The Effect of In-house Procurement on Input and Output Markets

Yonghoon Choi[1], DongJoon Lee[2], Tatsuhiko Nariu[3]

ABSTRACT

We consider a vertically related market in which manufacturers (e. g., Apple, HP, Dell, and Lenovo, and so on) produce a homogenous product by assembling a key input (e. g., a CPU) from a common supplier (e.g., Intel) and the other inputs (e. g., monitors, memory chips, and keyboards, and so on) from their dedicated suppliers. We study the effects of in-house procurement of the key input on input and output markets. We show that every supplier and manufacturer, except the common supplier, can earn greater profits through in-house procurement of the key input compared to using a common supplier, provided that the marginal production cost of the key input is not excessively high under in-house procurement. We also show that when a manufacturer chooses in-house procurement, every dedicated supplier will increase its input prices. This is why Apple began transitioning its entire Mac product line to in-house processors rather the Intel's CPUs.

Key Words: In-house Procurement, Common Supplier Procurement, Relative Cost Effect, Cost-saving Effect

JEL Classification: D43, L13, L22, M21

---

[1] Faculty of Commerce, Doshisha University, Karasuma-Imadegawa, Kamigyo-ku, Kyoto 602-8580, Japan. (e-mail: ychoi@mail.doshisha.ac.jp).

[2] Faculty of Economics, Osaka Sangyo University, 3-1-1, Nakagaido, Daito, Osaka 574-8530, Japan. (e-mail: dongjoon@eco.osaka-sandai.ac.jp). Graduate School of Management, Nagoya University of Commerce & Business, 1-3-1, Nishiki, Naka-ku, Nagoya, Aichi 463-0003, Japan. (e-mail: dongjoon@nucba.ac.jp).

[3] Graduate School of Business, Doshisha University, Karasuma-Imadegawa, Kamigyo-ku, Kyoto 602-8580, Japan. (e-mail: tnariu@mail.doshisha.ac.jp).

The Effect of In-house Procurement on Input and Output Markets

1. Introduction

In 2020, Apple announced that it would begin transitioning its entire Mac product line to in-house ARM-based processors from the Intel X86 CPUs that it has been using for the past 15 years. In November of that year, Apple released the first Macs with an ARM-based M1 chip, including the 13-inch MacBook Pro, MacBook Air, and Mac mini models. In early 2021, Apple also released the M1 iMac and the M1 iPad Pro. The M1 chip, which is the culmination of more than a decade of work by Apple on chips for the iPhone and the iPad, has received rave reviews for its incredible performance and efficiency. This was the first Apple-designed system on a chip to be developed for use in Macs, and marked Apple's first step toward transitioning away from the Intel chips that the company had been using since 2006.

In this study, we bridge the gap between theory and reality by examining the effect of in-house procurement on input and output markets. Our motivation is to explain why manufacturing firms are increasingly seeking independent suppliers instead of relying on strong suppliers with whom they have long-standing strategic alliances. Another aim is to theoretically to examine the effect of in-house procurement on input and output markets.

We develop a game theoretic model in which two manufacturers produce a homogenous product, each assembling two components from their own independent supplier and from a common supplier. Our study examines the effects of the key input's in-house procurement on both input and output markets. Our main results are as follows. First, every manufacturer and supplier, except a common supplier, can earn greater profits through in-house procurement of the key input compared to using a common supplier, provided that the marginal production cost of the key input is not excessively high under in-house procurement.[4] Second, when a manufacturer chooses in-house procurement, every dedicated supplier will increase its input prices. From the standpoint of consumer surplus, the in-house procurement case is more efficient than the common supplier case if the marginal production cost of the in-house manufacturer is not too high.

The rest of this paper is organized as follows. In Section 2, we review the related studies. In Section 3, we introduce the model. Section 4 discusses the correspond analyses. Section 5 presents the main results. Finally, we conclude this paper and discuss extension and future research in Section 6.

