Trade Liberalization and Technology Transfer through an Intermediate Product*

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Abstract

Horiuchi and Ishikawa (2007) examine the relationship between tariffs on the final good and international technology transfer through trade in an intermediate good. They show that a decrease in the tariff as well as an increase may lead the North monopolist to transfer technology to a South potential entrant. This paper shows that tariff-reductions may induce technology transfer even if technology-transfer competition among multiple North firms is taken into account.

Keywords: technology transfer, intermediate products, tariffs, licensing, North-South trade

JEL Classification: F12, F21, F23

1 Introduction

International technology transfer has attracted widespread attention in the international trade literature. Constructing a simple oligopolistic model, Horiuchi and Ishikawa (2007) examine the relationship between tariffs and technology transfer from developed countries (the North) to developing countries (the South). They are specifically concerned with technology transfer through trade in an intermediate good. The essence of technology is often embodied in sophisticated intermediate products which the South is unable to produce¹⁾. In this case, even if know-how to produce final products is known to the South, they cannot produce those final products by themselves. To produce the final products, they have to import such key inputs from the North. For example, when Hyundai Motor Co. (a Korean auto maker) manufactured the first Korean car in 1975, the engine was pro-

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1) Coe et al. (1977) point out that between 1971 and 1977, R&D in the North increased total factor productivity in the South through their imports of intermediate products and capital goods from the North.

vided by Mitsubishi Motors Co. (a Japanese auto maker), which transferred its technology to Hyundai²⁾.

In Horiuchi and Ishikawa (2007), a North firm (firm N_1) initially monopolizes the South final-good market. Firm N_1 serves the market by exports. They show that an increase in the tariff on the final good may induce technology transfer from firm N_1 to a potential entrant in the South (firm S). As the tariff increases, the profits of firm N_1 decrease. In order to offset the loss, it transfers technology to a potential local entrant by selling the essential intermediate product. That is, an increase in the tariff on the final good may cause the “tariff-jumping” technology transfer from the North to the South.

They also show that a decrease in the tariff on the final good may lead to technology transfer. In their model, there is another North firm (firm N_2) which is also a potential entrant to the South final-good market. Firm N_2 has to incur some fixed costs to start exporting its product to the South. In the absence of firm N_2 , a decrease in the tariff on the final good never results in technology transfer. When the tariff becomes low enough for firm N_2 to cover its FC, however, firm N_2 starts exporting to the South. For firm N_1 , the duopoly between firms N_1 and S is preferable to the duopoly between firms N_1 and N_2 , because not only firm N_1 gains from selling the intermediate good to firm S but also firm S is less efficient than firm N_2 . Thus, firm N_1 strategically lets firm S enter the market just before firm N_2 enters. That is, a decrease in the tariff on the final good may result in the “entry-deterring” technology transfer from the North to the South.

The purpose of this paper is to show that tariff-reductions may induce technology transfer in an extended model in which both firms N_1 and N_2 are incumbents, that is, the initial market structure is the duopoly between firms N_1 and N_2 . When trade is liberalized, the firms may have an incentive for technology transfer. Since there are two potential technology suppliers, we have to take the interaction between these firms into account. We specifically examine a case in which firm N_1 is more efficient than firm N_2 in production of intermediate goods.

Strategic technology transfer (such as strategic licensing) within a closed economy has received extensive attention in the industrial organization literature³⁾. However, strategic aspects of international technology transfer have not been analyzed as extensively as those of domestic technology transfer. Kabiraj and Marjit (2003) and Mukherjee and Pennings (2006) point out the possibility of “tariff-induced” technology transfer through licensing. Using a duopoly model, Kabiraj and Marjit (2003) show that the foreign firm has an incentive to license its superior technology to the domestic rival only if the initial cost-difference between the foreign and domestic firms is small. By reducing the cost-difference, a tariff may induce licensing. Mukherjee and Pennings (2006) consider the relationship between licensing by the foreign monopolist to potential entrants and the timing of the imposition of the (optimal) tariff.

