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https://doi.org/10.15017/4493039

出版情報：經濟學研究. 57 (5/6), pp.121-129, 1992-09-10. 九州大学経済学会
バージョン：
権利関係：

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ABSTRACT

We consider the influence of the existence of a transaction-specific investment on a transaction relationship under a duopoly market. In a buyer-supplier paradigm a supplier often tries to make an investment to raise the trade profit. The investment may be transaction-specific. This implies that the supplier cannot appropriate all the increase of the trade profit due to the investment. As a result, the level of the supplier's investment may be inefficient. We investigate the optimal level of the transaction-specific investment under a duopoly market. Since the transaction-specific investment problem under a duopoly market has so far hardly been considered, it is interesting to investigate the issue. We show that the specific investment may be less than in a competitive market.

Introduction

Many economic relationships are said to receive the trade benefit by making an investment in relationship-specific assets. In a trade of intermediates goods, suppliers and purchasers may receive the benefit by buying a machine specifically adapted to the needs of the other. Once one party has made a specific investment, there is possible for the other to bargain away some of the trade benefit from the investment because they have become essential to realize the benefit. If the investing party cannot get all the benefit from the investment, the level of investment may be inefficient. This is insisted on by O. Williamson (1985), Klein, Crawford and Alchian (1978), and Grout (1984).

The first point we consider here is the problem of an optimal selection between specific investment and general one, that is, the optimal degree of transaction-specificity of investment. There is a trade off in making more specific investment. More specific investment brings more benefit of trade, but weaker bargaining power to the investing party. Therefore the determination of the optimal specificity of the investment is meaningfull. The second point is to consider this specific investment problem under a duopoly market. So far this problem has been analyzed explicitly or implicitly under a bilateral monopoly. We introduce two groups of supplier-buyer. In each group a supplier makes investment to lower his production cost before bargaining over trade conditions with his partner (a buyer). As we said, his power of the bargaining with the buyer over the trade conditions depends on the level of the investment. However, his bargaining power also depends on the level of the investment by a supplier in another group. The more the specific investment in one group is made, the weaker the bargaining power of the investing party in the other group may be. Therefore the specific investment has an external effect. This may lead to under-investment.

1 A Basic Model

We have two group of supplier-buyer. Each one may be called group $i(i=1, 2)$ (or "Keiretu"). A group consists of a supplier and a buyer. Each supplier can make two types of investments to realize a production. One is called a general investment, which has no specificity effect. The other is called a specific investment. Both investments have a reduction effect on marginal production cost. The difference between both investments is that the reduction effect of the specific investment vanishes in a trade with an outsider. For a non-specific investment I and a specific one s, we assume that each supplier has marginal production $C(s)F(I)$ and investment cost $K(s)I$, where

$$C'<0,\ C''>0,\ F'<0,\ F''>0,\ K'<0,\ K''>0,\ C(0)=1,\quad K(0)=1.$$

We also assume that the minimum level I_0 of general investment is necessary for production. While in a group the marginal production cost is $C(s)F(I)$, it increases to $F(I)$, out of the group.

On the other hand a buyer has a value for the goods which a supplier produced. However the value is uncertain. In each group, the transaction process between both parties is assumed as follows. There are two periods: $t=1$ (ex ante) and $t=2$ (ex post). In the first period supplier makes two kinds of investment. His investments are observable to the buyer but unverifiable. Hence, the level of investment itself is not a term in a bargaining between them. In the period the value of the goods that he produces is unknown to both parties. In the second period it is known to both parties and they make bargaining over whether to trade and at what price. We assume that gains from negotiation are evenly distributed (i.e. assuming the Nash bargaing solution). In the following we consider a duopoly model with two groups.

