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Procurement System and Competitive Advantage

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Abstract

We examine which type of assembler—American-type or Japanese-type—will occupy a dominant position in a duopoly competition. An American-type assembler such as GM produces the parts internally, while a Japanese-type such as Toyota purchases them from its affiliated (keiretsu) supplier. This subject is also related to an institutional choice of boundaries of the firm, which affects firms' competitiveness. In an affiliated procurement system, it is usual for a parent firm to support its affiliated supplier in various ways prior to purchasing the parts. The support can work as a commitment device that enables the parent firm to purchase the parts at a low price. Subsequently, the low price of the intermediate good gives the parent firm a competitive advantage in the final product market.

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1 Introduction

Japanese automakers enjoy competitive power in the North American market. The competitive power of Japanese automobiles originates from both their moderate price and high quality. In fact, it is no exaggeration to say that the majority of the competitive power is created by the affiliated supplier. Generally, GM produces about 70 percent of the parts used in its cars by itself, while Toyota produces only 20-30 percent[4]. We analyze a theoretical competition model in which one firm produces an intermediate good by itself, whereas the other procures the intermediate good from its affiliated supplier.

Much empirical literature has examined the Japanese-American subcontracting system, such as Asanuma (1985), Womack et al. (1990), Fujimoto (1997), Cusmano and Takeishi (1991), and Nishguchi (1994) and so on. They concluded that such a different subcontracting system has exerted great influence on the difference in performance between Japanese and American automakers. They especially emphasized the importance of a cooperative relationship between automakers and suppliers as well as that of the suppliers' skills and abilities in the Japanese subcontracting system, which can be contrasted with the arm's length relationship in the American subcontracting system[5]. However, these studies are no more than comparative analyses to show the priority of the Japanese subcontracting system in comparison with the American subcontracting system.

Concretely speaking, much economic literature has devoted focused attention to the comparative analysis of the Japanese-American automobile industry. However, there has been less focus on the theoretical competition model between the different subcontracting systems. Therefore, this paper bridges a logical gap in the competition theory between the Japanese and the American subcontracting systems. This paper will shed light on the research of this area.

[4] See Womack et al. (1990) for details. However, Chrysler among American automakers relatively procures a great deal of parts and components from competitive market.
[5] See Taylor and Wiggins (1997) that contrast the Keiretsu subcontracting system with spot transaction procured from the competitive market.

The Japanese automakers have maintained the long-term relationships with their affiliated suppliers. These long-term relationships enable them to make proper relation-specific investments without the hold-up problem[6]. These investments are made in both physical assets and intangible skill-and-abilities. On the one hand, the skills and abilities of suppliers enable them to implement the quality control (QC) of the parts, execute the just-in-time (JIT) delivery, and make the value engineering (VE) or value analysis (VA) proposal to the assembler[7]. Japanese manufacturers have provided their suppliers with several kinds of supports, which enable them to accumulate and upgrade their skill-and-abilities. The resulting high skill-and-abilities of suppliers help them to strengthen the automaker's own competitive power. The supports include several pieces of the instruction for quality control, technological advice on cost reduction, and financial aid[8]. These supports can be regarded as a lump sum transfer paid by the automaker to the supplier before the transaction is implemented. This paper shows that the ex-ante transfer works as a commitment device which enables the automaker to purchase the parts at a low price. The low price subsequently offers the automaker a competitive advantage in the final product market.

The support from an automaker to a supplier is a typical feature of the cooperative relationship in the Keiretsu system. This system is different from the spot market procurement between the buyer and the seller is bounded within a transaction. The system is also different from the in-house procurement where the assembler department is unable to commit itself to

[6] See Klein et al. (1978) and Williamson (1985) for hold-up problem. The repeated transactions can be expressed by the repeated game. See Baker et al. (2001) for the repeated transactions from a game theory approach.

[7] The supplier is expected to propose ideas for improving the design of parts and components at the development phase (VE proposal) and/or at the mass production phase (VA proposal). VE and VA mean the value engineering and the value analysis, respectively.

[8] From the supplier's point of view, the transaction with its keiretsu manufacturer is not merely to take an order but to secure an opportunity to improve its own skill and ability.

paying the ex ante transfer to the intermediate department.

We analyze a three-stage model, which incorporates the features of the keiretsu system contrasted with the in-house procurement. At first stage, in keiretsu system, the assembler offers the supplier a contract including a price of an intermediate good and a lump sum transfer. At second stage, the cost reduction investment is executed in both systems, and at the third stage, each output of final goods is determined in a duopoly market. The main result is that the assembler in the keiretsu system enjoys more output, payoff, and investment than those of the assembler in the in-house procurement. The lump sum transfer enables the assembler to set a lower price for the intermediate good. It makes the manufacturer occupy a dominant position in the Cournot competition.

