_t'(a_t^{ODM}) = \frac{\alpha}{1+\frac{\lambda\gamma}{1-\gamma}} \le \alpha \; .$$

Proof

The ODM supplier's objective function can be expressed as

$$V = \sum_{j=1}^{T} \gamma^{j-1} u_j \; . \qquad (4)$$

To have a closed-form solution, let $T \to \infty$[12] and use the fact that

$$\sum_{j=t+1}^{\infty} \gamma^{j-1}(1-\lambda)^{j-t-1} = \frac{\gamma^t}{1-\gamma+\lambda\gamma} \; .$$

Then (4) can be rewritten as

$$V_\infty = \sum_{t=1}^{\infty} \gamma^{t-1}[k + \alpha(c_0^T(1-\lambda)^t - c_t^A) - H_t(a_t)] + \sum_{t=0}^{\infty} \alpha(\lambda c_t^A - \delta)\frac{\gamma^t}{1-\gamma+\lambda\gamma} , \qquad (5)$$

where V_∞ indicates that an infinite horizon problem is being solved.

Using (3), (5) can be reduced to

$$V_\infty = \sum_{t=1}^{\infty} \gamma^{t-1}[\frac{\alpha}{1+\frac{\lambda\gamma}{1-\gamma}} a_t - H_t(a_t)] + Z \; , \qquad (6)$$

where

$$Z = \sum_{t=1}^{\infty} \gamma^{t-1}[k + \alpha c_0^T(1-\lambda)^t - \frac{\alpha}{1+\frac{\lambda\gamma}{1-\gamma}}(c_t^T + w_t)] + \alpha\lambda c_0^A \frac{1}{1-\gamma+\lambda\gamma} - \sum_{t=0}^{\infty} \alpha\delta \frac{\gamma^t}{1-\gamma+\lambda\gamma} \; .$$

Note that Z is a constant independent of $\{a_t\}$. The variable part of (6) is additively separable across periods in functions of a_t. Therefore, (6) will be maximized if and only if in each period t, a_t is selected to maximize

$$\frac{\alpha}{1+\frac{\lambda\gamma}{1-\gamma}} a_t - H_t(a_t) \; ,$$

or

$$H'_t(a_t^{ODM}) = \frac{\alpha}{1+\frac{\lambda\gamma}{1-\gamma}} \le \alpha .$$

Note that the optimal value a_t^{ODM} does not depend on c_t^T. Given that the second-order condition ($H''_t > 0$) is satisfied by assumption, the optimal value must be an interior solution. *Q.E.D.*

Overall, the solutions seem myopic at best. Both types of the suppliers will only look at the parameters negotiated at time 0 to determine their behaviors. In the case of (A-ODM), where the assembler has imperfect information about w_t, the supplier will be able to exert less effort and enjoy more information rent than in the case of (A-OEM), where the assembler has complete control. To induce more effort, the assembler has to reward more (*i.e.,* increase α) and/or punish less (*i.e.*, decrease λ) for the ODM supplier 's investment in cost-reducing effort.

The solution to (A-OEM) says nothing about λ with respect to the ODM supplier. Presumably, it should be higher than that for the ODM supplier to bring the OEM supplier in line with the assembler 's policy. It can be called a "carrot-and-stick" approach toward the OEM supplier.

On the other hand, since these parameters are determined ex ante during the negotiation process before mass production begins, this scheme calls for more bargaining power for the ODM supplier as opposed to the OEM supplier, relative to that of the assembler. This may be called a "honey-and-sugar" policy for the ODM supplier.

It seems paradoxical at first to compare the results of Propositions 1 and 2 because the OEM supplier receives $H'_t(a_t^{OEM}) = \alpha = 1$ while the ODM supplier receives $H'_t(a_t^{ODM}) \le \alpha$, implying that the OEM supplier may be given a better bargaining position in terms of α. In fact, the larger share of (relation-specific) investment gain paid to the OEM supplier can be interpreted as merit from the assembler and his intention to cultivate the OEM supplier, who is more vulnerable, rather than an expression of larger bargaining power on the part of the OEM supplier.