Lin and Saggi (1999), Pack and Saggi (2001), and Ishikawa and Horiuchi (2007) also indicate other strategic uses of the North-South technology transfer. Lin and Saggi (1999) show a paradoxical result that technology

2) Similar examples include a Malaysian auto maker, Proton, established in 1983 and another Korean auto maker, Samsung Motors, established in 1994. Mitsubishi Motors Co. and Nissan Motor Co., Ltd., respectively, provided technological assistance to Proton and Samsung.

3) For example, see Gallini (1984), Rockett (1990), and Arya and Mittendorf (2006).

spillovers through FDI may facilitate FDI rather than discourage it in a dynamic North-South model. This is because FDI makes the South firm's imitation of an advanced technology easier and intensifies competition in the South market and hence FDI undertaken by one of the North firms may delay the other North firm's switch from exports to FDI. Similarly, Ishikawa and Horiuchi (2007) point out that technology spillovers through FDI may benefit the investing firm. In their model, vertically related markets play a crucial role. Spillovers to the South downstream firm affect the pricing behavior of the upstream firm. This may soften double marginalization in vertically related markets and benefit the North downstream firm. In fact, technology spillovers through FDI may result in Pareto gains. Pack and Saggi (2001) also show a possibility of Pareto-improving technology transfer in vertically related markets. However, Pack and Saggi (2001) are primarily concerned with vertical technology transfer (through outsourcing).

The rest of the paper is organized as follows. Section 2 presents the basic model. Section 3 investigates the effects of trade liberalization on technology transfer. Section 4 concludes the paper.

2 The Basic Model

There are two countries, the North and the South. We consider the interactions among two incumbents in the North, firms N_1 and N_2 , and a potential entrant in the South, firm S . Firms produce homogenous final goods and engage in Cournot competition in the South market. Firms N_1 and N_2 export their final goods to the South⁴⁾.

To start production, firm S needs to have technology transferred from a North firm, that is, firm S has to purchase a key intermediate good from one of the North firms. Firms N_1 and N_2 have two different technologies and compete for technology transfer to firm S . Each technology requires a specific intermediate good. That is, the intermediate goods produced by firms N_1 and N_2 are differentiated. Firm S adopts either of the two technologies. Once one technology is adopted, the other is idle⁵⁾.

One unit of the intermediate good is required for each unit of the final good. The marginal cost (MC) to produce the intermediate product is zero for firm N_1 and $c(>0)$ for N_2 . Firm S purchases the intermediate good at price r . The MC to produce the final good from the intermediate good is zero for all firms.

The South government imposes a specific tariff on the intermediate good, T , as well as a specific tariff on the final good, t . The inverse demand is given by the following linear function:⁶⁾

$$p(X) = b - aX,$$

4) We assume away FDI by the North firms. Firms refrain from FDI in the presence of high setup costs of FDI and high risk of expropriation, for example.

5) For example, typical eco-friendly cars are currently hybrid vehicles and diesel vehicles. Their engines are completely different. Once a firm decides to manufacture hybrid cars, for instance, diesel engines are useless. Similar examples include plasma display panel vs. liquid crystal display panel in TV production and Blu-ray Disc vs. High-Definition Digital Versatile Disc (HD DVD) in DVD-player production.

6) Even if the demand function is non-linear, the essence of our results would not change.

where p and X are, respectively, the price and the demand of the final good. a and b are parameters.

The model involves four stages of decision. In stage 0, the South government determines the tariff rates. In stage 1, firms N_1 and N_2 decide whether to transfer technology to firm S and whether to serve the final-good market. If it decides to transfer technology, firms N_1 and N_2 offer the intermediate-good prices. In stage 2, firm S decides whether to accept the offer. In stage 3, the firms compete in the final-good market. The game is solved by backward induction.

3 Tariffs and Technology Transfer

In this section, we show that tariff-reductions may induce technology transfer from firm N_1 to firm S . The benchmark is a case without technology transfer, that is, the duopoly between firms N_1 and N_2 .

