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Strategic Technology Transfer through FDI in Vertically Related Markets*

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Abstract

Using a simple North-South trade model with vertically related markets, we show that a North downstream firm may have an incentive to strategically utilize technology spillovers to a local rival caused by foreign direct investment (FDI). Whether the North firm invests in the South depends on the South firm's capacity to absorb the North technology. FDI arises only if the capacity is medium. Technology spillovers through FDI may benefit all producers and consumers. Our analysis also suggests that very tight intellectual property rights protection in the South may benefit neither the North nor the South, because it "discourages" FDI.

Keywords: FDI, international technology transfer, technology spillovers, vertically related markets, IPR protection, segmented and integrated markets

JEL Classification: F12, F21, F23

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1 Introduction

There are many channels through which technology is transferred from developed countries (the North) to developing countries (the South). One channel is technology or knowledge spillovers caused by foreign direct investment (FDI). Keller (2004) says "For instance, both micro-econometric studies and case studies point in the same direction. The evidence suggests that there can be FDI spillovers, ..."[1] It is expected that such spillovers benefit local firms and reduce incentives for multinational enterprises to undertake FDI. In particular, it is likely that firms refrain from investing in countries where intellectual property rights (IPR) are not well enforced.

The purpose of this paper is to show that contrary to this conjecture, a North firm may benefit from such technology spillovers in the South, that is, a North firm may have an incentive to strategically utilize technology spillovers through FDI. To this end, we construct a simple North-South model with vertically related markets. In the North, there are an upstream firm and a downstream firm. In the South, there is a downstream firm, which may be a potential entrant. The North downstream firm chooses its plant location, North or South. The advanced technology of the North downstream firm spills over to the South rival only if the North firm builds its plant in the South.[2] In the case of the potential entrant, such technology spillovers may lead the potential entrant to enter the market.

At first glance, FDI seems detrimental to the interests of the investing firm, because it makes competition tougher either by making the local incumbent firm more efficient or by creating a new rival. In vertically related markets, however, this affects the pricing behavior of the upstream firm. This may soften double marginalization in vertically related markets and benefit the North downstream firm. In fact, under certain situations, all producers as well as consumers gain from FDI, that is, technology spillovers through FDI result in Pareto gains.

Technology spillovers through FDI have been explored extensively,[3] though its strategic aspect has received little attention.[4] An exception is Lin and Saggi (1999). They show a paradoxical result that technology spillovers may facilitate FDI rather than discourage it in a dynamic North-South model where there exist two North firms and a single South firm. FDI makes the South firm's imitation of an advanced technology easier and intensifies competition in the South market. Thus, FDI undertaken by one of the North firms may delay the other North firm's switch from exports to FDI.

[1] For emprical evidences, see Dimelis and Louri (2002), Griffith et al. (2002), Smarzynska Javorcik (2004), and Branstetter (2006), for example.

[2] Empirical studies such as Eaton and Kortum (1999), Branstetter (2001) and Keller (2002) suggest that knowledge spillovers are geographically localized.

[3] For theoretical studies, see Findlay (1978), Ethier and Markusen (1986), Markusen and Venables (1998), and Glass and Saggi (1999,2002), for example.

[4] Strategic technology transfer (such as strategic licensing) within a closed economy has received extensive attention in the industrial organization literature. For example, see Gallini (1984), Rockett (1990), and Arya and Mittendorf (2006).

Pack and Saggi (2001), Mukherjee and Pennings (2006), and Horiuchi and Ishikawa (2007) consider strategic uses of other types of international technology transfer.[5] In particular, Pack and Saggi (2001) also show a possibility of Pareto-improving technology transfer in vertically related markets. However, their focus is different from ours. They are primarily concerned with vertical technology transfer (through outsourcing) rather than horizontal one. Horiuchi and Ishikawa (2007) also use the framework of vertically related markets. In their model, a vertically integrated North firm strategically transfers technology to a South potential entrant through trade in an intermediate product in order to deter a North rival from entering the market.

Our analysis is also related to Markusen and Venables (1999) which develops a theoretical model with monopolistically competitive industries where FDI generates both backward and forward linkages in the host country. In their model, there is initially no local production at all. Then FDI makes it possible for local suppliers to enter the local market by creating demand for non-tradable intermediate goods (backward linkage) and this in turn induces local final-good producers to enter the local market (forward linkage). In their model, however, technology spillovers are absent. Moreover, they highlight a possibility that local production eventually overtakes and forces out FDI plants. It should be noted that in contrast with Markusen and Venables (1999), our backward linkage is not directly created by FDI. It is an outgrowth of technology spillovers to the local final-good producer.

Although Arya and Mittendorf (2006) examine only licensing within a closed economy, their model is somewhat similar to our potential-entrant case.[6] In the context of patent laws and regulations, they show a possibility of Pareto-improving licensing which creates another downstream firm. A critical difference between our model and theirs is that the upstream firm is forced to set the uniform price (as long as both downstream firms are located within the same country) in our model but can always set differentiated prices in their model.[7] Because of this feature, the licensing revenue plays a crucial role in their model. Furthermore, our focus is rather on the North-South technology transfer and we obtain interesting policy implications in the North-South trade context. For example, our analysis suggests that neither very lax nor very tight IPR protection may induce strategic FDI. This implies that contrary to conventional wisdom,[8] tight IPR protection in the South may not benefit the North.[9]

In addition to the potential-entrant case, we examine the case in which the South firm is an incumbent. We find that some of the results obtained in the potential-entrant case are modified.

[5] 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.

[6] We have noticed Arya and Mittendorf (2006) after completing an earlier draft.

[7] For arguments over the price discrimination in the input market, see Katz (1987), DeGraba (1990), Yoshida (2000) and Valletti (2003), among others. It is actually illegal to price-discriminate in some countries.

[8] For the studies along conventional wisdom, see Chin and Grossman (1990), Deardorff (1992) and Helpman (1993), for example.

[9] Žigić K. (1998) also shows that the North may benefit from relaxing IPR protection in the presence of technology spillovers. However, his concern is the relationship between R&D spillovers and IPR protection and hence his model is completely different from ours.

Interestingly, FDI induces the South firm to enter the market in the potential-entrant case, while it may force the South firm to exit from the market in the incumbent case. This is likely to be the case when the IPR protection is very stringent. Thus, very tight IPR protection may be bad for the South in both potential-entrant and incumbent cases, but the reasons are different between the two cases.

Using the basic model, we also analyze policy measures often adopted to attract FDI in the South. We show that such a policy may be detrimental to the South. This suggests that careful examinations should be required for attempts to invite foreign firms even if FDI leads to technology spillovers to local firms.

The rest of the paper is organized as follows. Section 2 presents the basic model. The model is simple but is applicable to various situations such as those explored in section 4. Section 3 investigates strategic technology spillovers through FDI. We examine two cases. In the first case, the South firm can enter the market only if FDI is undertaken. In the second case, the South firm is an incumbent and can serve the market without FDI. Section 4 argues alternative setups. We specifically consider IPR protection, tax exemption, and import/export or production subsidies, all of which lead to similar results as the basic setup. Section 5 discusses some alternative assumptions and the robustness of our results. Section 6 concludes the paper.

2 The Basic Model

There are two countries, North and South. In the North, there is a firm called firm M which produces an intermediate good. Using the intermediate good, another North firm, firm N, and a South, firm S, produce a homogeneous final good. Firm N chooses its plant location, either North or South. If firm N locates in the North, technology spillovers do not arise because of strict enforcement of IPR protection in the North. Only if firm N produces in the South, its technology spills over to firm S. The final good is consumed in the North. There is no trade cost between two countries.

The model involves four stages of decision. In stage 1, firm N chooses its plant location. In stage 2, firm M sets the price(s) of the intermediate good. In stage 3, firm S decides whether to serve the final-good market. In stage 4, the firms engage in Cournot competition in the final-good market.