In a broad sense, this paper relates to the issue of make-or-buy i.e. the boundaries of the firm. The decision is associated with transaction costs both within and across firms, as authors such as Williamson (1985), Grossman and Hart (1986), and Hart and Moore (1990) have considered. Although these authors dealt with the make-or-buy decision within one party; we focus on a competitive between two parties. Bonnano and Vickers (1988) and Rey and Stiglitz (1988) analyzed the issue of make-or-buy from the perspective of strategic behavior. They showed that manufacturers mitigated the competition by selling their product through their independent retailers (vertical separation) rather than directly to consumers (vertical integration).

A large amount of literature treats forward integration in a similar manner, whereas relatively few studies focus on backward integration. Especially, when an investment takes place before the associated output is produced, two competitive firms may use the investment for strategic purposes other than for minimizing costs. Such a strategic use of investment will increase the total amount of investment, increase total output, and lower profit. The strategic use of investment produces inefficiency in that total costs are not minimized for the chosen output (Brander and Spencer, 1983). Taylor and Wiggins (1997) compare two fundamentally different subcontracting systems: the American system, which is characterized by competitive procurement, large orders, and inspection, and Japanese system, which is specified with repeated purchases from a supplier, small orders, no inspection, and supplier's positive profit. They show that although both systems coexist as local solutions, there is a growing trend a shift from the American system to the Japanese system. Chen (2005) examines whether or not an assembler integrates its parts production. When there exists economies of scale through learning-by-doing in the production of parts, it is profitable for an integrated firm to sell the parts to the rival firm. The rival's firm may strategically not purchase from an integrated firm unless the price of the intermediate good is sufficiently lower than those of alternative suppliers. Vertical separation occurs if and only if the total industry profit is higher under vertical separation than under integration. Lin (2006) analyzed a helping effect for rivals when a downstream firm directly entered into the input market. He also showed that separation exclusively occurs if the number of downstream firms exceeds a threshold level.

This paper is organized as follows. In the next section we describe the model. In section 3, we obtain the equilibrium of the model. In section 4, we discuss some propositions that relate to both firms' performances. Section 5 contains some implications and concluding remarks.

2 The Model

Consider two firms, i and j, producing a homogeneous final product. The inverse demand function for the final product is given by

$$p=a-b(q_i+q_j) \tag{1}$$

where p is the market price, q_k $(k=i,j)$ is the output (= sales volume) of firm k, and a and b is a positive parameter. Firm i produces an intermediate good for the final product internally, whereas assembler jA purchases it from its Keiretsu supplier *jS*. In the keiretsu procurement, firm *jA* provides several supports for its own keiretsu supplier *jS* before the transaction between them is implemented. For simplicity, the total amounts of the supports are simply given by *F*.

Firm *i* and keiretsu supplier *jS* are able to make an investment for reducing the marginal production cost of the intermediate good prior to producing it. When they invest $x_k(k=i,j)$ in the cost reduction for the intermediate good, their marginal costs are given as $c_k(x_k)$. Without loss of generality, we assume that the marginal cost function is as follow:

$$c_k(0)=c, \quad c_k'<0, \quad c_k'(x_k \to 0)<-\infty, \quad c_k''>0, \quad c_k(x_k \to \infty) \to \underline{c} \tag{2}$$

[Figure 1 here]

The last assumption in Eq. (2) means that no matter how they may invest, the marginal cost cannot fall under $\underline{c}$[9]. Put another way, some raw materials are absolutely required in order to produce the intermediate good. For simplicity, one unit of the final product needs exactly one unit of the intermediate (fixed-coefficient technology) and the cost of transforming the intermediate good into the final product is normalized to zero. We also assume that

$$2c<a<11\underline{c} \tag{3}$$

The timing of the game is as follows:

In stage one, firm *jA* offers to the keiretsu supplier *jS* a take-it-or-leave-it contract that consists of the intermediate good price $w(\geq 0)$[10] and the lump sum pecuniary transfer *F*. keiretsu supplier *jS* accepts the contract as long as the profit is non-negative under the expected order quantity. It is worth noting that

[9] We surmise that about 20-30 per cent of the marginal cost is saved from investment.
[10] We assume that the contract $\{w, F\}$ is observable to firm *i*.

$w \geq 0$[11]. In stage two, firm i and keiretsu supplier jS determine their cost reduction investments x_k $(k=i,j)$. Finally, firm i and firm jA choose their output levels q_k $(k=i,j)$ in stage three. The payment from firm jA to supplier jS is transferred according to the initial contract between stage two and three.