2. Literature Review

Previous studies on profit-enhancing market entry can be summarized as follows. When a monopolistic input supplier exists, and there is quantity competition in the downstream market, Tyagi (1999) demonstrates that entry into the final goods market is likely to raise profits if the demand

[4] Note that the marginal production cost for common supplier is zero.

function is sufficiently convex. Similarly to our paper, Tyagi (1999) noted that market entry has two main effects: a competition effect and an input-price effect. However, the input-price effect in his study differed sharply to that in our study. Due to the competition effect, entry reduces the outputs of the incumbents, but increases total outputs for a given price, thereby lowering the profits of the incumbents. Meanwhile, entry increases input demand. Thus, a monopolistic input supplier will increase the input price if the derived input demand comes from a sufficiently convex final goods demand. Considering free entry into the input market and assuming homogenous final goods, Matsushima (2006) demonstrated that entry into the final goods market increases industry profits but reduces the profits of the incumbent final goods producers. His result is attributed to the assumption of homogenous goods. Nariu et al. (2021) examined a vertical oligopoly model in which each manufacturer produces a differentiated final product by assembling n components provided by its dedicated suppliers. They found that when the initial number of manufacturers is sufficiently smaller than the number of input suppliers, entry into the final product market increases the profits of every firm. Our model is similar to that of Nariu et al. (2021), except that we assume a homogenous final product and consider only two types of input suppliers. Matsushima and Mizuno (2012) demonstrated that increased competition in the upstream market motivates downstream firms to invest in R&D. Thus, when the upstream market becomes more competitive, upstream firms can earn greater profits. Mukherjee (2019) also extended Matsushima (2006) by assuming differentiated goods. He showed that entry into the downstream market increases the profits of the incumbent producers if there is free entry in the input market and the goods are sufficiently differentiated. Mukherjee et al. (2009) also found profit-enhancing entry in situations involving asymmetric final goods producers. Profit-enhancing entry can occur due to other factors as well, such as Stackelberg leader-follower situation (Pal and Sakar, 2001; Mukherjee and Zhao, 2017), vertical product differentiation and heterogenous consumer groups (Ishibashi and Matsushima, 2009), and R&D innovation by cost-asymmetric firms (Ishida et al., 2011).

In short, our results are similar to those of previous studies focusing on profit-raising entry (Tyagi (1999), Matsushima (2006), Mukherjee and Zhao (2017), Ishida et al. (2011), Matsushima and Mizuno (2012)), even though the motivations of those studies are quite different from ours. While those studies examined the effect of profit-enhancing competitive pressure, they did not examine how or why manufacturers cope with the monopolistic power of the common supplier, which is the focus of our study.

3. The Model

We consider a vertical supply chain in which each manufacturer ($i = 1, 2$) has the same Leontief technology, in which producing one unit of final product requires two different kinds of input. Each manufacturer purchases one input from its dedicated supplier and purchases the other input, referred to as the "key input," from a common supplier who initially sells it to both manufacturers.[5] Additionally, one manufacturer may produce the key input in-house, perhaps by establishing its own input department or by integrating an input supplier. For example, Apple acquired the modem business from Intel, a common supplier, and in November 2020, it released the first Mac notebook with an M1 chip instead of Intel's CPU. For the sake of expositional and analytic simplicity, our model assumes that the common supplier is more efficient than the new entrant.[6]

Without loss of generality, we assume that $c \in (0, a)$ represents the marginal cost of production for the entrant who produces the key input. The marginal cost of production for each type of supplier is as follows: we denote c_i and c_0 as the marginal cost of production for the dedicated supplier and common supplier, respectively. For simplicity, we assume that c_i and c_0 are normalized to zero. Furthermore, no additional costs are required for transforming the inputs into the final product. We also denote w_i and w_0 as the input prices set by dedicated supplier i and the common supplier, respectively. Therefore, in the case of common supplier, the marginal cost for manufacturer i is $w_i + w_0$, and in the case of in-house procurement, it is $w_i + c$.

The inverse demand function is given by[7]

$$p = a - Q, \tag{1}$$

where p is the final price and $Q = q_i + q_j$ is the total output. We posit a two-stage game. In stage one, each dedicated supplier and the common supplier choose their input prices (w_i, w_j, w_0). Finally, in stage two, each manufacturer chooses its output (q_i, q_j). We derive the subgame perfect Nash equilibrium through backward induction.