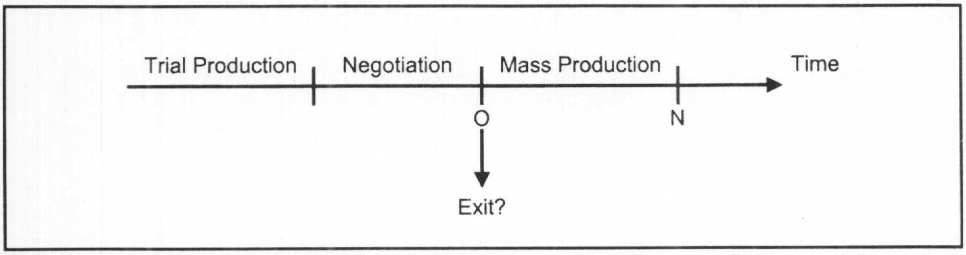

Figure 2. Procurement Process Sequence.

OPTIMAL PROCUREMENT POLICY

The detailed contractual relationship between the assembler and the supplier will be studied in this section. Figure 2 presents the sequence of the procurement process used.

In his procurement policy, the assembler specifies x units of a particular component for trial production and z units of projected demand for mass production by the designated supplier, if this stage is ever reached. The supplier realizes the unit cost of c during trial production and reports $\hat{c}$ instead.

Unit compensation is a function of the reported cost, $s = s(\hat{c})$ and is agreed upon beforehand. It is assumed that s is increasing in $\hat{c}$. The assembler has a procurement target cost, c^T, that he is willing to pay for each unit of the component acquired. This target cost is determined by considering competitive price in the market and his own desired target profit and is given exogenously in the model.

The final target unit price for mass production, p^T, is determined by

$$p^T = \min\{s(\hat{c}), c^T\}.$$

The rationale is simple. If the supplier reports $\hat{c}$ such that the required compensation $s(\hat{c})$ is smaller than c^T, the assembler will not insist on paying c^T. That is, $p^T = s(\hat{c})$ for $s(\hat{c}) \le c^T$. On the other hand, if $s(\hat{c})$ is larger, there will be no mass production allowed unless the supplier accepts a lower compensation, c^T. That is, $p^T = c^T$ for $s(\hat{c}) > c^T$.

In order to produce the x units (and the z units, if called for later) of the component, the supplier has to invest a fixed cost F in capital assets, which will also enable her to find out the actual cost of production. A portion of the fixed cost, $(1-\beta)F$, can be recovered if no mass production follows. In other words, βF can be regarded as sunk once trial production begins.

In this section, a long-term relationship between the assembler and the supplier exists when the mass production is conducted following the trial production. Short-term relationship, on the other hand, indicates a situation where the supplier quits after just the trial production.

The Supplier's Problem

The model is developed backward from the mass production stage on. At mass production stage, it is assumed that a price target, p^T, has been agreed upon. Then the supplier has to choose an optimal level of cost-reducing effort, a^*, to maximize

$$V^P = \int_0^N \{p^T - [c - B(a)]\} z e^{-\gamma t} dt - \phi a,$$

where

V^P = the net present value of the supplier's profit during mass production, evaluated at time 0, when mass production begins (see Figure 2),

ϕ = the acquisition cost per unit of cost-reducing effort.

γ = the discount rate, or the supplier's cost of borrowing funds elsewhere.

N = the length of the mass production period.

a = the number of units of cost-reducing effort, and

B(a) = cost saving per unit time upon adoption of a units of cost-reducing effort, $B'(a) > 0$.

Recall that c and z are, respectively, the supplier's realized unit cost of production and mass production volume. The following proposition summarizes the supplier's optimal responses at mass production stage.

Proposition 3

(1) Increases in cost-reducing effort reduce production costs at a diminishing rate.

(2) Cost-reducing effort will not be undertaken unless the supplier is allowed to at least recover her costs.

(3) Increases in the length of the mass production period encourage more cost-reducing effort.