3 Analysis

3.1 The Third Stage

We focus on the subgame perfect equilibrium of the game. In stage three, firm i selects an output level for the final product in order to maximize its profit given the output of a rival firm. It is worth noting that firm i produces an intermediate good at cost c_i, while firm jA procures a unit of intermediate good at cost w. Then, firm i's maximization problem is

$$\text{Max } \pi_i=(p-c_i)q_i-x_i=(a-b(q_i+q_j)-c_i)q_i-x_i, \quad \text{w.r.t. } q_i.$$

From the first-order condition that $\partial\pi_i/\partial q_i=a-2bq_i-bq_j-c_i=0$, the reaction function is given by

$$q_i(q_j)=(a-bq_j-c_i)/(2b) .$$

Then, firm jA's maximization problem is

$$Max\ \pi_{jA}=(p-w)q_j-F=(a-b(q_i+q_j)-w)q_j-F, \quad w.r.t.\ q_j.$$

From the first-order condition that $\partial\pi_{jA}/\partial q_j=a-bq_i-2bq_j-w=0$, the reaction function is given by

[11] Suppose that the manufacturer cannot make commitment to its order quantity. When w<0, the supplier's payoff becomes negative owing to the manufacturer's infinitive order quantity. It is evident that this case is not an equilibrium.

$$q_j(q_i)=(a-bq_i-w)/(2b).$$

The above two reaction functions yield the equilibrium outputs as solutions to the third stage

$$q_i(c_i,w)=(a+w-2c_i)/(3b) \tag{4-1}$$

$$q_j(c_i,w)=(a-2w+c_i)/(3b) \tag{4-2}$$

We can also solve the price for the final product by substituting Eq. (4-1) and Eq. (4-2) into Eq. (1) as follows:

$$p(c_i,w)=(a+w+c_i)/3 \tag{4-3}$$

What is important to note from Eq. (4-1) and Eq. (4-2) is that

$$q_i \lesseqgtr q_j \quad iff \quad w \lesseqgtr c_i \tag{5}$$

Eq. (4-1) and Eq. (4-2) show how the marginal procurement cost w and marginal production cost c_i affect their output levels. Concisely speaking, the higher the firm *i*'s marginal cost c_i, the greater firm *jA*'s output q_j, and *vice versa*. It is also worth noting from Eq. (4-1) and Eq. (4-3) that

$$q_i>0 \quad \Leftrightarrow \quad c_i<(a+w)/2 \quad \Leftrightarrow \quad p>c_i$$

$$q_j>0 \quad \Leftrightarrow \quad w<(a+c_i)/2 \quad \Leftrightarrow \quad p>w$$

The above equations imply that the price of the final product must be higher than marginal cost c_i and marginal procurement cost w in order to have a positive output.

3.2 The Second Stage

In stage two, firm i and keiretsu supplier jS choose the investment level in order to maximize their profits. From Eq. (4-1) and Eq. (4-3), firm i's maximization problem is

$$Max\ \pi_i=(p-c_i)q_i(c_i,w)-x_i=(a+w-2c_i(x_i))^2/(9b)-x_i, \quad w.r.t.\ x_i$$

The first-order and second-order condition are given by

$$\frac{\partial \pi_i}{\partial x_i} = -\frac{4(a+w-2c_i)c_i'}{9b} - 1 = -\frac{4q_i c_i'}{3} - 1 = 0 \tag{6-1}$$

$$\frac{\partial^2 \pi_i}{\partial x_i^2} = \frac{4\{2(c_i')^2 - (a+w-2c_i)c_i''\}}{9b} < 0 \tag{6-2}$$

where $c_i'=\partial c_i/\partial x_i$ and $c_i''=\partial^2 c_i/\partial x_i^2$. We assume that $c_i''>27b/(8q_i^3)$ for satisfying the second-order condition. Note that firm i's output $q_i\ (c_i(x_i),w)$ is independent of x_j. Firm i's investment level is given by

$$c_i'(x_i) = -\frac{3}{4q_i(c_i, w)} \tag{6-3}$$

Note that $a>2c\geq 2c_i$. Then, Given Eq. (3) and $w\geq 0$, Eq. (4-1) produces the following conclusions:

$$q_i = \frac{(a+w-2c_i)}{3b} \geq \frac{(a-2c_i)}{3b} \geq \frac{(a-2c)}{3b} > 0 \text{ and } x_i > 0$$

On the other hand, keiretsu supplier jS's maximization problem is

$$\text{Max}\ \pi_{jS} = (w - c_j)q_j - x_j + F = \frac{(w - c_j(x_j))(a - 2w + c_i(x_i))}{3b} - x_j + F, \ \text{w.r.t.}\ x_j$$