2 Reservation Profit

Let us begin from the second period. At the begining of the period, the level I of non-specific investment and the level s of the specific one that a supplier made ≒ in the previous period are given. The value of the goods to the buyer is known to both parties. First we consider the case the supplier cancells the trade with his partner and bargains with an external buyer. By the assumption, the specific investment that he commited himself to is invalid under the trade with the new partner. The price bargaining with the buyer leads to $p=(v+F(I))/2$ from the even split $v-p=p-F(I)$. Hence, both parties have the profit of $(v-F(I))/2$. Note that this bargaining is under perfect information. Also note that if

$$v<F(I)$$

, the trade is cancelled, because otherwise negative profit would be realized. Therefore the profit of the buyer is represented by

$$\Pi_b(v_i,\ I_j) = \max\{(v_i-F(I))/2,\ 0\} \tag{1}$$

Then the supplier's profit is the same as the buyer's. But we assume that he does not know the value of his new partner at the time he cancelled the relationship with the old partner. Then the expected profit of the supplier is given by

$$\Pi_{si}(I_i) = \int \max\{(v_j-F(I_i)/2,\ 0\}dG(v_j) \tag{2}$$

where $G(v)$ is a distribution function of v, commonly known to both parties. We also assume that $G(v)$ is common to all buyers, but the value for each is realized independently.

Now we consider the bargainning between the supplier and the buyer under the relationship-specific investment at the beginning of the second period. If the probability of the group 2 being cancelled is θ_2, the reservation profit of the buyer 1 and the supplier 1 become respectively $\theta_2\Pi_{b1}(v,\ I_2)$ and $\theta_2\Pi_{s1}(I_1)$. Note that the relevant investment to the reservation profit for the buyer 1 is an external supplier's one. Considering this, the price bargaining among the group 1 leads to the following equation under the principle of even split.

$$v_1-p_1-\theta_{b1}(v_1,\ I_2) = p_1-C(s_1)F(I_1)-\theta_2\Pi_{s1}(I_1) \tag{3}$$

Therefore the price in the group 1 is written as

$$p_1(v_1\ ,\ I_1,\ I_2) = [v_1+C(s_1)F(I_1)+\theta_2\Pi_{s1}(I_1)-\theta_2\Pi_{b1}(v_1,\ I_2)]/2 = 0 \tag{4}$$

Let v_1^+ be the value v_1 satisfying

$$v_1+C(s_1)F(I_1)+\theta_2\Pi_{s1}(I_1)-\theta_2\Pi_{b1}(v_1,\ I_2)]/2 = 0 \tag{5}$$

If $v_1<v_1^+$, the group will be cancelled. Therefore $G(v_1^+)$ means the cancelling probability of group 1. For $v_1(>v_1^+)$, the profits of the supplier and the buyer become respectively

$$\Pi_{s1}(v_1,\ s_1,\ I_1,\ I_2,\ \theta_2) = v_1-C(s_1)F(I_1)+\theta_2\Pi_{s1}(I_1)+\theta_2\Pi_{b1}(v,\ I_2)/2 \tag{6}$$

$$\Pi_{b1}(v_1,\ s_1,\ I_1,\ I_2,\ \theta_2) = v_1 - C(s_1)F(I_1) - \theta_2\Pi_{s1}(I_1) + \theta_2\Pi_{b1}(v_1,\ I_2)/2 \tag{7}$$

Lemma 1 *Given a probability of group cancelling $\theta_i(i=1, 2)$, the following properties are hold.*

$$\frac{\partial\Pi_{si}}{\partial s_i} = \frac{\partial\Pi_{bi}}{\partial s_i}>0,\ \frac{\partial\Pi_{si}}{\partial I_i}\lesseqgtr 0 \Longleftrightarrow \theta_j(1-F(I_i))\gtreqless 2C(s_i),\ \frac{\partial\Pi_{si}}{\partial I_j}<0,\ \frac{\partial\Pi_{bi}}{\partial I_j}>0.$$

Lemma 2

$$\frac{\partial v_i^+}{\partial I_i}\lesseqgtr 0 \Longleftrightarrow \theta_j(1-F(I_i))\gtreqless 2C(s_i),\ \frac{\partial v_i^+}{\theta I_j}>0,\ \frac{\partial v_i^+}{\partial s_i}>0.$$