4. Analysis

In this section, we examine two cases. One is the common supplier case in which both manufacturers procure the key input from a common supplier. The other is the in-house procurement case in which one manufacturer chooses in-house production of the key input instead of procuring from the common supplier.

4-1. Common Supplier Case

As a benchmark, we first consider the common supplier case in which both manufacturers purchase the key input from a common supplier.

---

[5] In Section 3, we examine two cases: a common supplier case and an in-house procurement case. In the former, both manufacturers procure the key input from the common supplier, while the latter, one manufacturer produces the key input in-house, while the other procures the key input from the common supplier.

[6] See Arya et al. (2007).

[7] We assume that both products are homogenous. One is wondering that high-end PCs are differentiated from low-end PCs by Intel's advertisements. But, the degree of differentiation is relatively low among high-end PCs.

[Figure 1 about here]

In stage 2, manufacturer i chooses its output q_i to maximize its profit, given the input prices (w_i, w_0) and its rivals' output q_j. Its maximization problem is

$$\max\ \pi_i = (p - w_i - w_0)q_i = \left(a - q_i - q_j - w_i - w_0\right)q_i, \quad \text{w. r. t. } q_i. \tag{2}$$

From the first-order condition, we obtain the reaction function as follows:

$$q_i = \frac{a - q_j - w_i - w_0}{2}, \qquad i, j = 1, 2, i \neq j. \tag{3}$$

Solving Eq. (3), we obtain the equilibrium output as follows:

$$q_i = \frac{a - 2w_i + w_j - w_0}{3}, \qquad i, j = 1, 2, i \neq j. \tag{4-1}$$

Substituting Eq. (4-1) into Eq. (1) and Eq. (2), we obtain the equilibrium price and profit as follows:

$$p = \frac{a + w_i + w_j + 2w_0}{3}, \tag{4-2}$$

$$\pi_i = \left(\frac{a - 2w_i + w_j - w_0}{3}\right)^2. \tag{4-3}$$

In the first stage, each dedicated supplier and the common supplier choose their own input prices $\left(w_i, w_j, w_0\right)$ to maximize their profits $\left(\Pi_i, \Pi_j, \Pi_0\right)$, given their rivals' input prices. Dedicated supplier i's maximization problem is given by

$$\max\ \Pi_i = w_i q_i = w_i\left(\frac{a - 2w_i + w_j - w_0}{3}\right), \quad \text{w. r. t. } w_i. \tag{5}$$

From the first-order condition, we obtain the reaction function of dedicated supplier i as follows:

$$w_i = \frac{a + w_j - w_0}{4}. \tag{6}$$

Note that w_i is a strategic complement to w_j, but is a strategic substitute for w_0.

Conversely, the maximization problem for the common supplier is as follows:

$$\max\ \Pi_0 = w_0 Q = w_0\left(\frac{2a-w_i-w_j-2w_0}{3}\right),\quad \text{w. r. t. } w_0. \tag{7}$$

From the first-order condition, we obtain the reaction function as follows:

$$w_0 = \frac{2a-w_i-w_j}{4}. \tag{8}$$

Note that w_0 is a strategic substitute for w_i and w_j. By solving Eq. (6) and Eq. (8), we can obtain the equilibrium input prices as follows:

$$w_i^C = w_j^C = \frac{a}{5} \text{ and } w_0^C = \frac{2a}{5}, \tag{9}$$

where the superscript "C" denotes the common supplier case. From Eq. (9), we know that the marginal costs for each manufacturer are $3a/5$. Suppose that a monopolistic supplier provides both inputs to manufacturers. The marginal costs for manufacturers are $a/2$. Therefore, the marginal costs are higher under common supplier case than under monopolistic supplier case.

We solved the game for the common supplier case through backward induction. The equilibrium outcomes in the common supplier case are summarized in Table 1.