The inverse demand for the final good is given by

$$p(X) = b - aX \tag{1}$$

where p and X are, respectively, the price and the demand of the final good. a and b are parameters.[10] One unit of the intermediate good is required for each unit of the final good. The MC to produce the intermediate good is normalized to be zero. If firms N and S are, respectively, located in the North and the South, firm M can set the different prices across firms, r_N and r_S,

[10] Even if the demand function is non-linear, the essence of our results would not change.

because of market segmentation. If both firms are located in the South, however, firm M is forced to set the uniform price, r. The MC to produce the final good from the intermediate good is c_N for firm N and c_S for firm S. When firm N does not invest in the South, c_S is equal to $\bar{c}_S$ which is exogenously given. When firm N undertakes FDI, on the other hand, c_S depends on the firm S's capacity to absorb firm N's technology. Following Cohen and Levinthal (1989,1990), we call such a capacity "absorptive capacity."[11] For simplicity, the absorptive capacity, α, is exogenously given. Specifically, in the presence of FDI, the relationship between the MC and the absorptive capacity is given by

$$c_S = \bar{c}_S - \alpha(\bar{c}_S - c_N) = (1-\alpha)\bar{c}_S + \alpha c_N, \alpha \in [0,1]. \tag{2}$$

$\alpha = 0$ implies the nil capacity and $c_S = \bar{c}_S$ holds. On the other hand, $\alpha = 1$ implies the perfect capacity and $c_S = c_N$.

The profits of firms M, N, and S are, respectively, given by

$$\begin{aligned}
\pi_M &= r_N x_N + r_S x_S, \\
\pi_N &= [p - (c_N + r_N)]x_N - f_N, \\
\pi_S &= [p - (c_S + r_S)]x_S - f_S,
\end{aligned}$$

where x_i $(i = N, S)$ is the output of firm i; and f_i $(i = N, S)$ is the setup fixed cost (FC). To focus on the strategic motive of FDI, we assume that for firm N, both MC and FC are identical between North and South. That is, there is no cost-saving motive for firm N to undertake FDI. Since the setup FCs are not crucial to derive our main result, we set $f_i = 0$ $(i = N, S)$ for simplicity.

3 Strategic Technology Transfer

We specifically consider two cases. In the first case, $\bar{c}_S$ is too high for firm S to enter the market. That is, firm S is a potential entrant and its entry is possible only if firm N undertakes FDI. We call this case "potential-entrant case." In the second case, $\bar{c}_S$ is low enough for firm S to serve the final-good market, that is, firm S can serve the final-good market without firm N's FDI. This case is called "incumbent case."[12]

3.1 The Potential-Entrant Case

We solve the game by backward induction. There are two cases in the last stage. Firm S does not enter the market in the first case and does in the second case. Without firm S's entry, firm N monopolizes the market. In either case, a single intermediate-good price prevails. In the absence of firm S, firm N is the monopolist in the final-good market.

[11] Cohen and Levinthal (1989,1990) argue the relationship between absorptive capacity and R&D.

[12] The conditions under which each case arises are given in footnote 15.

In the first case, given the intermediate-good price, the equilibrium is given by

$$x_N^N = X^N = \frac{b - c_N - r}{2a} > 0, p^N = \frac{b + c_N + r}{2}, \pi_N^N = \frac{(b - c_N - r)^2}{4a}, \tag{3}$$

where a superscript "N" stands for the case without firm S's entry. With firm S's entry, the duopoly between firms N and S arises. Given r, we obtain

$$\begin{aligned}
x_N^{SS} &= \frac{b + (c_S + r) - 2(c_N + r)}{3a}, x_S^{SS} = \frac{b + (c_N + r) - 2(c_S + r)}{3a}, &(4)\\
X^{SS} &= \frac{2b - (c_S + r) - (c_N + r)}{3a}, p^{SS} = \frac{1}{3}\left(b + 2r + c_N + c_S\right), &(5)\\
\pi_N^{SS} &= \frac{[b + (c_S + r) - 2(c_N + r)]^2}{9a}, \pi_S^{SS} = \frac{[b + (c_N + r) - 2(c_S + r)]^2}{9a}, &(6)
\end{aligned}$$

where a superscript "SS" stands for the case with firm S's entry. In stage 3, firm S enters the market if and only if $\pi_S^{SS} > 0$.

We now consider stage 2 in which given the FDI decision of firm N, firm M sets the price in the intermediate-good market to maximize its profits under the derived demand. Without FDI, noting $x_M = x_N$ (where x_M is the output of firm M), we have

$$\begin{aligned}
x_M^{N*} &= \frac{1}{4a}\left(b - c_N\right), r^{N*} = \frac{b - c_N}{2}, \pi_M^{N*} = \frac{1}{8a}\left(b - c_N\right)^2, &(7)\\
x_N^{N*} &= X^{N*} = \frac{1}{4a}\left(b - c_N\right), p^{N*} = \frac{1}{4}\left(3b + c_N\right), \pi_N^{N*} = \frac{1}{16a}\left(b - c_N\right)^2. &(8)
\end{aligned}$$

Asterisk "$*$"denotes equilibrium value.

With FDI, on the other hand, firm M has two options: charging the high price so that only firm N is served or charging the low price to accommodate firm S's entry. Firm M compares its profits between these two cases. In the former case, the equilibrium is given by (7) and (8). In the latter, facing the derived demand (5), firm M charges the uniform price

$$r^{SS*} = \frac{2b - c_N - c_S}{4}$$

for the intermediate good. Therefore,

$$\begin{aligned}
x_N^{SS*} &= \frac{2b - 7c_N + 5c_S}{12a}, x_S^{SS*} = \frac{2b - 7c_S + 5c_N}{12a}, \qquad (9)\\
X^{SS*} &= \frac{2b - c_N - c_S}{6a}, p^{SS*} = \frac{1}{6}\left(4b + c_N + c_S\right),\\
\pi_N^{SS*} &= \frac{1}{144a}\left(2b - 7c_N + 5c_S\right)^2, \pi_S^{SS*} = \frac{1}{144a}\left(2b - 7c_S + 5c_N\right)^2,\\
\pi_M^{SS*} &= \frac{\left(2b - c_N - c_S\right)^2}{24a}.
\end{aligned}$$

For $x_S^{SS*} > 0$, we need $2b - 7c_S + 5c_N > 0$, i.e., $c_S < (2b + 5c_N)/7 \equiv \widetilde{c}$.[13]

The above two cases are depicted in Figure 1. In panel (a), $d^N d^{N'}$ is the derived demand for the intermediate good without FDI. The marginal revenue (MR) curve associated with $d^N d^{N'}$

[13]Since $c_N \leq c_S$, $x_N^{SS*} > 0$ holds if $x_S^{SS*} > 0$.

is $d^N m^N$. Since $MC = 0$, the equilibrium in the intermediate-good market is given by point E^N. Once FDI is undertaken, the derived demand and its MR curve become $d^N d^{SS} d^{SS'}$ and $d^N m^{N'}$ plus $m^{SS} m^{SS'}$, respectively. Since the demand curve kinks at d^{SS}, the MR curve becomes discontinuous and consists of two segments. Then the equilibrium becomes E^{SS}. In the presence of FDI, firm M obtains the higher profits at E^{SS} than at E^N and hence induces firm S to enter. In panel (b), d^{SS} is located to the southeast of E^N. Then, both E^N and E^{SS} are a candidate for equilibrium. If point E^N gives the higher profits for firm M, it charges r^{N*} for the intermediate good. Hence, firm S cannot enter even with FDI.

The difference in the profits of firm M between the two cases is

$$\Delta\pi_M^E \equiv \pi_M^{SS*} - \pi_M^{N*} = \frac{1}{24a}\left(b^2 + 2bc_N - 4bc_S - 2c_N^2 + 2c_N c_S + c_S^2\right), \tag{10}$$

where $\Delta\pi_M^E = 0$ holds at $c_S = \left(2+\sqrt{3}\right)b - \left(\sqrt{3}+1\right)c_N$ and $\left(2-\sqrt{3}\right)b + (\sqrt{3}-1)c_N (\equiv c_2)$. A superscript "$E$" stands for the potential-entrant case. We can verify $c_N < c_2 < \widetilde{c} < \left(2+\sqrt{3}\right)b - \left(\sqrt{3}+1\right)c_N$.

Thus, the following lemma is immediate.

Lemma 1 *When firm N undertakes FDI, firm M induces firm S's entry if $c_N \le c_S < c_2$.*

Intuitively, firm M is likely to benefit from the presence of firm S as a result of FDI, because the demand for the intermediate good rises. However, if firm S is not very efficient, firm M has to lower the intermediate-good price sufficiently to serve both firms N and S. In this case, since the firm M's profits fall, firm M serves only firm N by charging high price. This case is equivalent to the case without FDI. Thus, firm M never loses from FDI.