3 Symmetric Equilibrium Probability of Group Cancelling

In section 2, we introduced the cancelling probability of group 1 when the cancelling probability of group 2 is believed to be θ_2. Likewise, the cancelling probability of group 2 can be introduced when that of group 1 is believed to be θ_1. Therefore, under the rational expectation of the probability of cancellation, $G(v_i^+)=\theta_i(i=1, 2)$ are held. From (5),

$$v_1^+ - C(s_1)F(I_1) - G(v_2^+)\Pi_{s1}(I_1) - G(v_2^+)\Pi_{b1}(v_1^+,\ I_2) = 0 \tag{8}$$

$$v_2^+ - C(s_2)F(I_2) - G(v_1^+)\Pi_{s2}(I_2) - G(v_1^+)\Pi_{b2}(v_2^+,\ I_1) = 0 \tag{9}$$

Then the probability of equilibrium cancelation is a function of s_1, s_2, I_1, I_2.

$$v_i^+ = v_i^+(s_1,\ s_2,\ I_1,\ I_2)(i=1,\ 2) \tag{10}$$

Let us confine ourself to the investigation on the symmetric situation (i.e. $I_1=I_2(=I)$, $s_1=s_2(=s)$) in this section. Then $v_1^+=v_2^+$ is obviouly held. By writing this value as v^+, from (8) (or (9))

$$v^+ - C(s)F(I) - G(v^+)\Pi_s(I) - G(v^+)\Pi_b(v^+,\ I) = 0 \tag{11}$$

is satisfied. From (11), the probability of symmetric equilibrium cancellation is written as a function of I and s, that is, $v^+(s,\ I)$. Differentiating this, we have

$$\frac{\partial v^+}{\partial s} = \frac{C'(I)F(I)}{1-\Pi_s-\Pi_b-v^+\dfrac{\partial\Pi_b}{\partial v^+}},\ \frac{\partial v^+}{\partial F} = \frac{1-\Pi_s-\Pi_b+F\dfrac{\partial\Pi_b}{\partial F}+F\dfrac{\partial\Pi_s}{\partial F}}{\left(1-\Pi_s-\Pi_b-v^+\dfrac{\partial\Pi_b}{\partial v^+}\right)F/v^+} \tag{12}$$

In order to make the working of our model clearer, in the following we assume that the probability distribution G of v is a uniform one on the interval [0, 1]. Considering this, assume $F(I_0)=1$. Then (11) is rewritten as follows.

$$\textit{If}\ v^+>F,\ 1-(1-F)^2/4 = CF/v^+ + (v^+-F)/2 \tag{13}$$

$$\textit{If}\ v^+>F,\quad 1-(1-F)^2/4 = CF/v^+ \tag{14}$$

In the region $v^+>F$, from (13) we get

$$v^+ = \frac{-(F^2-4F-3)-\sqrt{(F^2-4F-3)^2-32CF}}{4} \tag{15}$$

When $v^{+}=F$ is held in (15), we obtain $v^{+}=0$ or $1-2\sqrt{1-C}$. Therefore we see in (15) that $v^{+}=F$ is satisfied only if $C>3/4$. Note that at $F=1$ we have $v^{+}=(3-\sqrt{9-8C})/2<1$. Then

$$\frac{\partial v^{+}}{\partial F}=\frac{-(F-2)}{2}-\frac{(F^{2}-4F-3)(2F-4)-16C}{4\sqrt{(F^{2}-4F-3)^{2}-32CF}} \tag{16}$$

From this, we get $\partial v^{+}/\partial F>0$. (see Figure 1)

In the region $v^{+}<F$, (14) implies

$$v^{+}=CF/(1-\Pi_{s}) \tag{17}$$

so that $\partial v^{+}/\partial F>0$ is held. In the same way as the previous discussion, $v^{+}=F$ is satisfied in this region only if $C>3/4$. (17) is shown in Figure 2 and 3.