Table 1: Equilibrium outcomes in common supplier case

	Manufacturers		Suppliers		
	i	j	i	j	common
q^C	$\frac{2a}{15}$	$\frac{2a}{15}$	$\frac{2a}{15}$	$\frac{2a}{15}$	$\frac{4a}{15}$
p^C	$\frac{11a}{15}$				
w^C			$\frac{a}{5}$	$\frac{a}{5}$	$\frac{2a}{5}$
π^C or Π^C	$\frac{4a^2}{225}$	$\frac{4a^2}{225}$	$\frac{2a^2}{75}$	$\frac{2a^2}{75}$	$\frac{8a^2}{75}$

4-2. In-house Procurement Case

In this subsection, we consider the in-house procurement case in which one manufacturer produces the key input in-house, while the other manufacturer procures it from the common supplier. Without loss of generality, we assume that manufacturer i produces the key input in-house while manufacturer j purchases it from the common supplier.[8]

[Figure 2 about here]

In this case, note that $c \in (0, a)$ denotes the marginal cost of production for manufacturer i to produce one unit of the key input. This means that the common supplier has a production advantage, which could be attributed to its superior technology in the production process. In stage 2, manufacturer i chooses its output q_i to maximize its profits, given the input price w_i and its rivals' output q_j. Its maximization problem is given by

$$\max\ \pi_i = (p - w_i - c)q_i = \left(a - q_i - q_j - w_i - c\right)q_i, \quad \text{w. r. t. } q_i. \tag{10}$$

From the first-order condition, we obtain the reaction function for manufacturer i as follows:

$$q_i = \frac{a-c-w_i-q_j}{2}, \tag{11}$$

Note that the maximization problem for manufacturer j is the same as that in the common supplier case. Therefore, we obtain the same result in stage two as in the common supplier case (refer to Eq. (3)). We can obtain the equilibrium output by solving Eq. (3) and Eq. (11), as follows:

$$q_i = \frac{a-2c-2w_i+w_j+w_0}{3}, \tag{12-1}$$

$$q_j = \frac{a+c+w_i-2w_j-2w_0}{3}. \tag{12-2}$$

Comparing Eq. (4-1) with Eq. (12-1), we see that in Eq. (4-1), q_i decreases with w_0, whereas in Eq. (12-1), q_i increases with w_0. Furthermore, if $c \geq w_0$, then Eq. (4-1)≥Eq. (12-1). We also obtain the equilibrium price and manufacturers' profits as follows:

$$p = \frac{a+c+w_i+w_j+w_0}{3}, \tag{12-3}$$

[8] One may wonder if when manufacturer i produces the key input in-house, the common supplier could become a dedicated supplier for manufacturer j. If we incorporate a channel organized between a manufacturer and a dedicated supplier into our model, the common supplier remains unchanged. Furthermore, our findings remain unchanged in a three-channel model.

$$\pi_i = \left(\frac{a-2c-2w_i+w_j+w_0}{3}\right)^2, \tag{12-4}$$

$$\pi_j = \left(\frac{a+c+w_i-2w_j-2w_0}{3}\right)^2. \tag{12-5}$$

In the first stage, each dedicated supplier and the common supplier choose their own input prices (w_i, w_j, w_0) to maximize their profits (Π_i, Π_j, Π_0), given their rivals' input prices. The maximization problem for dedicated supplier i is given by

$$\max\ \Pi_i = w_i q_i = w_i \left(\frac{a-2c-2w_i+w_j+w_0}{3}\right), \quad \text{w. r. t. } w_i. \tag{13}$$

From the first-order condition, we can obtain the reaction function as follows:

$$w_i = \frac{a-2c+w_j+w_0}{4}. \tag{14}$$

Conversely, the maximization problem for dedicated supplier j is given by

$$\max\ \Pi_j = w_j q_j = w_j \left(\frac{a+c+w_i-2w_j-2w_0}{3}\right), \quad \text{w. r. t. } w_j. \tag{15}$$

From the first-order condition, we can obtain the reaction function as follows:

$$w_j = \frac{a+c+w_i-2w_0}{4}. \tag{16}$$

Finally, the maximization problem for common supplier is as follows:

$$\max\ \Pi_0 = w_0 q_j = w_0 \left(\frac{a+c+w_i-2w_j-2w_0}{3}\right), \quad \text{w. r. t. } w_0. \tag{17}$$

From the first-order condition, we can obtain the reaction function as follows:

$$w_0 = \frac{a+c+w_i-2w_j}{4}. \tag{18}$$

By solving Eq. (14), Eq. (16), and Eq. (18), we can obtain the equilibrium input prices as follows:

$$w_i^I = \frac{4a-5c}{11},\ w_j^I = \frac{5a+2c}{22} \text{ and } w_0^I = \frac{5a+2c}{22}, \tag{19}$$

where the superscript "I" denotes the in-house procurement case, where manufacturer i produces the key input in-house, while manufacturer j procures the key input from the common supplier.