We now consider stage 1. Comparing the profits of firm N with and without firm S's entry, we have

$$\Delta\pi_N^E \equiv \pi_N^{SS*} - \pi_N^{N*} = \frac{5}{144a}\left(-b^2 - 2bc_N + 4bc_S + 8c_N^2 - 14c_N c_S + 5c_S^2\right).$$

$\Delta\pi_N^E = 0$ holds at $c_S = 2c_N - b$ and $(b+4c_N)/5 (\equiv c_1)$. Noting $2c_N - b < c_N < c_1 < c_2 < \widetilde{c}$ and Lemma 1, we establish the following lemma.

Lemma 2 *Firm N benefits from FDI if $c_1 < c_S < c_2$.*

The reason why firm N benefits from FDI is as follows. Suppose that firm S enters the market as a result of FDI. Although the presence of a rival makes the final-good market more competitive, it reduces the intermediate-good price by shifting the derived demand for the intermediate good.[14] If the latter effects dominate the former, firm N gains. As the absorptive capacity of firm S becomes lower, the intermediate-good price becomes lower and hence firm N is more likely to gain. Put differently, by creating a technologically inferior rival, FDI can weaken firm M's market power. In the presence of FDI, therefore, firm N faces a trade-off between the presence of a rival and the lower intermediate-good price.

[14] Since firm S cannot be more efficient than firm N, firm S's enty never increases the intermediate-good price.

The difference in the total output is

$$\Delta X^E \equiv X^{SS*} - X^{N*} = \frac{1}{12a}(b + c_N - 2c_S) > \frac{1}{12a}(b - c_N)\left(2\sqrt{3} - 3\right) > 0,$$

where the inequality comes from $c_S < c_2$. As is expected, the total output is larger in the presence of firm S.

The above analysis establishes the following proposition.

Proposition 1 *Suppose that firm S cannot enter the market without firm N's FDI. If the absorptive capacity of firm S is medium so that $c_1 < c_S < c_2$ holds, then firm N undertakes FDI which benefits all producers (i.e. firms M, N and S) and consumers.*

This proposition is depicted in Figure 2. In the figure, π_N^{N*} and π_M^{N*} are horizontal because they are independent of the absorption ability, or, c_S. As the absorptive capacity rises (i.e., as c_S falls), π_N^{SS*} decreases but π_M^{SS*} increases. As long as $c_S > c_1$, firm N is willing to invest. However, firm M does not allow firm S's entry if $c_S > c_2$. On the other hand, as long as $c_S < c_2$, firm M is willing to accommodate firm S's entry but firm N does not undertake FDI if $c_S < c_1$.

3.2 The Incumbent Case

There are two cases in the last stage. In the first case, firm N undertakes FDI and both firms N and S are located in the South. This case has been examined in the last subsection. As we see below, however, firm S may be forced to exit from the market in this case. This depends on the pricing behavior of firm M.

In the second case, firms N and S, respectively, produce in the North and in the South. In this case, there exist no technology spillovers and hence $c_S = \overline{c}_S$. Also firm M can price-discriminate between firms N and S, because of market segmentation. Given the intermediate-good prices, the equilibrium is given by

$$\begin{aligned}
x_N^{NS} &= \frac{b + (\overline{c}_S + r_S) - 2(c_N + r_N)}{3a}, x_S^{NS} = \frac{b + (c_N + r_N) - 2(\overline{c}_S + r_S)}{3a}, && (11)\\
X^{NS} &= \frac{2b - (\overline{c}_S + r_S) - (c_N + r_N)}{3a}, p^{NS} = \frac{1}{3}(b + r_S + r_N + c_N + \overline{c}_S), && (12)\\
\pi_N^{NS} &= \frac{[b + (\overline{c}_S + r_S) - 2(c_N + r_N)]^2}{9a}, \pi_S^{NS} = \frac{[b + (c_N + r_N) - 2(\overline{c}_S + r_S)]^2}{9a}, && (13)
\end{aligned}$$

where "NS" stands for the case in which firms N and S, respectively, produce in the North and in the South.

With price discrimination, firm M sets the prices of the intermediate good, r_N and r_S as follows:[15]

$$r_N^{NS*} = \frac{b - c_N}{2}, r_S^{NS*} = \frac{b - \overline{c}_S}{2}. \qquad (14)$$

[15] We can conclude from (14) that the incumbent case arises if $\overline{c}_S < (b + c_N)/2$ and the potential-entrant case arises if $\overline{c}_S \geq (b + c_N)/2$.

Then,

$$
\begin{aligned}
x_N^{NS*} &= \frac{b - 2c_N + \overline{c}_S}{6a}, x_S^{NS*} = \frac{b + c_N - 2\overline{c}_S}{6a}, \\
X^{NS*} &= \frac{2b - c_N - \overline{c}_S}{6a}, p^{NS*} = \frac{1}{6}\left(4b + c_N + \overline{c}_S\right), \\
\pi_N^{NS*} &= \frac{1}{36a}\left(b - 2c_N + \overline{c}_S\right)^2, \pi_S^{NS*} = \frac{1}{36a}\left(b + c_N - 2\overline{c}_S\right)^2, \\
\pi_M^{NS*} &= \frac{1}{6a}\left(b^2 - bc_N - b\overline{c}_S + c_N^2 - c_N\overline{c}_S + \overline{c}_S^2\right).
\end{aligned} \tag{15}
$$

There are two opposing effects of firm N's FDI on firm M's profits. Under FDI, firm M is forced to set the uniform price, which reduces firm M's profits relative to the case without FDI. On the other hand, FDI generates technology spillovers from firm N to firm S, which makes it possible for firm M to increase the intermediate-good price relative to the case without any technology spillovers. Thus, firm M may or may not gain from FDI. We have

$$
\Delta\pi_M^I \equiv \pi_M^{SS*} - \pi_M^{NS*} = \frac{1}{24a}\left(c_S^2 + 2c_Sc_N - 4bc_S - 3c_N^2 + 4c_N\overline{c}_S - 4\overline{c}_S^2 + 4b\overline{c}_S\right),
$$

where a superscript "I" stands for the incumbent case. $\Delta\pi_M^I = 0$ holds at $c_S = 2b - c_N - 2\sqrt{Z}(\equiv c_3)$ and $2b - c_N + 2\sqrt{Z}$, where $Z \equiv b^2 - bc_N - b\overline{c}_S + c_N^2 - c_N\overline{c}_S + \overline{c}_S^2 = (b - \overline{c}_S)^2 + (b - c_N)(\overline{c}_S - c_N) > 0$. Since $c_3 < \widetilde{c} < 2b - c_N + 2\sqrt{Z}$, $\Delta\pi_M^I > 0$ ($\Delta\pi_M^I < 0$) if $c_N \leq c_S < c_3$ ($c_3 < c_S \leq \overline{c}_S$). When $\Delta\pi_M^I < 0$, firm M has two options in the presence of FDI. One is to keep serving both firms N and S. The other is to stop serving firm S by charging a high price for the intermediate good. It should be noted that in either case, firm N's FDI is harmful to firm M, which never happens in the potential-entrant case. By noting Lemma 1 and $c_2 > c_3$, the following lemma is immediate.[16]

Lemma 3 *Firm M gains from FDI if $c_N \leq c_S < c_3$ but loses if $c_3 < c_S \leq \overline{c}_S$. If it loses, firm M forces firm S to exit from the market when $c_2(\equiv \left(2 - \sqrt{3}\right)b + (\sqrt{3} - 1)c_N) < c_S \leq \overline{c}_S$.*

In stage 1, firm N decides its plant location. For this, firm N compares the profits of each location. If only firm N is served under FDI, firm N compares π_N^{NS*} with π_N^{N*}. Since the intermediate-good prices are the same between these two market structures, $\pi_N^{NS*} < \pi_N^{N*}$ holds. If firm M serves both firms N and S, on the other hand, firm N compares π_N^{NS*} with π_N^{SS*}:

$$
\Delta\pi_N^I \equiv \pi_N^{SS*} - \pi_N^{NS*} = -\frac{1}{144a}\left(3c_N - 5c_S + 2\overline{c}_S\right)\left(4b + 5c_S - 11c_N + 2\overline{c}_S\right),
$$

$\Delta\pi_N^I = 0$ holds at $c_S = \left(11c_N - 2\overline{c}_S - 4b\right)/5$ and $(3c_N + 2\overline{c}_S)/5(\equiv c_4)$. Noting $\left(11c_N - 2\overline{c}_S - 4b\right)/5 - c_N = -2\left(2b - 3c_N + c_S\right)/5 < 0$, we have $\Delta\pi_N^I > 0$ if $c_4 < c_S \leq \overline{c}_S$. This result stems from the following trade-off. Without FDI, firm M price-discriminates between firms N and S. Since firm N is more efficient than firm S, the price firm N faces is higher than that firm S does. On the one hand, firm N's FDI makes firm S more efficient because of technology spillovers: on the other hand, it leads firm M to set the uniform price and firm N faces the lower intermediate-good

[16] The appendix shows that there actually exist some parameter values which satisfy the conditions in the following lemmas.

price. If the latter effect exceeds the former, firm N gains from FDI. This is likely to be the case when the technology spillovers are not very strong.