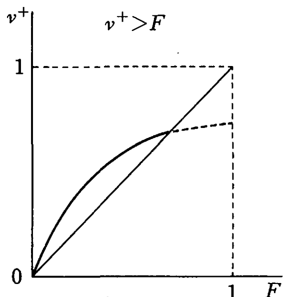

Fig. 1

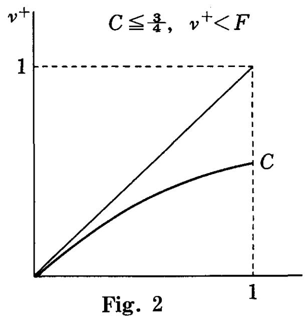

Fig. 2

The differentiation of v^{+} with respect to C is easily obtained from (13) and (14). By these discussion we can get Lemma 3 and Lemma 4.

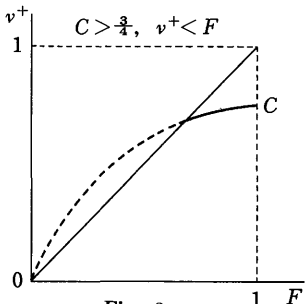

Fig. 3

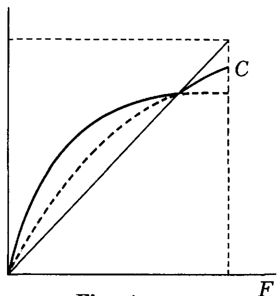

Fig. 4

Lemma 3 *Regarding the symmetric equiliblium probability of group cancellation, we have* (1) $\partial v^{+}/\partial F>0$, (2) $\partial v^{+}/\partial C>0$, (3) $v^{+}<C$.

Lemma 4 v^{+} *is larger than* F *only if* C *is larger than* $3/4$.

In the case $v^{+}<F$, practically the buyer cannot get any positive profit by the cancelation of grouping. Therefore Lemma 2 implies that there is a possibility of positive profit for a buyer by cancelling the group only if his partner (supplier) made a small specific investment.

Until now we have restricted our discussion to the symmetric equilibrium probability of cancelation. Now let us investigate the properties of general equilibrium probability of cancelation. To get these properties, in each region ($v^+>F$ and $v^+<F$) we must totally differentiate (9) and (10) with v^+, F and $C_i (i=1, 2)$, where $F_i=F(I_i)$, $C_i=C(s_i)$. By this procedure, in the region $v^+>F$, we obtain

$$\frac{\partial v_1^+}{\partial F_1}=D^{-1}\begin{vmatrix} C_1+v_1^+\dfrac{\partial \Pi_s(I_i)}{\partial F_1} & 1-\dfrac{v_1^+}{2} \\ v_2^+\dfrac{\partial \Pi_b(v_1^+, I_2)}{\partial F_1} & -\Pi_s(I_2)-\Pi_b(v_1^+, I_2) \end{vmatrix},$$

$$\frac{\partial v_1^+}{\partial C_1}=\frac{-F_1(\Pi_s(I_2)+\Pi_b(v_1^+, I_2))}{D},$$

$$\frac{\partial v_1^+}{\partial F_2}=D^{-1}\begin{vmatrix} \dfrac{-v_1^+}{2} & 1-\dfrac{v_1^+}{2} \\ C_2+\dfrac{\partial \Pi_s(I_2)}{\partial F_2} & -\Pi_s(I_2)-\Pi_b(v_1{}^+, I_2) \end{vmatrix},$$

$$\frac{\partial v_1^+}{\partial C_2}=-\frac{F_2(1-v_1^+/2)}{D},$$

$$D=\begin{vmatrix} -\Pi_s(I_1)-\Pi_b(v_2{}^+, I_1) & 1-\dfrac{v_1^+}{2} \\ 1-v_2{}^+/2 & -\Pi_s(I_2)-\Pi_b(v_1^+, I_2) \end{vmatrix}.$$

After some calculation, we can get Lemma 5.