We solved the game for the in-house procurement case through backward induction. The equilibrium outcomes for the in-house procurement case are summarized in Table 2.

Table 2: Equilibrium outcomes in in-house procurement case

	Manufacturers		Suppliers		
	i	j	i	j	common
q^I	$\frac{2(4a-5c)}{33}$	$\frac{(5a+2c)}{33}$	$\frac{2(4a-5c)}{33}$	$\frac{(5a+2c)}{33}$	$\frac{(5a+2c)}{33}$
p^I	$\frac{4(5a+2c)}{33}$				
w^I			$\frac{4a-5c}{11}$	$\frac{5a+2c}{22}$	$\frac{5a+2c}{22}$
π^I or Π^I	$\frac{4(4a-5c)^2}{1089}$	$\frac{(5a+2c)^2}{1089}$	$\frac{2(4a-5c)^2}{363}$	$\frac{(5a+2c)^2}{726}$	$\frac{(5a+2c)^2}{726}$

5. Results

In the previous section, we analyzed both the common supplier case and the in-house procurement case. In this section, we will present our results by comparing the two equilibria. To guarantee that all possible variables are positive in equilibrium, we make the following assumption. Specifically, this assumption takes the following form:[9]

$$c \in \left(0, \frac{4}{5}a\right). \tag{A}$$

First, we examine whether manufacturer i will produce the key input in-house or not. By comparing Table 1 and 2, we can obtain the following results:

[9] When manufacturer i's cost inefficiency is sufficiently large, its output will be zero in the in-house procurement case. We can easily check it from Table 2.

$$\pi_i^I - \pi_i^C = \frac{4(9a-25c)(31a-25c)}{27225} \geq 0 \text{ if } c \in \left(0, \frac{9}{25}a\right),\ \pi_j^I - \pi_j^C = \frac{(3a+10c)(47a+10c)}{27225} \geq 0.$$

Proposition 1 summarizes the results obtained thus far.

Proposition 1 When $c \in (0, 9a/25)$, manufacturer i chooses to procure the key input in-house. Moreover, the profit of manufacturer j is also greater under the in-house procurement case than under the common supplier case.

Proposition 1 can be explained as follows. Let us begin with two factors that affect the manufacturers' profits. Transitioning from the common supplier case to the in-house procurement case will affect the profits of manufacturer i through two key elements. The first element is the relative cost effect, which can be measured as the difference in total marginal costs between the two manufacturers under in-house procurement. Specifically, for manufacturer i, the cost advantage depends on whether the expression $\left(c + w_i^I\right) - \left(w_0^I + w_j^I\right)$ is positive or not. The second element is the cost-saving effect, which can be also expressed as the difference in total marginal costs of each manufacturer between the common supplier case and the in-house procurement case. Specifically, for manufacturer i, the cost-saving effect depends on whether the expression $\left(c + w_i^I\right) - \left(w_0^C + w_i^C\right)$ is positive or not, and for manufacturer j, it depends on whether the expression $\left(w_0^I + w_j^I\right) - \left(w_0^C + w_i^C\right)$ is positive or not. What happens when the total marginal costs of the two manufacturers are same? Suppose that the two manufacturers have identical marginal costs in the case of in-house procurement. When the marginal costs of both parties are the same, there is no relative cost effect between them.[10] Let's take a benchmark and compare the profits of manufacturer i in both cases, when $c = a/4$ with a relative cost effect of zero. By directly comparing of Eq. (9-4) and Eq. (19-4), we can obtain the following result:

$$\pi_i^I\big|_{c=a/4} - \pi_i^C\big|_{c=a/4} = \frac{a^2}{100} > 0.$$

Note that manufacturer $i(j)$'s profits decrease (increase) as the marginal production cost of the key input,c, increases. Next, let's compare the profits of manufacturer i when $c = \frac{9a}{25}$. By directly comparing of Table 1 and 2, we can also obtain the following results:

$$\pi_i^I\big|_{c=\frac{9a}{25}} - \pi_i^C\big|_{c=\frac{9a}{25}} = 0.$$

[10] In other words, we obtain that when $c = a/4$, $c + w_i^I = w_j^I + w_0^I$ from Eq. (19-1).