In view of Lemma 3, therefore, we establish the following lemma.

Lemma 4 *Firm N benefits from FDI if* $\min\{c_2, c_4\} < c_S \leq \overline{c}_S$ *but loses if* $c_N \leq c_S < \min\{c_2, c_4\}$.

Next we examine the effect of FDI on consumers and firm S's profits. First of all, it is obvious that if only firm N is served under FDI, both firm S and consumers lose from FDI. When firm M serves both firms N and S under FDI, FDI benefits consumers, because $p^{NS*} > p^{SS*}$. The difference in the profits of firm S is

$$\Delta\pi_S^I \equiv \pi_S^{SS*} - \pi_S^{NS*} = \frac{1}{144a}\left(3c_N - 7c_S + 4\overline{c}_S\right)\left(4b - 7c_S + 7c_N - 4\overline{c}_S\right).$$

We can easily verify $\Delta\pi_S^I = 0$ holds at $c_S = \left(4b + c_N - 4\overline{c}_S\right)/7$ and $(3c_N + 4\overline{c}_S)/7 (\equiv c_5)$. In view of (9) and (15), we can verify $c_5 < \overline{c}_S < \left(4b + c_N - 4\overline{c}_S\right)/7$. Thus, $\Delta\pi_S^I > 0$ holds if and only if $c_N \leq c_S < c_5$. The intuition is as follows. FDI makes the intermediate-good price higher for firm S. However, technology spillovers through FDI make firm S more efficient. If the spillovers are large enough, then firm S gains from FDI.

Thus, noting Lemma 3, we obtain

Lemma 5 *Firm S benefits from FDI if* $c_N \leq c_S < \min\{c_2, c_5\}$*, but loses if* $\min\{c_2, c_5\} < c_S \leq \overline{c}_S$.

Lemma 6 *Consumers benefits from FDI if* $c_N \leq c_S < c_2$*, but loses if* $c_2 < c_S \leq \overline{c}_S$.

Therefore, noting $c_4 < c_5$, we can establish the following proposition.

Proposition 2 *Suppose that firm S can serve the market without firm N's FDI. Firm N has an incentive to invest in the South if* $\min\{c_2, c_4\} < c_S \leq \overline{c}_S$. *If* $c_2 < c_4$*, then firm N's FDI forces firm S to exit from the market and harms all consumers and producers (except for firm N). If* $c_4 < c_S < \min\{c_2, c_5\}$*, then FDI benefits consumers and firm S as well as firm N. If* $c_4 < c_S < \min\{c_3, c_5\}$*, FDI results in Pareto gains.*

Figure 3 shows a case of Pareto gains. FDI is undertaken if $c_S > c_4$. As long as $c_4 < c_S < c_5$, all producers and consumers gain from FDI.

4 Alternative Setups

We have assumed that firm N's technology spills over to firm S once firm N invests in the South and firm S's productivity depends on the exogenous capacity to absorb firm N's technology. Firm N's location choice depends on the absorptive capacity. In this section, we apply the basic model to the analysis of three policy measures to attract FDI: IPR protection, tax exemption, and import/export or production subsidies.

4.1 IPR Protection

First, we consider the IPR protection in the South. Firm S attempts to imitate firm N's production technology, but the IPR protection introduced by the South government may prevent perfect imitation. Following the literature on IPR protection, we assume that the level of spillovers reflects the strength of IPR protection, that is, as IPR protection becomes weaker, the MC of firm S becomes lower.[17] We specifically assume that without any IPR protection, firm S can freely imitate firm N's technology and their MCs become identical. On the other hand, if the IPR protection is very tight, firm S cannot imitate firm N's technology and firm S's MC remains to be $\bar{c}_S$. In (2), we can regard $(1-\alpha)$ as the degree of IPR protection. $\alpha = 1$ means no IPR protection and firm S can freely imitate firm N's technology, while $\alpha = 0$ means perfect IPR protection and firm S cannot imitate it at all.

In the case of IPR protection, one more stage is added in the stage game. That is, in stage 0, the South government chooses the degree of the IPR protection. The degree of the IPR protection in stage 0 makes the MC of firm S endogenous. Then we can reinterpret the results in the basic model as follows. In the potential-entrant case, the intermediate level of IPR protection such that $c_1 < c_S < c_2$ induces FDI, while in the incumbent case, the high level of IPR protection such that $\min\{c_2, c_4\} < c_S \leq \bar{c}_S$ is necessary for FDI. In the latter case, however, if $c_S > c_2$, firm S is forced to exit from the market as a result of FDI. Thus, if $c_2 < c_4$, the South government should set $c_S < c_2$ so that FDI is not induced.

Since the South does not consume the good, its welfare is measured by the profits of firm S. In the potential-entrant case, FDI improves South welfare. In the incumbent case, Lemma 5 gives the condition under which South welfare is enhanced. Obviously, among the IPR protection levels which raise South welfare, the South government has an incentive to make the IPR protection as weak as possible.

We obtain the following proposition.

Proposition 3 *If firm S cannot enter the market without firm N's FDI, then neither lax IPR protection (i.e. $c_S < c_1$) nor tight IPR protection (i.e. $c_S > c_2$) leads firm N to invest in the South. If firm S can serve the market without firm N's FDI, on the other hand, FDI is induced only when the IPR protection is strong (i.e. $c_S > \min\{c_2, c_4\}$). In this case, if the IPR protection is too strong (i.e. $c_S > c_2$), firm S is driven out from the market by FDI.*

4.2 Tax Exemption

It is often observed that in order to promote FDI, some kinds of tax exemption are provided to foreign firms. In this subsection, we consider a production tax with tax exemption to firm

[17] See for example Chin and Grossman (1990). However, they deal with only extreme cases in which either $\alpha = 0$ or $\alpha = 1$ holds. Žigić (1998, 2000) considers the relationship between R&D and IPR protection. Both firms N and S initially face the identical MCs. R&D conducted by firm N decreases not only firm N's MC but also firm S's. The reduction of firm S's MC depends on the degree of IPR protection.

N. Suppose that the South government imposes a specific production tax, $t(>0)$, but firm N is allowed not to pay the tax. For simplicity, we assume perfect technology spillovers (i.e., $c_S = c_N$ with FDI). Then the profits of firms N and S, respectively, become

$$\begin{aligned}\pi_N(t) &= [p - (c_N + r_N)]x_N, \\ \pi_S(t) &= [p - (c_S + t + r_S)]x_S.\end{aligned}$$

Whereas $c_S = c_N$ and $r_S = r_N$ with FDI, $c_S = \bar{c}_S$ without FDI. The stage game is just like the one in the IPR protection. In the fist stage, the South government chooses the production tax rate. In the potential-entrant case, firm N invests in the South if the tax rate satisfies $c_1 - c_N < t < c_2 - c_N$. In the incumbent case, firm N undertakes FDI if $\min\{c_2 - c_N, c_4 - c_N\} < t \leq \bar{c}_S - c_N$. In this case, however, FDI deteriorates South welfare if firm S is forced to exit from the market.