(4) Higher cost of borrowing funds will lower the optimal level of the cost-reducing effort.

(5) Increases in the cost of cost-reducing effort decrease the optimal level of the cost-reducing effort.

Proof

V^P can be rewritten as

$$V^P = \frac{1}{\gamma}(1-e^{-\gamma N})\{p^T - [c - B(a)]\}z - \phi a \,.$$

Necessary and sufficient conditions for the supplier's problem are, respectively,

$$V^{P'} = \frac{dV^P}{da} = \frac{1}{\gamma}(1-e^{-\gamma N})B'z - \phi = 0 \qquad (7)$$

and

$$V^{P''} = \frac{d^2V^P}{da^2} = \frac{1}{\gamma}(1-e^{-\gamma N})B''z < 0 \tag{8}$$

From (8), we know that $B'' < 0$. In other words, cost savings are increasing at a decreasing rate as the level of cost-reducing effort increases.

If $N = 0$, then $V^P = -\phi a$. In this case, the optimal solution will have the supplier exert no cost-reducing effort; i.e., $a = 0$. Comparative statistics results are derived from (7) using implicit function rule.

$$\frac{da}{dN} = \frac{-\gamma e^{-\gamma N}B'}{(1-e^{-\gamma N})B''} > 0 .$$

$$\frac{da}{d\gamma} = \frac{[1-(1+\gamma N)e^{-\gamma N}]B'}{\gamma(1-e^{-\gamma N})B''} < 0 .$$

$$\frac{da}{d\phi} = \frac{\gamma}{(1-e^{-\gamma N})B''z} < 0 \text{ .Q.E.D.}$$

This proposition shows the possibility to implement a lagged price adjustment scheme in which the assembler sets a price which will last for a certain period of time (in this model, N periods) and allows the supplier to exert cost-reducing effort and enjoy cost savings therein.[13] However, it is only partially implemented because in this model there is no review of target cost after mass production begins and therefore no new (lower) target cost being set. The results are still valid and can provide policy guidance for the assembler. For example, to encourage cost-reducing effort, the assembler can extend the mass production period, arrange low-cost funds for the supplier, or even make the supplier 's effort less costly by providing technical assistance.

Next, assume that the supplier wants to maintain a long-term relationship with the assembler. To formalize this idea, let the supplier choose $\hat{c}$ so that $s(\hat{c})$ satisfies

$$V^S(a^*) + sx - F - cx \geq sx - \beta F - cx , \tag{9}$$

where

$$V^S(a^*) = \max_a \; V^S \left(= \int_0^N \{s(\hat{c}) - [c - B(a)]\} z e^{-\gamma t} dt - \phi a \right).$$

The left-hand side of the inequality (9) represents what the supplier will receive, evaluated at time 0, if she participates in mass production when $s(\hat{c})$ is paid; the right-hand side, her exit compensation from trial production. (9) can be simplified to get

$$V^S(a^*) \geq (1-\beta)F . \tag{10}$$

In other words, it is assumed that the supplier will not exaggerate reported cost of production "too much" in order to earn higher short-term profit from trial production and quit afterwards. From this assumption follows the next proposition.

Proposition 4

(1) There exists a critical value, $\underline{s}$, such that the supplier will participate in mass production only if $s(\hat{c}) \geq \underline{s}$.

(2) In the model, a full-cost-plus compensation scheme is necessary to sustain the long-term relationship between the assembler and the supplier.

Proof

From (10), by solving explicitly for $s(\hat{c})$, a critical value, $\underline{s}$, can be found such that

$$s(\hat{c}) \geq \underline{s} = [c - B(a^*)] + \frac{\gamma}{1-e^{-\gamma N}} \frac{(1-\beta)F + \phi a^*}{z}. \tag{11}$$

It is consistent with a full-cost-plus contract as is normally observed in practice. To see why, express $s(\hat{c})$ as

$$s(\hat{c}) = \underline{s} + k_1$$

or

$$s(\hat{c}) = \underline{s}(1 + k_2), \tag{12}$$

where $k_1 \geq 0$ is the profit margin and $k_2 \geq 0$ the profit margin ratio. It is obvious that both equations in (12) satisfy (11) and are indeed full-cost-plus contracts desired by the supplier. *Q.E.D.*

The right-hand side of (11) indicates that, from the supplier's perspective, the assembler should pay, for each unit produced, at least the cost of production less the cost savings achieved ($c - B(a^*)$) plus the compensation for part of the fixed cost ($(1-\beta)F$), which would have been recovered from quitting after trial production and cost-reducing effort (ϕa^*), both unitized by the mass production volume and multiplied by a time factor.