The first-order and second-order condition are given by

$$\frac{\partial \pi_{jS}}{\partial x_j} = -\frac{(a - 2w + c_i)c_j'}{3b} - 1 = -q_j c_j'(x_j) - 1 = 0 \tag{7-1}$$

$$\frac{\partial^2 \pi_{jS}}{\partial x_j^2} = -\frac{(a - 2w + c_i)c_j''}{3b} < 0 \tag{7-2}$$

where $c_j'=\partial c_j/\partial x_j$ and $c_j''=\partial^2 c_j/\partial x_j^2$. Note that Eq. (7-2) is satisfied by Eq. (2) as long as $q_j>0$. Hence, keiretsu supplier *jS* sets the investment level as follows:

$$c_j'(x_j) = -\frac{1}{q_j(c_i(x_i), w)} \tag{7-3}$$

To see the effect of firm *i*'s investment level x_i on firm *j*'s investment level x_j, and vice versa, we compare Eq. (6-3) with Eq. (7-3). The investment level x_j of firm *j* is negatively affected by firm *i*'s investment level x_i, while the investment level x_i of firm *i* is independent of keiretsu supplier *jS*'s investment level x_j. If $q_i=q_j$, $x_i>x_j$[12]. Therefore, note that firm *i* makes a more aggressive investment in cost reduction than keiretsu supplier *jS*. The reason why firm *i* makes a more aggressive investment is that it uses the cost reduction investment strategically[13]. However, keiretsu supplier *jS* does not use the cost reduction investment in the strategic purpose.

Let their investments $(x_i(w), x_j(w))$ be the function of intermediate price w. To see how change in w affects x_i and x_j, let us see the total differential of Eq.

12 If $q_i=q_j$, $c_i'=-3/(4q_i)>-1/q_j=c_j'$. Hence, from $c''>0$, $x_i>x_j$.

13 See Brander and Spencer (1983) for a detail. Such a strategic use for investment induces the firm to overinvest for the chosen output.

(6-1) and Eq. (7-1). Rearranging and differentiating Eq. (6-1) and Eq. (7-1), we have

$$\{2c_i'^2 - (a + w - 2c_i)c_i''\}dx_i + 0dx_j = c_i'dw$$
$$c_i'c_j'dx_i - (a - 2w + c_i)c_j''dx_j = 2c_j'dw$$

From the second-order condition, we have

$$D = \{2c_i'^2 - (a + w - 2c_i)c_i''\}\{-(a - 2w + c_i)\, c_j''\} > 0$$

From Eq. (2) and Eq. (6-2), we reach the following conclusions.

$$dx_i/dw = -c_i'(a - 2w + c_i)c_j''/D > 0 \tag{8-1}$$
$$dx_j/dw = [-2c_j'\{2c_i'^2 - (a + w - 2c_i)c_i''\} + c_j'c_i'^2\,]/D < 0 \tag{8-2}$$

Eq. (8-1) and Eq. (8-2) imply that the lower the procurement price *w* is, the lesser the firm *i*'s investment amount x_i is, but higher the supplier *jS*'s investment amount x_j.

3.3 The First Stage

We now turn to the first stage of the game. Firm *jA* chooses intermediate price *w* and pecuniary transfer *F* to maximize its own profit given two constraint conditions that keiretsu supplier *jS*'s profit and intermediate price *w* are nonnegative . The maximization problem is

$$\text{Max}\ \pi_{jA} = (a - 2w + c_i)^2/(9b) - F, \quad \text{w.r.t.}\quad w \text{ and } F$$
$$\text{s.t.}\ \pi_{jS} = (w - c_j)(a - 2w + c_i)/(3b) - x_j + F \geq 0,\ \text{ and } w \geq 0$$

Note that the first constraint condition is binding[14]. Then, the above constrained maximization problem can be rewritten as follows:

$$\text{Max } \pi_{jA} = \frac{\{a + w + c_i(x_i(w)) - 3c_j(x_j(w))\}\{a - 2w + c_i(x_i(w))\}}{9b} - x_j, \text{ w.r.t. } w$$

$$\text{s.t.} \quad w \geq 0$$

Noting Eq. (6-1), the first-order condition is given by

$$\frac{\partial \pi_{jA}}{\partial w} = \frac{(-a - 4w - c_i + 6c_j)}{9b} + \frac{(2a - w + 2c_i - 3c_j)}{9b} c_i'(dx_i/dw) \leq 0, \tag{9-1-1}$$

$$\frac{\partial \pi_{jA}}{\partial w} w = 0, \text{ and } w \geq 0 \tag{9-1-2}$$

The first term of RHS in Eq. (9-1-1) is the direct effect and the second term of RHS in Eq. (9-1-1) is the strategic effect based on how the rival's investment amount x_i is affected by the change in w. We also assume that the second-order condition is satisfied for all domain of w.

$$\frac{\partial^2 \pi_{jA}}{\partial w^2} < 0, \text{ for all } w \geq 0 \tag{9-2}$$

If it has satisfied the condition that $\partial\pi_{jA}/\partial w(w=0)<0$[15], it is efficient for firm *jA* to set the intermediate price w^* at zero. If it has satisfied the condition that $\partial\pi_{jA}/\partial w(w=0)\geq 0$, it is efficient for firm *jA* to set the intermediate price $w^*\geq 0$. Firm *jA* also chooses pecuniary transfer F^* in order to set keiretsu supplier *jS*'s profit to be zero. Under the equilibrium intermediate price w*, let $x_i^*= x_i(w^*)$,

[14] When the first constraint condition is binding, assembler *jA* obtains the same profit as that of the total keiretsu channel.