Lemma 5 *In the region $v^+>F$, we have the following properties about $v_1^+(F_1, F_2, C_1, C_2)$.*

$$\frac{\partial v_i^+}{\partial F_i}>0,\ \frac{\partial v_i^+}{\partial F_j}<0,\ \frac{\partial v_i^+}{\partial C_j}>0,\ \frac{\partial v_i^+}{\partial C_j}>0,\ (i\neq j)$$

which are evaluated at a pair of symmetric investment(i.e. $I_1=I_2=s_1=s_2$).

Thus, while decreasing a general investment increases the possibility of their group cancelation, it decreases the external oppotunities. By contrast, decreasing a specific investment increases the external oppotunities as well as the possibility of their group cancelation.

On the other hand we have the following Lemma in the region $v^+<F$.

Lemma 6 *In the region $v^+<F$, we have*

$$\frac{\partial v_i^+}{\partial F_i}>0,\ \frac{\partial v_i^+}{\partial F_j}>0,\ \frac{\partial v_i^+}{\partial C_i}>0,\ \frac{\partial v_i^+}{\partial C_j}>0,\ (i\neq j),$$

which are evaluated at a pair of symmetric investment.

Therefore in this region there is no distinction between a general investment ant a specific one in terms of effects on cancellation probability.

4 Optimal Specific Investment

Using the equilibrium probaility of group cancellation v_i^+ in (11), the expected profits of both partners are formulated as follows. The expected profit of a supplier is taken over two periods.

This is represented by

$$\Pi_{s1}^{+}(s_1,\ s_2,\ I_1,\ I_2)=\int_{v_{1^+}}^{1}\frac{v_1-C(s_1)F(I_1)+V_2^{+}\Pi_s(I_1)-v_2^{+}\Pi_b(v_1,\ I_2)}{2}dG(v_1)$$
$$+\int_0^{v_{1^+}}v_2{}^{+}\Pi_s(I_1)dG(v_1)-K(s)I_1 \tag{18}$$

On the other hand, the expected profit of a buyer is only related to the second period. This is shown as

$$\Pi_{b1}^{+}(s_1,\ s_2,\ I_1,\ I_2)=\int_{v_{1^+}}^{1}\frac{v_1-C(s_1)F(I_1)-V_2^{+}\Pi_s(I_1)+v_2^{+}\Pi_b(v_1,\ I_2)}{2}dG(v_1)$$
$$+\int_0^{v_{1^+}}v_2{}^{+}\Pi_b(v_1,\ I_2)dG(v_1) \tag{19}$$

We consider the Cournot-Nash competition over general and specific investments between two suppliers. Each supplier makes investment $(I_i,\ s_i)$ to maximize his expected profit Π_{si}^{+} given the other supplier's levels $(I_j,\ s_j)$ of investments. In the region $v^{+}>F$, the first-order conditions for this maximization problem are

$$\frac{\partial\Pi_{s1}^{+}}{\partial F_1}=-\frac{1+v_2^{+}}{4}\frac{\partial v_2^{+}}{\partial F_1}+\frac{1-v_2^{+}}{4}\frac{\partial v_1^{+}}{\partial F_1}+\frac{\partial v_2^{+}}{\partial F_1}F_1+(v_2^{+}-C(s_1))+\frac{\partial v_2^{+}}{\partial F_1}\Pi_s(I_1)$$
$$+v_2^{+}\frac{\partial\Pi_s(I_1)}{\partial F_1}+(1-v_1^{+})/2+\frac{v_2-C(s_1)F(I_1)+V_2^{+}\Pi_s(I_1)}{2}\frac{\partial v_1^{+}}{\partial F_1}$$
$$+\frac{\partial\Pi_s(I_2)}{\partial F_1}v_1^{+}+\Pi_s(I_1)\frac{\partial v_1^{+}}{\partial F_1}-K(s_1)\frac{dI_1}{dF_1}=0 \tag{20}$$

