STAY OR LEAVE?
CHOICE OF PLANT LOCATION
WITH COST HETEROGENEITY*

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Abstract

Using a two-country model, we examine location choices by two domestic firms when they serve only the domestic market and their cost structures differ. The findings indicate that whether the firm that has a greater incentive for foreign direct investment (FDI) is more or less efficient depends on the differences in domestic and foreign marginal costs, trade costs, and the presence of fixed costs. Plant locations may not be uniquely determined. In particular, a small change in trade costs may reverse plant location. Moreover, a decrease in transport costs in the presence of FDI may deteriorate domestic welfare.

Keywords: foreign direct investment; heterogeneous firms; oligopoly; location choices; reverse imports

JEL Classification: F12, F21, F23

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1 Introduction

Foreign direct investment (FDI) has been growing rapidly. In particular, the global flow of FDI has dramatically increased over the last quarter century. There are two kinds of FDI. The first serves only the host market; the second, by exporting products to other markets (including the source country), is referred to as export-platform FDI. Although there are many reasons for FDI, one of the most important reasons for export-platform FDI is low production costs in the host country. For example, many firms shift their production facilities to developing countries such as China and Vietnam because of cheap labor. However, we can attribute recent growth in export-platform FDI not only to low production costs, but also to falling trade costs, including transport costs, tariffs, and communications costs. In particular, recent improvements in transportation and communications technology allow firms to locate their plants all over the world to lower production costs.[1]

When products are exported back to the source country, it is called "reverse imports" from the viewpoint of the source country.[2] Recently, reverse imports have been observed throughout the world. For example, many Japanese firms have invested in Asian countries to serve the Japanese market.[3] Figure 1 shows reverse imports as a percentage of the total sales of Japanese affiliates in China, the ASEAN 4 (Thailand, the Philippines, Malaysia, and Indonesia), and the NIES 3 (Singapore, Korea, and Taiwan). In particular, the share of reverse imports for precision machinery has been high in all of these regions and the share of reverse imports for industrial machinery has been high in China and ASEAN 4.[4] According to Liu and Huang (2005), Taiwanese reverse imports comprise about 40% of foreign affiliate production. Many Taiwanese firms invest in China for reverse imports. Moreover, Ekholm et al. (2007) argue that while overall export sales to the US by US manufacturing affiliates amounted to 13% of sales in 2003, it exceeded 30% for US manufacturing affiliates in Malaysia, the Philippines, Canada, and Mexico.

It is often observed in many industries that while some firms produce abroad, others stay at home. An interesting question is why this occurs. This paper tackles this question in the context of reverse imports. It is quite natural to conjecture that plant location is strongly affected by cost structures. Thus, we specifically pay attention to inter-firm cost asymmetry. We examine which firm has a greater incentive for FDI, a more efficient firm or a less efficient firm. To this end, we construct a simple Cournot model with cost heterogeneity and investigate the relationship

[1] Grossman and Rossi-Hansberg (2008) state "Indeed, improvements in transportation and communications technology have spurred the rapid growth of offshoring in a wide range of sector." For empirical support, see Hanson et al. (2001), for example.

[2] Ekholm et al. (2007) refer to this kind of FDI as home-country export-platform FDI. When products are exported to third countries, they are referred to as third-country export-platform FDI.

[3] Significant amounts of reverse imports also exist between developed countries. Greaney (2003) finds "Reverse imports accounted for 51.2% of Japan's total imports from the US in 1987 and 39.8% in 1997." See also Ekholm et al. (2007).

[4] In 2004, the share of Japanese reverse imports amounted to 19.1% of total Japanese imports and about 80% of reverse imports is from Asia. Japanese plants in Asia export 20% of their products to Japan (The Nikkei, April 25, 2006).

between firms' location choices and trade costs. In our model, there are two countries (domestic and foreign) and two domestic firms whose marginal costs (MCs) are different. Both firms choose their production locations to serve the domestic market. We find that trade costs and the cost differences within a firm (i.e., the difference between domestic and foreign MCs) play a crucial role. Moreover, in the presence of fixed costs (FCs), multiple equilibria may exist and a small change in trade costs can reverse plant locations.