[15] The condition can be rewritten by $(-a-c_i+6c_j)<-(2a+2c_i-3c_j)c_i'(dx_i/dw)$.

c_i*$=c(x_i$*$)$, q_i*$=q(c_i$*$,w$*$)$, p*$=p(c_i$*$,w$*$)$, and π_i*$=(p_i$*$-c_i$*$)q_i$*$-x_i$* denote, respectively, the equilibrium investment amount, the equilibrium marginal cost, the equilibrium output of the final product, the equilibrium price of the final product, and the equilibrium profit of firm *i*. Notation about keiretsu firm is treated as the same.

4 Some Propositions

In this section, we introduce some propositions which relate to the performances of both firms. Under the assumption that the subgame perfect equilibrium is satisfied, we examine the price determination of the parts of the keiretsu firm in stage one. To guarantee a duopoly market existence, we assume that

$$p^* > \max\{c_i^*, w^*\} \tag{10}$$

Proposition 1*: In equilibrium, the keiretsu procurement firm jA sets the intermediate good price to be lower than the marginal production cost of its supplier jS.*

Proof)

Let us, to begin with, see the corner solution. It is easy to verify that $w^*=0<\underline{c}\leq c_j^*$ when $w^*=0$. Next, we consider the interior solution. From Eq. (9-1), the equilibrium intermediate price w^* should be satisfied with the following equation:

$$d\pi_{jA}/dw = (-a - 4w^* - c_i^* + 6c_j^*)/(9b) + \{(2a - w^* + 2c_i^* - 3c_j^*)/(9b)\}c_i'^*(dx_i/dw) = 0 \tag{11}$$

where $c_i'^*=\partial c_i/\partial x_i|x_i=x_i^*$ and $c_j'^*=\partial c_j/\partial x_j|x_j=x_j^*$. If we note that

$$(c_j^*-w^*)-(p^*-c_j^*)=2c_j^*-w^*-(a+w^*+c_i^*)/3=(-a-4w^*-c_i^*+6c_j^*)/3$$

$$0<(p^*-w^*)+(p^*- c_j^*)=2(a+w^*+ c_i^*)/3-w^*- c_j^*=(2a-w^*+2 c_i^*-3 c_j^*)/3,$$

dividing Eq. (11) into (1/3b) and rewriting it yields

$$\partial\pi_{jA}/\partial w=[(c_j^*-w^*)-(p^*-c_j^*)]+c_i'^*(dx_i/dw)[(p^*-w^*)+(p^*-c_j^*)]=0$$
$$\Rightarrow \quad (c_j^*-w^*)=(p^*-c_j^*)-c_i'^*(dx_i/dw)[(p^*-w^*)+(p^*-c_j^*)]>0$$

Applying $c_i'^*<0, dx_i/dw>0$, and Eq. (10), it is obvious that $c_j^*>w^*$.

Q.E.D

Note that keiretsu procurement firm *jA* sets the efficient lump sum transfer F^* at the level which makes its supplier profit be zero. The efficient lump sum transfer F^* can be written

$$F^*=x_j^*-(w^*-c_j^*)q_j^*>0 \tag{12}$$

Eq. (12) implies that firm *jA* pays its supplier *jS* a positive lump-sum transfer in equilibrium.

Lemma 1: *Suppose that $w\in[0, (a+c)/2]$. There exists any w satisfying that $x_i(w)=x_j(w)$. When $x_i(w)=x_j(w)$, $q_j(w)>q_i(w)$and $\pi_j(w)>\pi_i(w)$, respectively.*

Proof)

If $x_i(w)=x_j(w)$, $c_i=c_j$ and $c_i'=c_j'$. From Eq. (6-3) and Eq. (7-3), we obtain

$$c_i'=c_j' \quad \Leftrightarrow \ -3/4q_i=-1/q_j \quad \Leftrightarrow \quad q_j=4q_i/3>q_i$$

Note that the profit of keiretsu procurement firm *jA* is the same as the sum of keiretsu manufacturer's and supplier's profits because the supplier's profit is zero. Applying Proposition 1, $F=x_j-(w-c_j)q_j$, and $\pi_{jS}=0$ yields

$$\pi_{jA}=(p-c_j)q_j-x_j>(p-c_i)q_i-x_i=\pi_i$$

To get the value of $\underline{w}$ that satisfies $x_i(\underline{w})=x_j(\underline{w})$, rearranging and substituting Eq. (4-1) and Eq. (4-2) into Eq. (6-3) and Eq. (7-3), respectively, yields

$$x_i \lesseqgtr x_j \quad \Leftrightarrow \quad w \gtreqless c_i(x_i)-(a-c_i(x_i))/10 \equiv \underline{w}.$$

Q.E.D.