Finally, let's compare the profits manufacturer j when $c = 0$. By making a direct comparison of Eq. (9-4) and Eq. (19-4), we can obtain the following results:

$$\pi_j^I\big|_{c=0} - \pi_j^C\big|_{c=0} = \frac{47a^2}{9075} > 0.$$

We explained two factors that affect the manufacturers' profits. The two factors are summarized in Table 3.

Table 3: Two factors affecting manufacturers' profits

	Manufacturer i			Manufacturer j		
	Relative Cost Effect $(c + w_i^I) - (w_0^I + w_j^I)$	Cost-saving Effect $(w_0^C + w_i^C) - (c + w_i^I)$	Total Effect	Relative Cost Effect $(w_0^I + w_j^I) - (c + w_i^I)$	Cost-saving Effect $(w_0^C + w_i^C) - (w_0^I + w_j^I)$	Total Effect
$c = 0$	$\frac{a}{11}$	$\frac{13a}{55}$	$\frac{18a}{55}$	$-\frac{a}{11}$	$\frac{8a}{55}$	$\frac{3a}{55}$
$c \in \left(0, \frac{a}{4}\right)$	$\frac{(a-4c)}{11}$	$\frac{(13a-30c)}{55}$	$\frac{2(9a-25c)}{55}$	$-\frac{(a-4c)}{11}$	$\frac{2(4a-5c)}{55}$	$\frac{(3a+10c)}{55}$
$c = \frac{a}{4}$	0	$a/10$	$a/10$	0	$a/10$	$a/10$
$c \in \left(\frac{a}{4}, \frac{9a}{25}\right)$	$\frac{(a-4c)}{11}$	$\frac{(13a-30c)}{55}$	$\frac{2(9a-25c)}{55}$	$-\frac{(a-4c)}{11}$	$\frac{2(4a-5c)}{55}$	$\frac{(3a+10c)}{55}$
$c = \frac{9a}{25}$	$-\frac{a}{25}$	$\frac{a}{25}$	0	$\frac{a}{25}$	$\frac{2a}{25}$	$\frac{3a}{25}$

Next, we will compare the profits of suppliers. By comparing Table 1 and 2, we can obtain the following results:

$$\Pi_i^I - \Pi_i^C = \frac{2(9a-25c)(31a-25c)}{9075} \geq 0 \text{ if } c \in \left(0, \frac{9}{25}a\right),\ \Pi_j^I - \Pi_j^C = \frac{(3a+10c)(47a+10c)}{18150} \geq 0, \text{ and}$$

$$\Pi_0^I - \Pi_0^C = -\frac{(19a-10c)(69a+10c)}{18150} < 0.$$

Proposition 2 summarizes the results obtained thus far.

Proposition 2 When $c \in \left(0, \frac{9}{25}a\right)$, the suppliers' profits entail that:

(1) The profits of dedicated supplier i are higher under the in-house procurement case than under the common supplier case;

(2) In addition, the profits of dedicated supplier j are also higher under the in-house procurement case than under the common supplier case;

(3) However, the profits of common supplier are always lower under the in-house procurement case compared to the common supplier case.

Proposition 2 can be explained as follows. It is obvious that in-house procurement leads to a reduction in the common supplier's profit due to the downward shift in the derived demand facing the common supplier. Additionally, as the profits of dedicated suppliers are positively correlated with their input prices, we can easily understand that dedicated suppliers' profits are higher under the in-house procurement case than under the common supplier case.[11]

Next, we will compare the input prices of suppliers. By comparing Eq. (9) and Eq. (19), we can obtain the following results:

$$w_0^I - w_0^C = -\frac{19a-10c}{110} < 0,\ w_i^I - w_i^C = \frac{9a-25c}{55} > 0 \text{ for } c \in \left(0, \frac{9}{25}a\right),\ w_j^I - w_j^C = \frac{3a+10c}{110} > 0.$$

Proposition 3 summarizes the results obtained thus far.