Many studies theoretically analyze the location choices of multinational firms (MNFs), including the choice between exports and FDI (local production) and the choice between North and South countries, etc. (see Horstmann and Markusen, 1992; Yeaple, 2003; and Ekholm et al., 2007, among others). However, oligopolistic models typically assume a single firm in each country.[5] The cost asymmetry among firms of the same nationality has been paid relatively little attention.[6] With the exception of Katayama et al. (2005), location choices among heterogeneous firms of the same nationality have not been analyzed in oligopolistic settings.[7]

Qiu and Tao (2001) examine the choice between FDI and exports by two heterogeneous firms. In their paper, FCs are assumed away and heterogeneity stems from different MCs. In contrast, FCs play an important role in the current analysis. Moreover, the focus in Qiu and Tao (2001) is on the relationship between local content requirement and location choice. They show that the less productive firm engages in FDI if the two firms are located in different countries.

There is empirical and theoretical literature that relates firm heterogeneity to plant location in monopolistically competitive models, as originally developed by Montagna (1995) and Melitz (2003). In particular, Helpman et al. (2004) show why exporting firms and MNFs coexist and, by using firm-level data, find that more productive firms engage in FDI.[8] However, Head and Ries (2003) and Yeaple (2005) show that this finding is not necessarily the case.[9]

Ishikawa and Miyagiwa (2005) extend our static analysis to a dynamic framework. They specifically investigate the relationship between inter-firm cost asymmetry and the timing of international outsourcing or FDI. In particular, they show that a more efficient firm does not

[5] In Horstmann and Markusen (1992), for example, a domestic firm and a foreign firm serve both the domestic and foreign markets. In Xing and Zhao (2008), a domestic firm and a foreign firm compete only in the domestic market. In response to changes in exchange rates, the domestic firm alone undertakes FDI–generating reverse imports.

[6] In the international oligopoly framework, a number of papers, such as Neary (1994), are concerned with cost asymmetries across countries. However, only a few studies consider asymmetry within a country. Exceptions include Long and Soubeyran (1997), Lahiri and Ono (1997), and Ishikawa and Komoriya (2008). In Ishikawa and Komoriya (2008), the companion to the present paper, we fully examine the welfare effects of trade costs and foreign wage rates in the presence of inter-firm cost asymmetry.

[7] In Katayama et al. (2005), each firm chooses either home-country export-platform FDI or third-country export-platform FDI. Assuming two identical domestic firms (potential MNFs), Yomogida (2007) considers the choice between foreign and domestic production to serve the domestic market and shows the possibility of socially undesirable offshoring.

[8] Grossman et al. (2006) also theoretically explore the coexistence of various patterns of FDI in the same industry. Nocke and Yeaple (2007) analyze the choice among exports, M&A, and greenfield FDI.

[9] Sinn (2004), for instance, reports that 60% of German small and medium firms have established plants outside the old EU.

always undertake FDI before a less efficient one.

The rest of the paper is organized as follows. In Section 2, we present the basic model. We examine the effects of trade-cost reductions on firms' profits in different regimes. In Section 3, we analyze the location choices with and without plant-specific FCs. In Section 4, we explore the welfare effects of transport costs with FCs. Section 5 concludes the paper.

2 Basic Model

We consider a duopoly model where there are two countries (domestic and foreign) and two domestic firms (firms 1 and 2). Both firms produce a homogeneous good in either domestic country or foreign country and serve only domestic market.[10] The model involves two stages of decision. In stage 1, both firms simultaneously choose their plant locations.[11] Plant locations are determined by Nash equilibrium. In stage 2, the firms compete in quantities with Cournot conjectures. The game is solved by backward induction.

The inverse demand function is given by

$$P = P(X); \quad P' < 0, \tag{1}$$

where X and P are, respectively, the demand and consumer price. We define the elasticity of the slope of the inverse demand function for the following analysis:

$$\epsilon(X) \equiv -\frac{XP''(X)}{P'(X)}.$$

The (inverse) demand curve is concave if $\epsilon(X) \leq 0$ and convex if $\epsilon(X) \geq 0$. In the following analysis, we assume $\epsilon(X) < 1$, implying that the goods produced by the two firms are strategic substitutes (i.e., $P' + P''x_i < 0$ where x_i is the output of firm i $(i = 1, 2)$).[12]

The profits of firm i $(i = 1, 2)$ are given by

$$\Pi_i(x_i; t) = (P(X) - t)x_i - C_i(x_i), \tag{2}$$

where t is a specific trade cost such as transport costs and $C_i(\cdot)$ is the cost function. The firms incur the trade cost only when they produce in the foreign country. The cost function of firm i $(i = 1, 2)$ is given by

$$C_i(x_i) = \begin{cases} c_i x_i + f_i \\ c_i^* x_i + f_i^* \end{cases},$$

where c_i and f_i are, respectively, a constant MC and a plant-specific FC. An asterisk denotes the parameters in the case of foreign production. We assume that firm 1 is more efficient than firm 2 in the sense that $c_1 < c_2$, $c_1^* < c_2^*$, $f_1 = f_2 (\equiv f)$, and $f_1^* = f_2^* (\equiv f^*)$;[13] and that the MCs are

[10] For example, all goods produced in export processing zones must be exported.