$$\frac{\partial\Pi_{s1}^{+}}{\partial C_1}=-\frac{1+v_1^{+}}{4}\frac{\partial v_2^{+}}{\partial C_1}+\frac{1-v_2^{+}}{4}\frac{\partial v_1^{+}}{\partial C_1}+\left(\left(\frac{\partial v_2^{+}}{\partial C_1}-1\right)F_1+\frac{\partial v_2^{+}}{\partial C_1}\Pi_s(I_1)\right)(1-v_1^{+})/2$$
$$-\frac{v_2-C(s_1)F(I_1)+V_2^{+}\Pi_s(I_1)}{2}\frac{\partial v_1^{+}}{\partial C_1}$$
$$+\Pi_s(I_1)\frac{\partial v_1^{+}}{\partial C_1}-\frac{K'(s_1)}{C'(s_1)}I_1=0 \tag{21}$$

Theorem 1 *If* $-K'(s)I_0/C'(s)>1/2$ *for all* s, *the symmetric equilibrium investment in the duopoly competition is in the region* $v^{+}>F$.

In Theorem 1, I_0 is the smallest amount of investment necessary for production. This theorem roughly means that if the marginal cost of a specific investment is suffuciently larger than it's reduction effects of marginal production cost, the optimal specific investment is so small that a buyer has a possibility of positive profit from the outside by group cancellation.

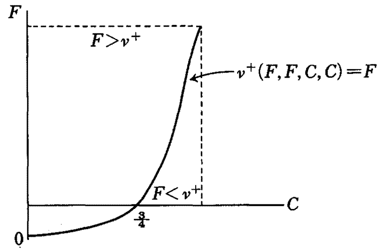

Fig. 5

5 A Competitive Market and Specific Investment

Finally we consider a competitive market with specific investment. Assume that there are many groups in a market each of which we have so far seen. Then each party in any group does not need to be afraid of not being able to find his new partner when he cancells his present group. Hence $\theta_i=1$. Then his own probability v^* of his group cancellation is determined by the following equation.

$$(v^*+C(s_1)F(I_1)+\prod_{s1}(I_1)-\prod_{b1}(v^+, I_2))/2 = 0 \tag{22}$$

We can see easily that v^* satisfying the above equation is always smaller that F. Therefore from (19) we obtain

$$v^* = CF-(1-F)^2/4 \tag{23}$$

The condition that v^* is non-negative is

$$C>(1-F)^2/2C \tag{24}$$

Hence we have the following lemmata.

Lemma 7 *In a competitive market with specific investment,*

$$\frac{\partial v^*}{\partial C}>0,\ \frac{\partial v^*}{\partial F}>0.$$

Lemma 8 *For any pair of investments* (I, s),

$$v^*<v^+$$

This means that "lock-in effect"of specific investment is larger in a competitive market than in a duopoly market in the meanings of our difinition. Then regarding the determination of the optimal investment, we have two first-order conditions corresponding to (20) and (21). Since we can easily see that the curve $(C,, F)$ satisfying $\partial \Pi_s^+/\partial C=0$ is positive, the following theorem is obtained by considering Theorem 1.

Theorem 2 *When* $\max -K'(s)/C'(s)$ *is sufficiently large, an optimal specific investment in the competitive market is larger than that in the duopoly market.*

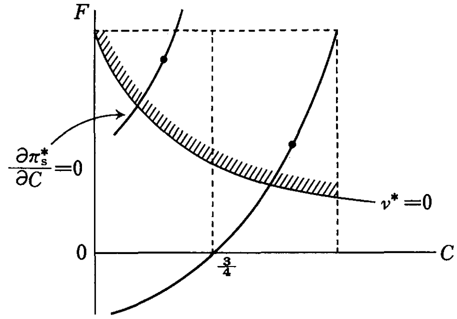

Fig. 6

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