On the other hand, under the condition that $w=\underline{w}$, Lemma 2 is satisfied.

Lemma 2 *: Suppose that $\underline{w} \in [0, (a+c)/2]$. There exists $\underline{w}$ such that $x_i(\underline{w})=x_j(\underline{w})$. If $w<\underline{w}$, then $x_i(w)<x_j(w)$.*

Proof)

Suppose that $w=0$. Substituting $w=0$ into Eq. (6-3) and Eq. (7-3) yields $q_i=(a-2c_i)/(3b)$ and $q_j=(a+c_i)/(3b)$, respectively. Note that $4q_i/3<q_j$ for $x_i<x_j$. Therefore, the condition that $x_i<x_j$ is given by

$$4(a-2c_i)<3(a+c_i) \Leftrightarrow a<11c_i$$

Eq. (3) implies $a<11\underline{c}\leq 11c_i$. Therefore, the sufficiently small w satisfies $x_i(w)<x_j(w)$.

Now, suppose that $w=(a+c_i)/2<(a+c)/2$. Substituting $w=(a+c_i)/2$ into Eq. (6-3) and Eq. (7-3) yields

$$q_j=0<q_i=(a-2c_i)/(3b)$$

Note that $4q_i/3>q_j$ for $x_i>x_j$. Therefore, the condition that $x_i>x_j$ is given by

$$a>2c_i$$

Eq. (3) yields $2c_i<2c<a$. Therefore, the sufficiently large w satisfies $x_i(w)>x_j(w)$. From Eq. (8-1) and Eq. (8-2), as $x_i(w)$ is monotone increasing and $x_j(w)$ is monotone decreasing with respect to w, Lemma 2 is satisfied by intermediate value theorem.

Q.E.D.

[Figure 2 here]

By using Proposition 1 and Lemma 1 and 2, we get the following proposition which shows the comparative advantage of the Japanese procurement system.

Proposition 2*: Under Eq. (3), the equilibrium profit and output of the firm jA as well as the equilibrium investment amount of keiretsu supplier jS is larger than those of integrated firm i, that is.* $x_i^*<x_j^*$, $q_i^*<q_j^*$, *and* $\pi_i^*<\pi_{jA}^*$.

Proof)

To begin with, let us check the corner solution. As $w^*=0<\underline{w}$, $x_i^*<x_j^*$ by Proposition 3. If $x_i^*<x_j^*$, $c_i^*>c_j^*$. Proposition 1 and Eq. (5) give us that $c_j^*>w^*$ and $q_i^*<q_j^*$. Differentiating firm i's profit $\pi_i =(a-2c_i+w)^2/(9b)-x_i$ with respect to w gives[16]

$$\partial\pi_i/\partial w=2(a-2c_i+w)/(9b)-\{4(a-2c_i+w)c_i'/(9b)+1\}(dx_i/dw)=2q_i^*/3>0.$$

The above equation means that firm i's profit is monotone increasing in w. Meanwhile, if $w\in[0, \underline{w}]$, $\partial\pi_{jA}/\partial w<0$ by Eq. (9-2). Because $\pi_i(\underline{w})<\pi_{jA}(\underline{w})$ by Lemma 1, $\pi_i^*<\pi_i(\underline{w})<\pi_{jA}(\underline{w})=\pi_{jA}^*$.

[16] Noting Eq. (6-1) gives us that the second-term of RHS in the below equation is zero.

[Figure 3 here]

Next, let us check the interior solution. Note that if $w=\underline{w}$, $\underline{x}_i=\underline{x}_j$. Substituting $\underline{w}$ into the first-order condition yields

$$\partial\pi_{jA}/\partial w(w=\underline{w})=(-a-4\underline{w}-\underline{c}_i+6\underline{c}_j)/(9b) \\ +\{(2a-\underline{w}+2\underline{c}_i-3\underline{c}_j)/(9b)\}\underline{c}_i'(dx_i/dw)=0 \quad (13)$$

where $\underline{c}_i=c_i(x_i(\underline{w}))$. If Eq. (13)<0, $w^*<\underline{w}$ by Eq. (9-2). Noting that when $w=\underline{w}$, $\underline{x}_i=\underline{x}_j$ and $\underline{c}_i=\underline{c}_j$. Let us check the sign of Eq. (13) when $w=\underline{w}$. To begin with, substituting $\underline{w}=c_i(x_i)-(a-c_i(x_i))/10$ into the second term of Eq. (13) yields

$$2a-\underline{w}+2\underline{c}_i-3\underline{c}_j=2(a-\underline{c}_i)+(a-\underline{c}_i)/10+3(\underline{c}_i-\underline{c}_j)>0$$