South welfare is measured by sum of the profits of firm S and tax revenue. When both firms N and S serve the market with FDI, South welfare is given by the following quadratic function:

$$\begin{aligned}W_S^{SS}(t) &= \frac{1}{144a}\left(2b - 7(c_N + t) + 5c_N\right)^2 + t\frac{2b - 7(c_N + t) + 5c_N}{12a} \\ &= \frac{1}{144a}\left(4b^2 - 4bt - 8bc_N - 35t^2 + 4tc_N + 4c_N^2\right).\end{aligned}$$

W_S^{SS} takes the maximum value at $t = 2(c_N - b)/35 < 0$ without any constraint. This implies that with FDI, the South government sets the tax rate as low as possible. Thus, in the potential-entrant case, the optimal tax, t^{E*}, is $c_1 - c_N$.[18]

In the incumbent case, we need to compare $W_S^{SS}(t)$ with $W_S^{NS}(t)$:

$$\begin{aligned}W_S^{NS}(t) &= \frac{1}{36a}\left(b + c_N - 2(\bar{c}_S + t)\right)^2 + t\frac{b + c_N - 2(\bar{c}_S + t)}{6a} \\ &= \frac{1}{36a}\left(b + 4t + c_N - 2\bar{c}_S\right)\left(b - 2t + c_N - 2\bar{c}_S\right),\end{aligned}$$

which is a quadratic function. W_S^{NS} takes the maximum value at $t = (b + c_N - 2\bar{c}_S)/8 (\equiv t^{NS}) > 0$ without any constraint. When $c_2 < c_4$, FDI forces firm S to exit from the market and harms the South. Thus, the South sets the optimal tax so that FDI does not occur. The optimal tax is t^{NS} if $t^{NS} < c_2 - c_N$ and c_2 if $t^{NS} \geq c_2 - c_N$. When $c_2 > c_4$, we have two cases. Since $W_S^{SS}(t) > W_S^{NS}(t)$ for the same t, it is obvious that $W_S^{SS}(c_4 - c_N) > W_S^{NS}(t^{NS})$ if $t^{NS} \geq c_4 - c_N$. Thus, the optimal tax is $c_4 - c_N$ either if $t^{NS} \geq c_4 - c_N$ or if both $W_S^{SS}(c_4 - c_N) > W_S^{NS}(t^{NS})$ and $t^{NS} < c_4 - c_N$ hold, and is t^{NS} if $W_S^{SS}(c_4 - c_N) < W_S^{NS}(t^{NS})$ and $t^{NS} < c_4 - c_N$.

Therefore, we obtain

Proposition 4 *Suppose that technology spillovers through FDI are perfect. Then the introduction of a production tax coupled with tax exemption to firm N can induce FDI. Such FDI enhances South welfare if it leads firm S to enter the market, but may deteriorate it if firm S serves the market without FDI.*

[18] Strictly speaking, $t^* = c_1 - c_N + \varepsilon$ where ε is an infinitesimal positive number.

4.3 Subsidies

The South government may provide a subsidy to import the intermediate good which is produced in the North. Also it may provide a subsidy to export or produce the final good, because it is consumed in the North.[19]

The South government chooses a specific import subsidy, s_I, or a specific export subsidy, s_X, in the first stage. In the case of the import subsidy, the profits of each firm under perfect technology spillovers are, respectively,

$$\begin{aligned}\pi_M(s_I) &= rx_N + (r_S + s_I)x_S,\\ \pi_N(s_I) &= [p - (c_N + r_N)]x_N,\\ \pi_S(s_I) &= [p - (c_S + r_S)]x_S.\end{aligned}$$

While $c_S = c_N$, $r_N = r_S$ and $r = r_S + s_I$ with FDI, $c_S = \overline{c}_S$ and $r = r_N$ without FDI. In the case of the production or export subsidy, on the other hand, the profits are

$$\begin{aligned}\pi_M(s_X) &= r_N x_N + r_S x_S,\\ \pi_N(s_X) &= [p - (c + r_N)]x_N,\\ \pi_S(s_X) &= [p - (c_S - s_X + r_S)]x_S.\end{aligned}$$

While $r_N{=}r_S$, $c = c_N - s_X$ and $c_S = c_N$ with FDI, $c = c_N$ and $c_S = \overline{c}_S$ without FDI. We should note that firms N and S face the same (effective) MCs in the presence of FDI.

The appendix shows the following lemma.

Lemma 7 *An import subsidy to the intermediate good and an export or production subsidy to the final good set at the same levels are equivalent.*

Intuitively, since all output of the final good produced in the South is exported, an import subsidy to the intermediate good gives rise to the same output and welfare effects as an equal subsidy to final-good exports or production.[20]

The appendix also proves the following lemmas.

Lemma 8 *When the South government provides a subsidy, firm M is willing to serve firm S.*

Lemma 9 *When firm S cannot enter the market without firm N's FDI, firm N benefits from FDI if $s > (b - c_N)/2$. When firm S can serve the market without firm N's FDI, firm N gains from FDI if $s > (\overline{c}_S - c_N)/2$.*

Under an import subsidy, the intermediate-good price falls. This causes the rent-shifting from firm M to firms N and S. If the rent-shifting dominates the technology spillovers to firm S, FDI benefits firm N. When an export or production subsidy is provided, the rent shifts from firms

[19] If the final good is consumed in the South instead, the South government may impose a tariff to induce FDI.
[20] See also Ishikawa and Spencer (1999).

N and S to firm M through an increase in the intermediate-good price. Although the final-good producers cannot capture the full rent from the subsidy, firm N gains from FDI as long as the subsidy rate is high.

If both firms N and S are served by firm M in the presence of FDI, South welfare is measured by

$$\begin{aligned} W_S^{SS}(s) &= \pi_S^{SS*}(s) - sX^{SS*}(s) \\ &= \frac{1}{36a}(b - c_N + s)^2 - s\frac{b - c_N + s}{3a} \\ &= \frac{1}{36a}\left(b^2 - 10bs - 2bc_N - 11s^2 + 10sc_N + c_N^2\right), \end{aligned}$$

which takes the maximum value at $s = 5(c_N - b)/11 < 0$ without any constraint. W_S^{SS} takes its maximum value $-3(b - c_N)^2/16a(< 0)$ at $s = (b - c_N)/2$ in the presence of FDI. Thus, the South government can induce FDI by providing a subsidy but such FDI deteriorates welfare. Intuitively, firm S benefits from the subsidy-induced FDI, but the most of the subsidy payments leak out of the South.[21]

Therefore, the following proposition is established.

Proposition 5 *Suppose that technology spillovers through FDI are perfect. Also suppose that the South government provides a subsidy to import the intermediate good or to export the final good or to produce the final good. Such a subsidy can induce firm N to invest in the South. FDI benefits all producers (i.e. firms M, N and S) and consumers, but reduces South welfare.*

5 Discussion

The basic point of this paper is to draw attention to a previously unidentified effect of technology spillovers through FDI, namely that the North downstream firm (i.e. firm N) affects the pricing behavior of the intermediate-good supplier (i.e. firm M) through technology spillovers to the South downstream firm (i.e. firm S) caused by FDI. In the potential-entrant case, if FDI induces the potential entrant to enter the market, firm M lowers the intermediate-good price because the South entrant, firm S, is less efficient than firm N. In the incumbent case, on the other hand, FDI makes firm S more competitive, but forces firm M to set the uniform price because both firms N and S are located in the same country. Since firm N is more efficient than firm S, the uniform pricing either lowers the intermediate-good price faced by firm N or forces firm S to exit from the market. To make our point in a transparent way, we have considered a highly stylized model. Naturally, one wonders to what extent our results are robust. In this section, we discuss some alternative assumptions to gain insight on this issue.

[21] If the good is consumed in the South instead of the North, one can verify that W_S^{SS} takes its maximum value 0 at $s = c_1 - c_N$. In this case, the South consumers can capture some of the benefit from the subsidy, though this is not large enough to enhance South welfare.

We have assumed that firm M sets the monopoly price for the intermediate good. If firm N has the monopsony power instead, the intermediate-good price becomes constant which is equal to the constant MC of firm M and hence our result would not hold. As far as FDI can induce firm M to lower the price, however, our result could hold. Therefore, some market power of firm M is indispensable to obtain the result, but the monopoly power in the intermediate-good market is not essential. Furthermore, Cournot competition in the final-good market is not crucial to the result. For example, it can be verified that our result is still valid even if the firms engage in Bertrand competition with differentiated goods. However, the firm M's monopoly power in the intermediate-good market as well as Cournot competition with a homogenous good in the final-good market enable us to describe the deriving force of our result very clearly. We should also mention that firm M could lose from FDI in the incumbent case even if it has the monopoly power in the intermediate-good market.

There is a single firm in the South. If non-zero setup FCs are introduced, one can easily construct situations under which only one South firm can enter the market. However, as long as the number of the South firm is very small, firm N still gains from technology spillovers even with more than one South firm. It should be noted that in the potential-entrant case, since firm M also gains from the firm S's entry, it may attempt to encourage the entry. In the presence of setup FCs, for example, firm M may have an incentive to share the cost.

One may wonder how crucial the North-South, two-country framework is. It is of importance in the following two senses. First, technology spillovers are geographically localized. Thus, technology does not spill over to the South as long as firm N locates in the North. Second, as is often assumed in the literature of strategic trade policy, two markets (the South and the North markets) are segmented. Therefore, firm M can set different prices between firms N and S in the absence of FDI, but is forced to set the uniform price in the presence of FDI. Because of this feature, firm M may force firm S to exit from the market in the incumbent case and may not allow firm S to enter the market in the potential-entrant case.