[11] Ishikawa and Miyagiwa (2005) consider the case of preemption in a dynamic framework.

[12] For further details, see Furusawa et al. (2003).

[13] Even if the FCs differ between the firms, the most important results are still valid.

lower in the foreign country, i.e., $c_i > c_i^*$ for $i = 1, 2$. The "effective" MC is c_i $(i = 1, 2)$ without FDI but is $c_i^* + t$ with FDI.

The first-order conditions for profit maximization are $(i = 1, 2)$

$$\frac{\partial \Pi_i}{\partial x_i} = P + P' x_i - (C_i' + t) = 0. \tag{3}$$

With $\epsilon(X) < 1$, the second-order sufficient conditions $(i = 1, 2)$:

$$2P' + P'' x_i = P'(2 - \epsilon \sigma_i) < 0 \tag{4}$$

and the stability condition:

$$|\Omega| = P'(3P' + P''X) = (P')^2(3 - \epsilon) > 0 \tag{5}$$

where σ_i is the market share of firm i (i.e., $\sigma_i \equiv x_i/X$) and

$$\Omega \equiv \begin{pmatrix} 2P' + P''x_1 & P' + P''x_1 \\ P' + P''x_2 & 2P' + P''x_2 \end{pmatrix}$$

are satisfied. While only one firm may serve the market in equilibrium, in the following analysis we focus on the equilibrium where both firms serve the market.

We first examine the effects of a change in t on equilibrium profits. For this, we need to obtain the effects of a change in t on outputs. When firm i produces in the domestic country but firm j produces in the foreign country, we have

$$\begin{pmatrix} \frac{dx_i}{dt} \\ \frac{dx_j}{dt} \end{pmatrix} = \frac{1}{|\Omega|} \begin{pmatrix} 2P' + P''x_j & -(P' + P''x_i) \\ -(P' + P''x_j) & 2P' + P''x_i \end{pmatrix} \begin{pmatrix} 0 \\ 1 \end{pmatrix}.$$

Thus, the effects on outputs are

$$\frac{dx_i}{dt} = -\frac{P' + P''x_i}{|\Omega|} > 0, \quad \frac{dx_j}{dt} = \frac{2P' + P''x_i}{|\Omega|} < 0, \ \frac{dX}{dt} = \frac{P'}{|\Omega|} < 0. \tag{6}$$

Using the first-order conditions and (6), we can obtain

$$\frac{d\Pi_i}{dt} = \frac{P'x_i}{|\Omega|}(2P' + P''x_i) > 0, \tag{7}$$

$$\frac{d\Pi_j}{dt} = -\frac{(P')^2 x_j}{|\Omega|}(4 - \epsilon - \epsilon\sigma_i) < 0. \tag{8}$$

Thus, when t falls, the profits of firm i decrease and those of firm j increase.

When both firms produce in the foreign country, we have:

$$\begin{pmatrix} \frac{dx_1}{dt} \\ \frac{dx_2}{dt} \end{pmatrix} = \frac{1}{|\Omega|} \begin{pmatrix} 2P' + P''x_2 & -(P' + P''x_1) \\ -(P' + P''x_2) & 2P' + P''x_1 \end{pmatrix} \begin{pmatrix} 1 \\ 1 \end{pmatrix}.$$

Thus, the effects on outputs are[14]

$$\frac{dx_1}{dt} = \frac{P' + P''(x_2 - x_1)}{|\Omega|} = \frac{P'}{|\Omega|}\{1 - \epsilon(1 - \sigma_1) + \epsilon\sigma_1\} = \frac{P'}{|\Omega|}(1 - \epsilon + 2\epsilon\sigma_1), \tag{9}$$

$$\frac{dx_2}{dt} = \frac{P' + P''(x_1 - x_2)}{|\Omega|} = \frac{P'}{|\Omega|}(1 + \epsilon - 2\epsilon\sigma_1) < 0, \tag{10}$$

$$\frac{dX}{dt} = \frac{2P'}{|\Omega|} < 0. \tag{11}$$

Using the first-order conditions and equations (9) through (10), we can obtain ($i = 1, 2$)

$$\frac{d\Pi_i}{dt} = -\frac{2P'x_i}{|\Omega|}(P' + P''x_j) < 0. \tag{12}$$

Therefore, when both firms produce in the foreign country, they gain from a lower t.