It is worth noting that $c(x_i)<0$ and $dx_i/dw>0$. We also know that the second term of Eq. (13) is negative. Accordingly, the sufficient condition that Eq. (13)<0 when $w=\underline{w}$ is that the first term of Eq. (13) should be negative. Substituting $\underline{w}=c_i(x_i)-(a-c_i(x_i))/10$ into the first term of Eq. (13) yields

$$-a-4\underline{w}-\underline{c}_i+6\underline{c}_j=-a-4(\underline{c}_i-(a-\underline{c}_i)/10)-\underline{c}_i+6\underline{c}_j=-(3/5)[(a-\underline{c}_j)-9(\underline{c}_j-\underline{c}_i)]<0$$

Note that $\underline{c}_i=\underline{c}_j$ and $a>\underline{c}_j$. The sufficient condition that Eq. (13)<0 when $w=\underline{w}$ is satisfied. As $w^*<\underline{w}$, we obtain that $x_j(w^*)>x_i(w^*)$ and $c_j^*<c_i^*$ by Proposition 2. We also have the facts that $w^*<c_j^*$ and $q_j^*>q_i^*$ by Proposition 1 and Eq. (5), respectively. In the end, the fact that $\pi_i^*<\pi_i(\underline{w})<\pi_{jA}(\underline{w})<\pi_{jA}^*$ is satisfied.

Q.E.D.

[Figure 4 here]

5 Some Implications and Concluding Remarks

Under the circumstance in which the cost reduction investment occurs before the intermediate good is produced, we have analyzed which firm—either the internal procurement firm or the keiretsu procurement firm—would have a competitive advantage. The main results reveal that the keiretsu procurement firm possesses a predominantly competitive advantage in output, cost reduction investment, and profit. This can be explained as follows. The keiretsu procurement firm is able to acquire two instrument variables by separating its input division: one is the intermediate good price and the lump sum transfer. Hence, the keiretsu procurement firm can set the price of the intermediate good to be lower than the marginal production cost of its affiliated supplier. Such a low price of the intermediate good leads the keiretsu procurement firm to occupy a predominant position in Cournot competition of the final product market. As the price of the intermediate good reduces, the keiretsu procurement firm stands at a more predominant position in terms of quantity competition of the final product market. On the other hand, the lump sum transfer will compensate the supplier's provisional loss than the marginal production cost. Therefore, the pecuniary transfer works as a commitment device which enables the assembler to purchase the parts from its supplier at a low price.

The international competitiveness of Japanese automakers, originating from both moderate price and high quality of Japanese automobiles, has been created by the cooperative relationship between automaker and supplier as well as the supplier's high skill and ability. According to the study of Fujimoto (1997), such a cooperative relationship was established in the 1960s, whereas formerly it was an arm's length transaction. In this period, the Japanese economy was under the high growth, and consumer tastes began to get diversified, which compelled automakers to produce more volumes and to develop more models. However, as they lacked internal resources, they have no choice but to shift to training and utilizing the suppliers. In this way, Japanese automakers assisted their suppliers in financial, managerial, and technological aspects, by which the cooperative relationship was established. Under this relationship, the supplier aggressively made investments in terms of relational physical assets and human resources. It is worth noting that the automaker's support to its suppliers plays a role of commitment in the transaction to solve the hold-up problem. Therefore, this support can be regarded as "hostage" as termed by Williamson (1985).

On the other hand, American automakers did not conceptualize the idea of training the suppliers and making efficient use of their suppliers. The in-house procurement is similar to an arm's length transaction procured from the competitive market with respect to being independent from the suppliers. Even towards the end of the 1980s, American automakers carried out the parts development and design by themselves. For instance, GM produced a considerable amount of the parts in-house. As long as American automakers compete within domestic fringes, the procurement system does not reveal any drawbacks. However, once they were faced with competition from Japanese automakers, they were outdone in price competition. Although American automakers have started introducing and incorporating many aspects of the Japanese system into their own, this adoption cannot be deemed as successful.