6 Concluding Remarks

In the presence of technology spillovers through FDI, we have pointed out strategic incentives for a North downstream firm to invest in the South. There are two cases. In the potential-entrant case, the South downstream firm can enter the market only if FDI is undertaken. In the incumbent case, the South downstream firm can serve the market without FDI. In both cases, FDI makes the South downstream firm more efficient and changes the derived demand for the intermediate good, which in turn affects the intermediate-good supplier. Although FDI could benefit the North downstream firm in both cases, the causes are different.

In the potential-entrant case, if FDI induces the potential entrant to enter the market, the intermediate-good price falls because the South entrant is less efficient than the North firm. If this positive effect dominates the negative effect caused by the creation of a new rival, then the North downstream firm is willing to invest in the South. Interestingly, all producers and consumers benefit from such FDI. This is basically because the distortion due to double marginalization is weakened. The upstream firm gains, because it has to decrease the intermediate-good price to serve both downstream firms but the derived demand for the intermediate good increases by the entry.

In the incumbent case, FDI makes the South downstream firm more competitive, but leads the upstream firm to set the uniform price. Since the North firm is more efficient than the South firm, the uniform pricing either lowers the intermediate-good price faced by the North firm or forces the South firm to exit from the market. If the South firm exits, the North firm gains from FDI but the other firms and consumers lose. Even if the South firm remains to stay, the reduction of the intermediate-good price may benefit the North firm. If it does, FDI could result in Pareto gains. FDI generates technology spillovers to the South firm and hence the South firm can gain even if FDI increases the intermediate-good price faced by it. FDI does not allow the upstream firm to price-discriminate between two downstream firms anymore but technology spillovers to the South firm expand the derived demand for the intermediate good. If the latter effect exceeds the former, the upstream firm gains.

Using the basic setup, we have also examined three policy measures (i.e. IPR protection, production taxes with tax exemption, and import/export or production subsidies) to attract FDI. Surprisingly, tight IPR protection in the South may not induce FDI in the potential-entrant case. Under tight IPR protection, FDI does not result in South firm's entry and hence the intermediate-good price does not fall. Under lax IPR protection, on the other hand, the decrease in the intermediate-good price is too small to benefit the investing firm. In the incumbent case, tight IPR protection generates FDI, but the South firm is driven out from the market. The reason why the South firm has to exit is not that it cannot imitate North technology but that the upstream firm raises the intermediate-good price. In both potential-entrant and incumbent cases, very rigorous IPR protection is not beneficial for the South. A production tax coupled with tax exemption to the North downstream can induce FDI. A subsidy to import the intermediate good is equivalent to a subsidy to produce or export the final good. Those subsidies may also lead to FDI. Under the subsidies, FDI generates technology spillovers to the South firm, but South welfare actually deteriorates. We can rank the three measures from the welfare point of view in the potential-entrant case. From the viewpoint of South welfare, the best is production taxes with tax exemption, followed by IPR protection and then subsidies. From the viewpoint of North welfare, the best is subsidies. Production taxes with tax exemption and IPR protection result in the same welfare level for the North.

There are various reasons to undertake FDI. This paper has identified an unknown motive for FDI in an oligopoly model. It is an indirect linkage generated by FDI that benefits the investing firm. That is, the investing downstream firm gains from FDI which affects the intermediate-good supplier indirectly through horizontal technology spillovers within the final-good sector. Thus, this is not a simple backward linkage often indicated in the literature of technology transfer. The empirical investigation of this kind of linkage is left for future research.

Appendix

Parameter Values in the Incumbent Case

In the incumbent case, firm M gains from firm N's FDI if $c_N \leq c_S < c_3$. We check if there actually exist some parameter values under which $c_N < c_3$ holds. Suppose $c_N = 0$. Then, $\Delta\pi_M^I > 0$ if $0 \leq c_S < c_3 = 2(b - \sqrt{b^2 - b\overline{c}_S + \overline{c}_S^2})$. By recalling footnote 15, $0 < \overline{c}_S < b/2$ for the incumbent case. c_3 takes the maximum value $(2-\sqrt{3})b$ at $\overline{c}_S = b/2$ without any constraint. Thus, $0 < c_3 < (2-\sqrt{3})b$ holds with $0 < \overline{c}_S < b/2$. This implies that given $\overline{c}_S \in (0, b/2)$ and $c_N = 0$, we can always find some range of c_S which satisfies $0 \leq c_S < c_3$.

Next we show that FDI may result in Pareto gains in the incumbent case. By recalling that both firms N and S gain from FDI if $c_4 < c_S < \min\{c_2, c_5\}$, i.e., $(3c_N + 2\overline{c}_S)/5 < c_S < \min\{\left(2-\sqrt{3}\right)b + (\sqrt{3}-1)c_N, (3c_N + 4\overline{c}_S)/7\}$, $c_3 > c_4$ is necessary for Pareto gains. Again, supposing $c_N = 0$, we check the condition under which $c_3 > c_4$ holds. We can easily verify $c_3 > c_4$ if $0 < \overline{c}_S < 5b/8$. By noting $0 < \overline{c}_S < b/2$ for the incumbent case, $c_3 > c_4$ always holds. Then we now check if there actually exists some range of c_S which satisfies $c_4 < c_S < \min\{c_2, c_3, c_5, \overline{c}_S\}$. For example, suppose $\overline{c}_S = b/4$ in addition to $c_N = 0$. Then $c_4 < c_S < \min\{c_2, c_3, c_5, \overline{c}_S\}$ becomes $b/10 < c_S < \min\{\left(2-\sqrt{3}\right)b, \left(2-\sqrt{13}/2\right)b, b/7, b/4\}$, i.e., $b/10 < c_S < b/7$.

If $c_2 < c_4$, then FDI forces firm S to exit from the market. With $c_N = 0$, $c_2 < c_4$ holds when $\overline{c}_S > 5\left(2-\sqrt{3}\right)b/2$.

Subsidies

In this appendix, we show Lemmas 7-9 obtained in the subsidy analysis. In the presence of FDI, firm M always serves both firms N and S, because firm S is as efficient as firm N under FDI and firm M has no incentive to stop serving firm S. We first derive the equilibrium with FDI. In the case of the import subsidy, s_I, (4) and (5) are not affected except for $c_S = c_N$. Thus, the intermediate-good price charged by firm M is

$$r^{SS*}(s_I) = \frac{b - c_N - s_I}{2}.$$

Then we obtain

$$\begin{aligned}
x_N^{SS*}(s_I) &= x_S^{SS*}(s_I) = \frac{b - c_N + s_I}{6a}, \\
X^{SS*}(s_I) &= \frac{b - c_N + s_I}{3a}, \\
\pi_N^{SS*}(s_I) &= \pi_S^{SS*} = \frac{1}{36a}\left(b - c_N + s_I\right)^2, \\
\pi_M^{SS*}(s_I) &= \frac{(b - c_N + s_I)^2}{6a}.
\end{aligned}$$

In the case of the export or production subsidy, s_X, both $(c_S + r)$ and $(c_N + r)$ in (4) and (5) are replaced by $(c_N - s_X + r)$, that is,

$$\begin{aligned} x_N^{SS}(s_X) &= x_S^{SS}(s_X) = \frac{b - (c_N - s_X + r)}{3a}, \\ X^{SS}(s_X) &= \frac{2[b - (c_N - s_X + r)]}{3a}. \end{aligned}$$

Then we obtain

$$\begin{aligned} r^{SS*}(s_X) &= \frac{b - c_N + s_X}{2}, \\ x_N^{SS*}(s_X) &= x_S^{NS*} = \frac{b - c_N + s_X}{6a}, \\ X^{SS*}(s_X) &= \frac{b - c_N + s_X}{3a}, \\ \pi_N^{SS*}(s_X) &= \pi_S^{NS*}(s_X) = \frac{1}{36a}\left(b - c_N + s_X\right)^2, \\ \pi_M^{SS*}(s_X) &= \frac{(b - c_N + s_X)^2}{6a}. \end{aligned}$$

We next obtain the equilibrium without FDI. Obviously, no subsidy is provided in the potential-entrant case. Thus, we consider the incumbent case. In the case of the import subsidy, we obtain

$$r_N^{NS*}(s_I) = \frac{b - c_N}{2}, r_S^{NS*}(s_I) = \frac{b - \bar{c}_S - s_I}{2}.$$