Given t , the duopoly equilibrium is given by

$$x_{N_1}^{NN}(t) = \frac{b + (c+t) - 2t}{3a}, \quad x_{N_2}^{NN}(t) = \frac{b + t - 2(c+t)}{3a}, \quad (1)$$

$$\pi_{N_1}^{NN}(t) = \frac{(b + (c+t) - 2t)^2}{9a}, \quad \pi_{N_2}^{NN}(t) = \frac{(b + t - 2(c+t))^2}{9a}, \quad (2)$$

where a superscript “ NN ” stands for the duopoly between firms N_1 and N_2 (henceforth the NN duopoly). $c < (b-t)/2$ is necessary for $x_{N_2}^{NN}(t) > 0$.

If firm S enters the market, we have three possible market structures. In the first case, all firms serve the market. Given r and t , we have

$$x_{N_1}^{NNS}(r; t) = \frac{b + (c+t) + r - 3t}{4a}, \quad (3)$$

$$x_{N_2}^{NNS}(r; t) = \frac{b + t + r - 3(c+t)}{4a}, \quad (4)$$

$$x_S^{NNS}(r; t) = \frac{b + t + (c+t) - 3r}{4a}, \quad (5)$$

where a superscript “ NNS ” stands for the oligopoly among firms N_1 , N_2 and S (henceforth the NNS oligopoly). $x_{N_2}^{NNS}(r; t) > 0$ (i.e., $b + r - 3c - 2t > 0$) and $x_S^{NNS}(r; t) > 0$ (i.e., $b + c - 3r + 2t > 0$) are necessary for the NNS oligopoly.

In the second case, firms N_1 and S serve the market:

$$x_{N_1}^{NS}(r; t) = \frac{b + r - 2t}{3a}, \quad x_S^{NS}(r; t) = \frac{b + t - 2r}{3a}, \quad (6)$$

where a superscript “ NS ” stands for the duopoly between firms N_1 and S (henceforth the NS duopoly). $x_{N_1}^{NS}(r; t) > 0$ (i.e., $b + r - 2t > 0$) and $x_S^{NS}(r; t) > 0$ (i.e., $b + t - 2r > 0$) are necessary for the NS duopoly.

In the last case, only firm S serves the market:

$$x_S^S(r; t) = \frac{b-r}{2a}, \quad (7)$$

where a superscript “S” stands for the monopoly by firm S (henceforth the S monopoly).

We now consider the second stage. In this stage, firms N_1 and N_2 compete for technology transfer. Since firm N_1 is more efficient than firm N_2 in production of the intermediate goods, firm N_1 provides the intermediate good to firm S in equilibrium. The price firm N_1 charges is less than or equal to c .

Under the NNS oligopoly, firm N_1 maximizes

$$\pi_{N_1}^{NNS}(r; t, T) = \frac{(b + (c+t) + r - 3t)^2}{16a} + (r-T) \frac{b+t + (c+t) - 3r}{4a}$$

subject to $r \leq c+T$. $\pi_{N_1}^{NNS}(r; t, T)$ takes its maximum value at $r^{NNS}(t, T) = (6T+3b+3c+2t)/11$ without any constraint. The constraint is binding if $c \leq (3b-5T+2t)/8 (\equiv c_1)$. Intuitively, the constraint is likely to bind when c is small.

Under the NS duopoly, firm N_1 maximizes

$$\pi_{N_1}^{NS}(r; t, T) = \frac{(b+r-2t)^2}{9a} + (r-T) \frac{b+t-2r}{3a}$$

subject to $r \leq c+T$. $\pi_{N_1}^{NS}(r; t, T)$ takes its maximum value at $r^{NS}(t, T) = (6T+5b-t)/10$ without any constraint. The constraint is binding if $c \leq (-4T+5b-t)/10 (\equiv c_2)$.