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Figure 1 : Investment and Marginal Cost

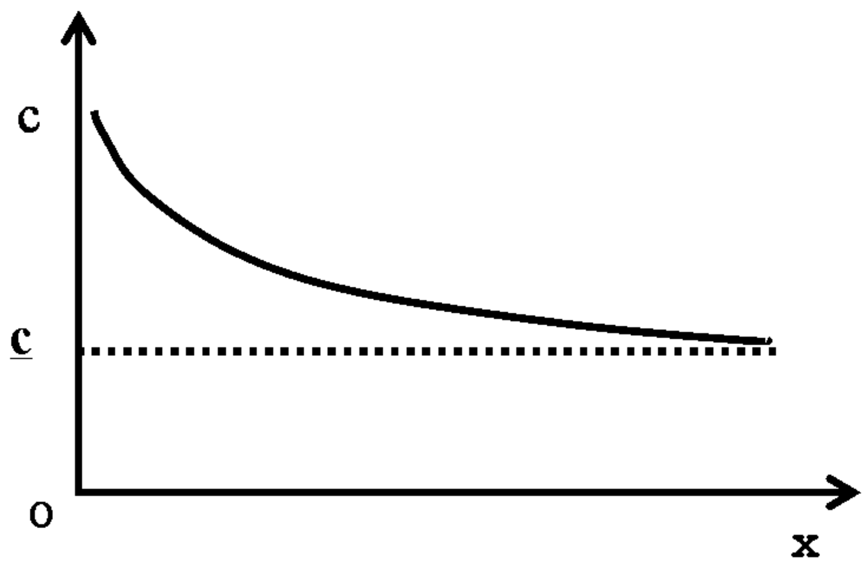

Figure 2 : Existence of $\underline{w}$

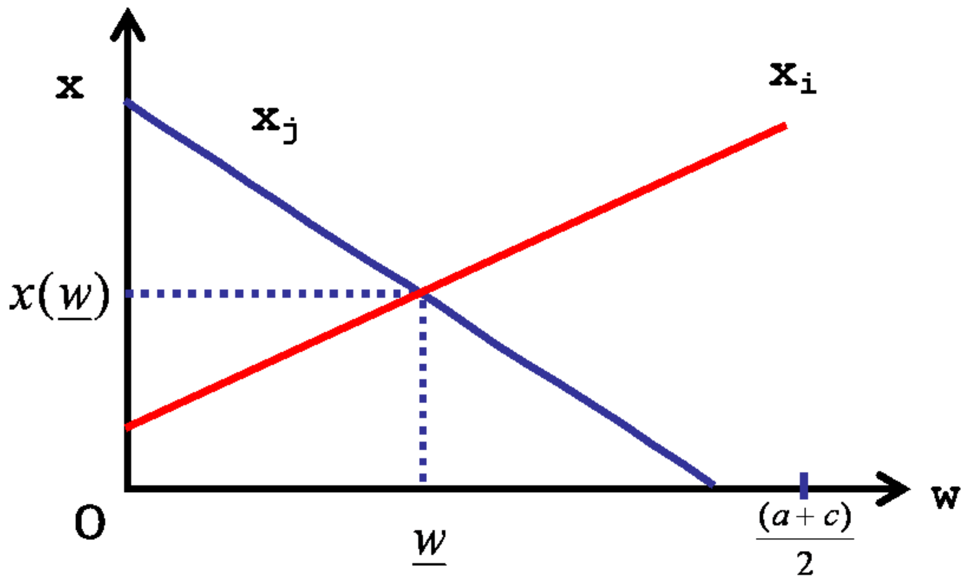

Figure 3 : Corner Solution

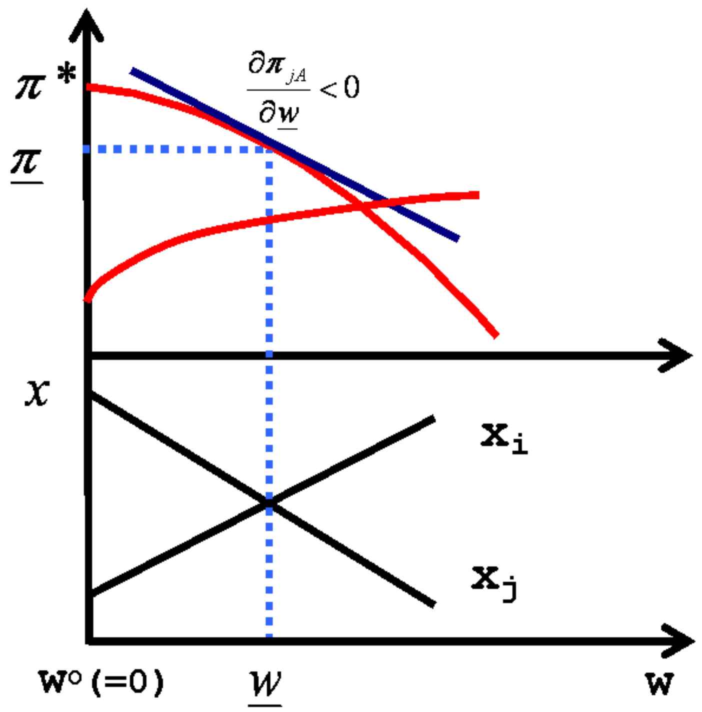

Figure 4 : Interior Solution