Notice that another part of the fixed cost, βF, is missing from the formula. It is tempting to interpret this as having been sunk already, with or without mass production. However, another interpretation for its absence in the critical value formula may be more plausible in this setting and has a counterpart in real-world situation. That is, it may be composed of capital outlays for equipment such as dies and tools which have alternative uses for the supplier in other projects. Since it is not specifically related to the assembler's project, the supplier does not expect to get reimbursed for such expenditures.

Since $s(\hat{c})$ is increasing in $\hat{c}$ by assumption, it is invertible. From (11), we can also find a critical value for $\hat{c}$, $\underline{c}$, such that

$$\hat{c} \geq \underline{c} = s^{-1}(\underline{s}) . \tag{13}$$

Proposition 5

To maintain a long-term relationship with the assembler and remain viable, the supplier will report cost of production satisfying (13).

Corollary

Whether the supplier reports the true cost or not is irrelevant in this model. Trying to induce the supplier to report the true cost of production may not be efficient.

Proof

The proof is done through a counterexample. Consider the case where the supplier underreports cost of production (*i.e.*, $\underline{c} \leq \hat{c} \leq c$) in order to launch mass production and recoup losses later through cost-reducing effort. If she is forced to tell the truth, mass production may never get started because of the assembler's target cost constraint. Both parties suffer. *Q.E.D.*

The Assembler's Problem

Designate the optimal value of V^P (the net present value of the supplier's profit during mass production, evaluated at time 0) by $V^P(a^*)$. Then it becomes obvious that, from the assembler's perspective, the supplier will participate in mass production only if she cannot do worse participating than simply pulling out after trial production. That is, the following condition must be satisfied:

$$V^P(a^*) \geq (1-\beta)F .$$

Equivalently, a sufficient condition for the supplier's departure is

$$V^P(a^*) < (1-\beta)F . \tag{14}$$

(11), (12) and (13) together show that the sufficient condition for the supplier's departure can be extended to

$$s(\hat{c}) \geq \underline{s} > p^T = c^T ,$$

or

$$\hat{c} \geq s^{-1}(\underline{s}) > s^{-1}(p^T) = s^{-1}(c^T) .$$

One the one hand, the supplier asks for at least $\underline{s}$ for each unit produced, taking into consideration cost savings potential from optimal cost-reducing effort exerted; on the other, constrained by target procurement cost, the assembler wants to pay less than that, effectively asking the supplier to exert more effort (than she is willing to). In this case, no agreement can be reached and the supplier 's departure becomes inevitable.

If the supplier decides to quit, the assembler 's project may be in jeopardy. In the model, there is no obvious way out unless it is extended. One possibility is to introduce a second qualified supplier, the timing of which can be either at the beginning of trial production stage or after breakdown of negotiation. The first case allows for competition and presumably will lower the target price, thereby bringing it under the cap. The second case takes advantage of the first supplier 's reported cost ($\hat{c}$), which is publicly available, and allows the assembler to invite only those qualified suppliers who are willing to produce the z units at a cost less than $\hat{c}$.[14]

A second possibility is to negotiate a long-term contract with the supplier whose duration will cover several mass production stages. In such a contract, the supplier will be asked to stay throughout the whole contract period and accept pre-defined cost-reducing targets over time in exchange for initial higher compensation. This way, the assembler will break even or do better, depending on his target cost goal.