Under the S monopoly, firm N_1 maximizes

$$\pi_{N_1}^S(r; T) = (r-T) \frac{b-r}{2a}$$

subject to $r \leq c+T$. $\pi_{N_1}^S(r; T)$ takes its maximum value at $r^S(T) = (b+T)/2$ without any constraint. The constraint is binding if $c \leq (b-T)/2 (\equiv c_3)$.

We are now ready to establish the following proposition.

Proposition 1 *Trade liberalization may lead firm N_1 to transfer technology to firm S.*

Trade liberalization means simultaneous reductions of t and T . For simplicity, therefore, we assume $T=kt$, where k is constant. Then a reduction of t implies that of T as well. The appendix shows that under the following parameter values, for example, the market structure shifts from the NN duopoly to the NNS oligopoly as trade is liberalized:

$$c = \frac{701}{2600}b, \quad \frac{b}{200} < t_0 < \frac{599}{13000}b, \quad k=4, \quad (8)$$

where t_0 is the initial t . Trade liberalization lowers both t and T . Intuitively, when the degree of the reduction of T exceeds that of t , trade liberalization makes the benefit from exporting the intermediate good larger. The degree of the reduction of T relative to that of t is reflected in k . Thus, when k is relatively large, trade liberalization is likely to induce technology transfer. It should be noted, however, that the initial T , T_0 , is not prohibitive under (8), that is, $x_S^{NNS}(t, T) > 0$ holds at T_0 (see the appendix).

4 Concluding Remarks

Horiuchi and Ishikawa (2007) showed that a decrease in the tariff on the final good as well as an increase may induce technology transfer from the North to the South. We have examined the relationship between trade liberalization and technology transfer in an extended model. Whereas the initial market structure is the monopoly by a North firm with two potential entrants in Horiuchi and Ishikawa (2007), ours is the duopoly between two North firms with a local potential entrant. Assuming that one of the North firms is more efficient in production of the intermediate good than the other North firm, we have shown that trade liberalization may induce technology transfer even if technology-transfer competition among multiple North firms is taken into account.

Following Horiuchi and Ishikawa (2007), we have specifically assumed that technology is embodied in a key component which only the North can produce. As pointed out in Horiuchi and Ishikawa (2007), we can easily incorporate licensing into our analysis. In particular, we can simply reinterpret the price of the intermediate good as the sum of the price of the intermediate good and the per-unit royalty. Focusing on technology transfer through trade in intermediate goods rather than licensing, however, we can not only get rid of arguments over the optimal licensing contracts⁷⁾ but also argue that North firms may have an incentive to transfer their technologies to South firms even if the licensing market does not exist or is restricted, which has been observed in many developing countries⁸⁾.

Appendix

This appendix shows Proposition 1. For this, we find parameter values under which the market structure shifts from the *NN* duopoly to the *NNS* oligopoly as trade is liberalized.

When $r = c + T$ under the *NNS* oligopoly, we obtain

$$\hat{x}_{N_1}^{NNS}(t, T) = \frac{b + 2c - 2t + T}{4a}, \quad (A1)$$

$$\hat{x}_{N_2}^{NNS}(t, T) = \frac{b - 2c - 2t + T}{4a}, \quad (A2)$$

$$\hat{x}_S^{NNS}(t, T) = \frac{b - 2c + 2t - 3T}{4a}, \quad (A3)$$

7) The licensing literature has extensively compared between per-unit royalty and fixed fee to argue the optimal licensing contracts. See, for example, Wang (1998) and Kamien and Tauman (2002).