Then

$$\begin{aligned} x_N^{NS*}(s_I) &= \frac{b - 2c_N + \bar{c}_S - s_I}{6a}, x_S^{NS*}(s_I) = \frac{b + c_N - 2c_S + 2s_I}{6a}, \\ X^{NS*}(s_I) &= \frac{2b - c_N - \bar{c}_S + s_I}{6a}, p^{NS*}(s_I) = \frac{1}{6}\left(4b + c_N + \bar{c}_S - s_I\right), \\ \pi_N^{NS*}(s_I) &= \frac{1}{36a}\left(b - 2c_N + \bar{c}_S - s_I\right)^2, \pi_S^{NS*}(s_I) = \frac{1}{36a}\left(b + c_N - 2\bar{c}_S + 2s_I\right)^2, \\ \pi_M^{NS*}(s_I) &= \frac{1}{6a}\left(b^2 + bs_I - bc_N - b\bar{c}_S + s_I^2 + s_I c_N - 2s_I\bar{c}_S + c_N^2 - c_N\bar{c}_S + \bar{c}_S^2\right) \end{aligned}$$

In the case of the export or production subsidy,

$$x_N^{NS}(s_X) = \frac{b + (\bar{c}_S - s_X + r_S) - 2(c_N + r_N)}{3a}, x_S^{NS}(s_X) = \frac{b + (c_N + r_N) - 2(\bar{c}_S - s_X + r_S)}{3a},$$

Then

$$\begin{aligned} r_N^{NS*}(s_X) &= \frac{b - c_N}{2}, r_S^{NS*}(s_X) = \frac{b - \bar{c}_S + s_X}{2}, \\ x_N^{NS*}(s_X) &= \frac{b - 2c_N + \bar{c}_S - s_X}{6a}, x_S^{NS*}(s_X) = \frac{b + c_N - 2\bar{c}_S + 2s_X}{6a}, \\ \pi_N^{NS*}(s_X) &= \frac{1}{36a}\left(b - 2c_N + \bar{c}_S - s_X\right)^2, \pi_S^{NS*}(s_X) = \frac{1}{36a}\left(b + c_N - 2\bar{c}_S + 2s_X\right)^2, \\ \pi_M^{NS*}(s_X) &= \frac{1}{6a}\left(b^2 + bs_X - bc_N - b\bar{c}_S + s_X^2 + s_X c_N - 2s_X\bar{c}_S + c_N^2 - c_N\bar{c}_S + \bar{c}_S^2\right). \end{aligned}$$

Thus, Lemma 7 is immediate. In the following, therefore, we let s denote the subsidy rate.

Noting that in the presence of FDI, firm M always serves both firms N and S, we compare the profits of firm M with and without FDI. In the potential-entrant case, we have

$$\begin{aligned}\Delta\pi_M(s) &\equiv \pi_M^{SS*}(s) - \pi_M^{N*}(s) = \frac{(b-c_N+s)^2}{6a} - \frac{1}{8a}(b-c_N)^2 \\ &= \frac{1}{24a}\left(b^2 - 2bc_N + 8bs + c_N^2 - 8c_N s + 4s^2\right),\end{aligned}$$

$\Delta\pi_M = 0$ holds at $s = \left(\sqrt{3}-2\right)(b-c_N)/2$ and $-\left(\sqrt{3}+2\right)(b-c_N)/2$, both of which are negative. This implies $\Delta\pi_M > 0$ for any $s > 0$. In the incumbent case,

$$\begin{aligned}\Delta\pi_M(s) &\equiv \pi_M^{SS*}(s) - \pi_M^{NS*}(s) \\ &= \frac{(b-c_N+s)^2}{6a} - \frac{b^2 + bs - bc_N - b\overline{c}_S + s^2 + sc_N - 2s\overline{c}_S + c_N^2 - c_N\overline{c}_S + c_S^2}{6a} \\ &= \frac{1}{6a}\left((b - 3c_N + 2\overline{c}_S)s + (\overline{c}_S - c_N)(b - \overline{c}_S)\right),\end{aligned}$$

which is positive for any $s > 0$. Thus, Lemma 8 follows.

In the potential-entrant case, comparing the profits of firm N with and without FDI, we have

$$\Delta\pi_N^E(s) \equiv \pi_N^{SS*}(s) - \pi_N^{N*}(s) = -\frac{1}{144a}\left(5b^2 - 8bs - 10bc_N - 4s^2 + 8sc_N + 5c_N^2\right).$$

$\Delta\pi_N = 0$ holds at $s = -5(b-c_N)/2$ and $(b-c_N)/2$. Since $-5(b-c_N)/2 < 0 < (b-c_N)/2$, $\Delta\pi_N^E(s) > 0$ if $s > (b-c_N)/2$. In the incumbent case,

$$\Delta\pi_N^I(s) \equiv \pi_N^{SS*}(s) - \pi_N^{NS*}(s) = \frac{1}{36a}(b-c_N+s)^2 - \frac{1}{36a}(b - 2c_N + \overline{c}_S - s)^2,$$

which implies $\Delta\pi_N^I(s) > 0$ holds if $s > (c_S - c_N)/2$. Thus, Lemma 9 follows.

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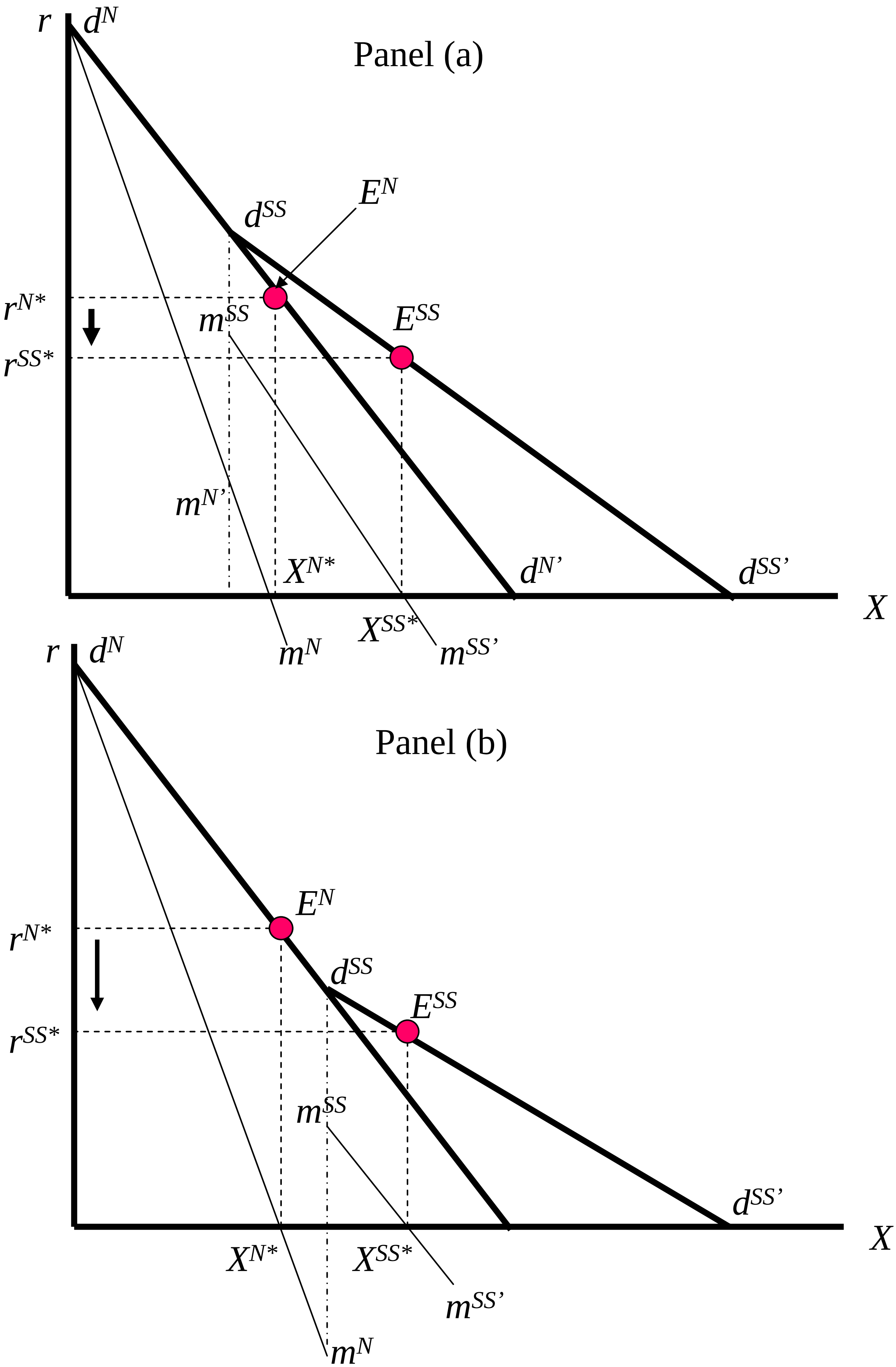