CONCLUSION

When confronted with increasing pressure to lower costs, a utility maximizing supplier will react to the assembler 's contract offer with corresponding level of cost-reducing effort exerted, given that the contract is accepted. However, different types of suppliers are expected to react differently. Considering the Japanese automotive industry in particular and manufacturing businesses in general as the backdrop, this paper compares the behavior of the OEM and the ODM suppliers in the presence of a fixed, cost-plus contract. The different degrees of information asymmetry between the assembler and the two suppliers lead the former to have complete control over the OEM supplier 's cost-reducing effort while leaving the ODM supplier room for information rent. The issue of bargaining power between contracting parties is also explored.

The contractual scheme is then relaxed to derive an optimal procurement policy for the assembler. It turns out to be a linear one, the transfer payment to the supplier consisting of net production cost (i.e., production cost net of savings from cost-reducing effort) plus compensation for the costs of cost-reducing effort and part of the fixed assets purchased for the project. The result also demonstrates the potential to implement a lagged price adjustment mechanism in which the supplier enjoys additional cost savings once the target cost has been met during the current contract period. In other words, the extra savings from the supplier 's cost-reducing effort will not be exploited by the assembler until the next round of contract negotiation begins, in which a new (and lower) target cost will be set. The assembler is encouraged to foster a closer tie with the supplier through longer-term relationship building, providing technical and technological assistance, and even arranging lower-cost loans for the supplier in exchange for the latter 's willingness to reduce costs further. The assembler will be better able to share market pressure with his network of suppliers and concentrate on improving products and services.

Two limitations to the modeling approach here can be relaxed or amended in future research. The assembler's target procurement cost plays a crucial role in determining the fate of the mass production stage and the project as a whole, but it is given exogenously. It would be better if this target cost can be determined as a decision variable in the model. Also, the model entails essentially one big period, leaving price adjustment incomplete and the assembler's role passive. Extending the model to one more period will infuse richer results.

ENDNOTES

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1. See the Outsourcing Institute's web site at www.outsourcing.com.
2. See, for example, Davis *et al.* (1998), Christopher (1998) and Simchi-Levi *et al.* (2000).
3. See also Gietzmann & Larsen (1998).
4. Survey of current and potential outsourcing end-users (The Outsourcing Institute Membership, 1998).
5. See, for example, Horngren, Foster & Datar (2000).
6. Cooper & Slagmulder (1997).
7. "An agent with a high performance today will tomorrow face a demanding incentive scheme. He should thus be reluctant to convey favorable information early in the relationship." (Laffont & Tirole 1988)
8. Let $p = b + a (c - b)$ be the unit price for a component, where b is the target price including negotiated profit margin and c the realized average cost preceding the price revision. If the sharing parameter a is zero, the contract is set at a fixed price. If a is one, the contract is cost-plus. If $0 < a < 1$, this is an incentive contract.
9. It will be interesting to see which contract form (i.e., incentive, fixed-price, or cost-plus) fares better in multi-period setting.
10. The industries included in their paper are textiles, clothing, iron and steel, nonferrous metals, metal products, machinery, electrical machinery and equipment, transportation equipment, and precision instruments. Some of them are related to the auto industry.
11. See Laffont & Tirole (1988).
12. Imagine that both the assembler and the ODM supplier determine the target infinitely often during the whole contract periods.
13. "Citizen Watch demands its suppliers decrease their costs a minimum of 3 percent per year. This 3 percent decrease in cost is included in the budget. *Suppliers keep any cost saving in excess of 3 percent* [emphasis added]" (Blocher, Chen & Lin, 1999, citing Cooper (1993)).
14. The timing differences may distinguish various types of sourcing schemes in the literature. In dual or multiple sourcing, the assembler sources from two or more suppliers at the same time. See Klotz & Chatterjee (1995) and Seshadri, Chatterjee & Lilien (1991). In second sourcing, the assembler allows a supplier to trial produce for some time, and then asks her to share technology with a second supplier, who will later compete with the first supplier in the reprocurement stage. See Anton & Yao (1987), Demski, Sappington & Spiller (1987), Farrell & Gallini (1988), and Riordan & Sappington (1989).

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