Proposition 3 The equilibrium input prices entail that:

(1) The input price of common supplier, denoted as w_0, is lower under the in-house procurement case than under the common supplier case;

(2) If $c \in (0, 9a/25)$, then the input price of supplier i, denoted as w_i, is higher under the in-house procurement case than under the common supplier case;

(3) Regardless of the value of c, the input price of supplier j, denoted as w_j, is higher under the in-house procurement case than under the common supplier case.

Proposition 3 can be explained as follows. Let us start with the input price set by considering the input

[11] For details, see Proposition 3.

price set by the common supplier. If manufacturer i switches from the common supplier case to the in-house procurement case, then the derived demand for the common supplier will shift downwards. This means that the key input price will be lower under the in-house procurement case compared to the input price offered by the common supplier case. Next, we turn to the input price of dedicated supplier j in both the common supplier case and the in-house procurement case. Since we already know that $w_0^I < w_0^C$ and the input price offered by dedicated supplier j is a substitute for the input price offered by the common supplier, then dedicated supplier j will increase its input price in the in-house procurement case. Finally, we turn to the input price offered by dedicated supplier i in both the common supplier case and the in-house procurement case. The input price (w_i) offered by supplier i is a substitute for the marginal production cost (c) of key input produced by manufacturer i. In contrast, it is complementary to the input prices (w_j, w_0) offered by dedicated supplier j and the common supplier.[12] Therefore, the input price of dedicated supplier i is a trade-off between the marginal production cost of manufacturer i, c, and its rivals' input prices, (w_j, w_0). Therefore, if the marginal cost of production for manufacturer i is not sufficiently large, dedicated supplier i increases its input price, and vice versa.

From Table 1 and 2, we get $p^I - p^C = -\frac{21a-40c}{165} < 0$, if $c < 21a/40$ (and similarly $Q^C - Q^I = -\frac{21a-40c}{165} < 0$, where $Q = q_i + q_j$, if $c < 21a/40$), which are negative. Quantities (prices) are larger (lower) under the in-house procurement case than under the common supplier case, if the marginal production cost (c) of key input produced by manufacturer i is not sufficiently large. In other words, when the marginal production cost of manufacturer i is not sufficiently large, the market is more monopolistic under the common supplier case than under the in-house procurement.

Let us compare consumer surplus in both cases. A straightforward comparison of consumer surplus in both the common supplier case and the in-house procurement case yields the following results:

$$CS^I - CS^C = \frac{(21a-40c)(109a-40c)}{54450} \geq 0 \text{ if } c \in \left(0, \frac{21}{40}a\right).$$ [13]

Proposition 4 summarizes the results obtained thus far.

Proposition 4 Outputs (prices) and Consumer surplus are larger (lower) under the in-house procurement case than under the common supplier case, if the marginal production cost for manufacturer i is not sufficiently high.

---

[12] See Eq. (14). Conversely, from Eq. (6) of the common supplier case, note that the input price is substitutable for the key input price, but it is complementary to the input price of dedicated supplier j.

[13] We can easily check the consumer surplus from $CS^I - CS^C = \int_0^{Q^I} p\, dQ - p^I Q^I - \left(\int_0^{Q^C} p\, dQ - p^C Q^C\right)$.

Proposition 4 can be explained as follows. Lower prices and larger outputs are always in welfare terms. Consumer surplus is decreasing and convex as a function of prices. Therefore, in terms of consumer surplus, the in-house procurement case dominates the common supplier case, when $c \in (0, 21a/40)$.