8) The South governments often demand technology transfer without any payments for licensing. Even if licensing opportunities are present, the South governments sometimes impose various regulations such as a cap on royalty rates. For example, see Davies (1977) for the Indian case and Peck and Tamura (1976) for the Japanese case.

$$\begin{aligned}\hat{\pi}_{N_1}^{NNS}(t, T) &= \frac{(b+2c-2t+T)^2}{16a} + c \frac{b-2c+2t-3T}{4a} \\ &= \frac{1}{16a} (2Tb-8Tc+8bc-4Tt-4bt+T^2+b^2-4c^2+4t^2),\end{aligned}\quad (A4)$$

where “hat” stands for equilibrium when the constraint is binding. $c < (b-2t+T)/2$ is necessary for $\hat{x}_{N_2}^{NNS}(t, T) > 0$. Moreover, $c < (b+2t-3T)/2$ is necessary for $\hat{x}_S^{NNS}(t, T) > 0$. With these constraints, we have

$$\Delta \pi_{N_1}^{NN} \equiv \pi_{N_1}^{NN}(t) - \hat{\pi}_{N_1}^{NNS}(t, T) = -\frac{1}{144a} (b-3T-2c+2t) (26c-7b-3T+10t).$$

Thus, $\Delta \pi_{N_1}^{NN} > 0$ holds if and only if $c < (7b-10t+3T)/26 (\equiv c^*)$ holds.

Thus, ignoring the possibilities of the *NS* duopoly and the *S* monopoly (for the moment), we can establish the following lemma which specifies the conditions under which the benchmark case (i.e., the *NN* duopoly) exists.

Lemma 1 Suppose $r=c+T$, or, $c \leq c_1$. Also suppose $c < \min \{(b-t)/2, (b-2t+T)/2, (b+2t-3T)/2\}$. Then the *NN* duopoly arises if $c < c^*$. The *NNS* oligopoly arises if $c > c^*$.

Under the parameter values (8), $c \leq c_1 = (3b-18t)/8$ for $t < t_0$ and hence the constraint is binding (i.e., $r=c+T$). Also $c < \min \{(b-t)/2, (b-2t+T)/2, (b+2t-3T)/2\} = (b-10t)/2$ holds for $t < t_0$. As t falls, $c^* (= (7b+2t)/26)$ falls and $c=c^*$ holds at $t=b/200 (\equiv t^*)$. Thus, once t becomes lower than t^* , technology transfer leads to larger profits for firm N_1 .

We next check if the market structure actually shifts from the *NN* duopoly to the *NNS* oligopoly. For this, we first consider the *NS* duopoly. In view of (4), the *NS* duopoly arises only if $r \leq -(b-3c-2t) (\equiv r^*)$. We can verify that with (8), both $r^* < (c+T)$ and $c < c_2$ hold. Thus, with (8), r^* maximizes the profits of firm N_1 under the *NS* duopoly

$$\pi_{N_1}^{NS}(r^*; t, T) = -\frac{1}{a} (Tb-2Tc-5bc-Tt-3bt+7ct+b^2+5c^2+2t^2).$$

Then

$$\Delta \pi_{N_1}^{NS} \equiv \pi_{N_1}^{NS}(r^*; t, T) - \hat{\pi}_{N_1}^{NNS}(t, T) = -\frac{1}{16a} (38c-17b-T+18t) (2c-b-T+2t).$$

We can verify that with (8), $\Delta \pi_{N_1}^{NS} < 0$ if $38c-17b-T+18t < 0$, that is, $c < (17b+T-18t)/38$. Besides, $c < (17b+T-18t)/38$ actually holds with (8). Thus, firm N_1 prefers the *NNS* oligopoly to the *NS* duopoly with (8).

Moreover, with (8), $c < c_3$ holds. When $r=c+T$, we obtain

$$\hat{\pi}_{N_1}^S(T) = c \frac{b-(c+T)}{2a}.$$

Then

$$\begin{aligned}\Delta \pi_{N_1}^S &\equiv \hat{\pi}_{N_1}^S(T) - \hat{\pi}_{N_1}^{NNS}(t, T) = -\frac{1}{16a} (T^2+2Tb-4Tt+b^2-4bt+4c^2+4t^2) \\ &= -\frac{4c^2+(T+b-2t)^2}{16a} < 0,\end{aligned}$$

which implies that firm N_1 prefers the NNS oligopoly to the S monopoly. With (8), therefore, Lemma 1 holds even if the possibilities of the NS duopoly and the S monopoly are taken into account.

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