Figure 1: Intermediate-good market

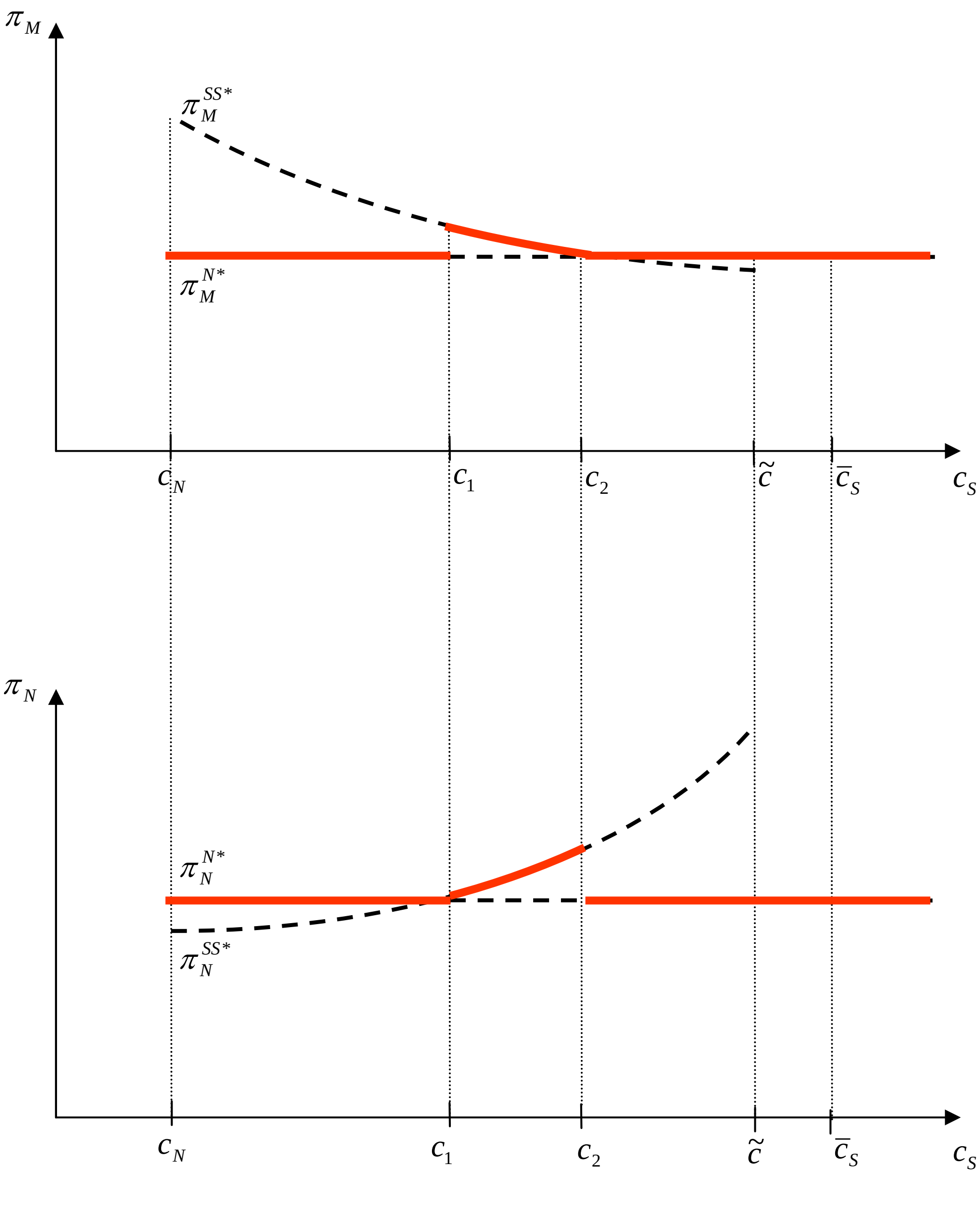

Figure 2: Relationship between profits and marginal cost:
Potential-Entrant case

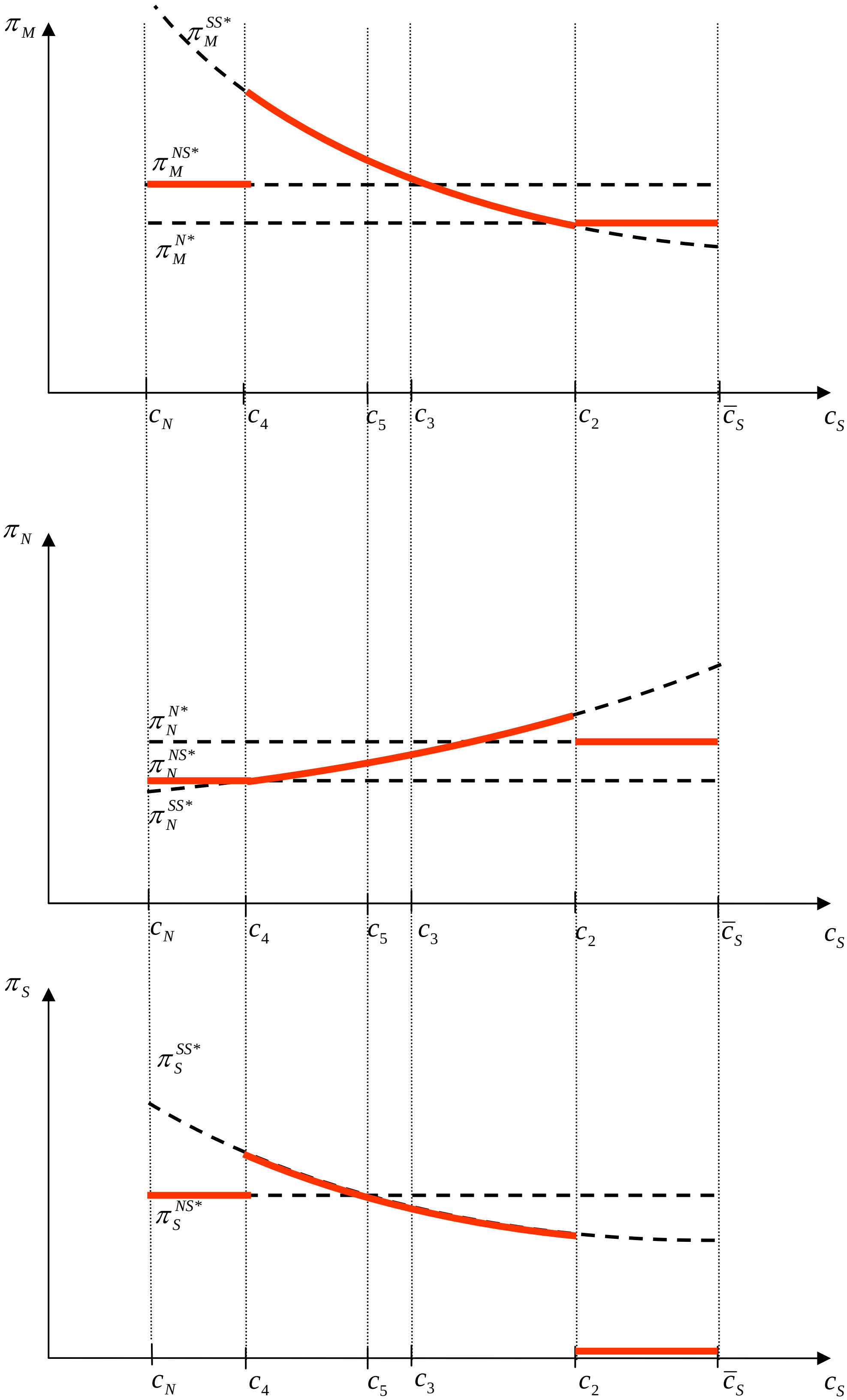

Figure 3: Relationship between profits and marginal cost: Incumbent case