6. Conclusion and Extension

The more competitive the market is, the lower the price tends to be while demand remains unchanged. In this study, we developed a vertical structure to analyze the interactions between manufacturers and their suppliers. The structure involves manufacturers producing a homogenous product by assembling two components, one supplied by a common supplier and the other by a dedicated supplier. This structure allows us to examine how different procurement strategies, such as in-house production versus procurement from a common supplier, affect input prices, quantities, profits for manufacturers and suppliers, and consumer surplus. Our study revealed that the entry of a manufacturer into a common input market has significant implications for profitability of firms in the industry. Specifically, we found that when a manufacturer enters the market, every supplier except the common supplier and every manufacturer may earn greater profits. We also showed that when a manufacturer enters into the common input market, every input supplier except the common supplier increases its input prices.

One is wondering what will happen if the number of manufacturers increases. The intuition behind this paper is as follows. Suppose that a manufacturer procures a key input in-house instead of from a common supplier. This will cause the derived demand for the common supplier to shift downwards, resulting in a lower key input price. However, each dedicated supplier will then increase its input price compared to if the manufacturer had procured the key input from the common supplier. As a result, our findings remain unchanged if the former effect dominates the latter effect. We assume that the final product is homogenous in this analysis. One is also wondering what will happen if both products are differentiated. Suppose that both products are completely differentiated. If so, this paper examines a model in which a monopoly manufacturer enters a common input market. We can easily understand that our findings will not be changed. We focused on a linear input pricing between each dedicated supplier and each manufacturer. One is wondering what will happen if the manufacturer proposes a two-part tariff pricing which combines an input price with a fixed fee. An extension of our model in these directions is left for future research.

Reference

Arya, A., B. Mittendorf, and D. Sappington (2007), "The Bright Side of Supplier Encroachment," ***Journal of Marketing Science***, Vol. 26, pp. 651-659.

Ishibashi, I. and N. Matsushima (2009), "The existence of Low-end Firms may help High-end Firms,"

Journal of Marketing Science, Vol. 28, pp. 136-147.

Ishida, J., T. Matsumura, and N. Matsushima (2011), "Market Competition, R&D and Firm Profit in Asymmetric Oligopoly," ***Journal of Industrial Economics***, Vol. 59, pp. 484-505.

Matsushima, N. (2006), "Industry Profits and Free Entry in Input Markets," ***Economics Letters***, Vol. 93, pp. 329-336.

Matsushima, N. and T. Mizuno (2012), "Profit-enhancing Competitive Pressure in Vertically Related Industries," ***Journal of Japanese and International Economies***, Vol. 26, pp.142-152.

Mukherjee, A., U. Broll, and S. Mukherjee (2009), "The Welfare Effects of Entry: the role of the input market," ***Journal of Economics***, Vol. 98, pp. 189-201.

Mukherjee, A. and L. Zhao (2017), "Profit Raising Entry," ***Journal of Industrial Economics***, Vol. 57, pp. 214-219.

Mukherjee, A. (2019), "Profit Raising Entry in a Vertical Structure," ***Economics Letters***, Vol. 183, 108543.

Nariu, T., D. Flath, and M. Okamoto (2021), "A Vertical Oligopoly in which Entry Increases Every Firm's Profit," ***Journal of Economics and Management Strategy***, Vol. 30, pp. 684-694.

Pal, D. and J. Sarkar (2001), "A Stackelberg Oligopoly with Nonidentical Firms," ***Bulletin of Economic Research***, Vol. 53, pp. 127-134.

Tyagi, R.K. (1999), "On the Effects of Downstream Entry," ***Management Science***, Vol. 45, pp. 59-71.

Figure 1: Common Supplier Case

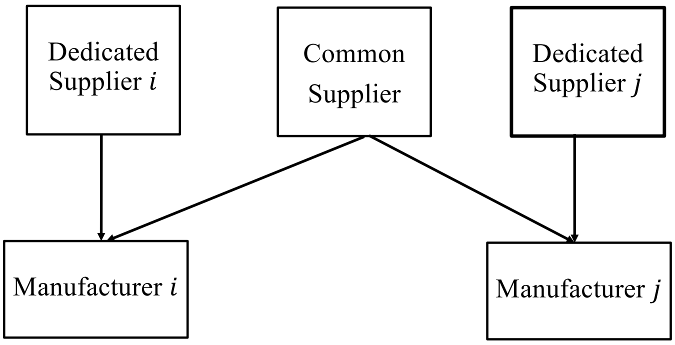

Figure 2: In-house Procurement Case