3 Location Choices

3.1 Location Choices without FCs

We are now ready to examine the relationship between trade costs and firms' location choices. As a benchmark, we briefly examine in this subsection the case where no FCs exist (i.e. $f = f^* = 0$).[15] It is obvious that in the absence of FCs, the firm's location decision does not depend on the other firm's decision. That is, in stage 1, dominant strategies exist for both firms. Regardless of the rival firm's decision, the firm chooses a location that results in a lower "effective" MC. Firm i ($i = 1, 2$) produces in the domestic country if and only if

$$\Delta c_i \equiv c_i - c_i^* \leq t. \tag{13}$$

If t is high enough (i.e., if $t \geq \max\{\Delta c_1, \Delta c_2\}$), both firms choose domestic production. On the other hand, if t is low enough (i.e., if $t < \min\{\Delta c_1, \Delta c_2\}$), both firms choose foreign production. It is possible that one firm produces in the domestic country while the other produces in the foreign country. Whereas firm 1 produces in the domestic country and firm 2 produces in the foreign country if $\Delta c_1 \leq t < \Delta c_2$, firm 1 produces in the foreign country and firm 2 produces in the domestic country if $\Delta c_2 \leq t < \Delta c_1$. Intuitively, the firm that can save more "real" MC through foreign production has a greater incentive for FDI. When $\Delta c_1 = \Delta c_2$, both firms simultaneously shift their production from the domestic country to the foreign country as t falls.

3.2 Location Choices with FCs

In this subsection, we introduce plant-specific FCs into the analysis. Once FCs are present, the production-location decision also depends on the level of output, and so decisions by one firm

[14] A decrease in t always raises the output of the less efficient firm but may lower the output of the more efficient firm if $\epsilon < -1$. For details, see Ishikawa and Komoriya (2006).

[15] See also Ishikawa and Komoriya (2008).

also affect those of the other firm. This leads to a potentially unlimited number of cases to be considered. Therefore, in the following analysis, we focus on a case with linear demand: $P = A - aX$ (i.e., $\epsilon = 0$). We still keep the assumptions $c_1 < c_2$, $c_1^* < c_2^*$, $f_1 = f_2 (\equiv f)$, $f_1^* = f_2^* (\equiv f^*)$, and $c_i > c_i^*$ for $i = 1, 2$. We further simplify the analysis by assuming $\Delta f \equiv f^* - f > 0$ and $f = 0$.[16]

We let DD (FF) and DF (FD) respectively denote the case where both firms are located in the domestic (foreign) country and the case where firm 1 is located in the domestic (foreign) country while firm 2 is located in the foreign (domestic) country. For example, Π_i^{FD} is the profits of firm i when firm 1 produces abroad and firm 2 produces at home.

Given that the rival firm (i.e., firm 2) produces in the domestic country, firm 1 will undertake FDI if $\Delta\Pi_1^D \equiv \Pi_1^{FD} - \Pi_1^{DD} > 0$. Similarly, given that firm 1 produces at home, firm 2 will produce abroad if $\Delta\Pi_2^D \equiv \Pi_2^{DF} - \Pi_2^{DD} > 0$. Since $\Delta f = f^* > 0$, firm i now has no incentive to locate its plant in the foreign country when $\Delta c_i = t$. Therefore, we let t_i^D denote the trade cost that makes $\Delta\Pi_i^D = 0$ hold. That is, at t_i^D, firm i is indifferent between domestic and foreign production, given that the rival firm stays in the domestic country. Similarly, given that the rival firm produces in the foreign country, firm i will undertake FDI if $\Delta\Pi_i^F > 0$ (where $\Delta\Pi_1^F \equiv \Pi_1^{FF} - \Pi_1^{DF}$ and $\Delta\Pi_2^F \equiv \Pi_2^{FF} - \Pi_2^{FD}$).[17] We also let t_i^F denote the trade cost that leads to $\Delta\Pi_i^F = 0$. Obviously, $\max\{t_i^D, t_i^F\} < \Delta c_i$ holds.

$\Delta\Pi_i^k$ ($i = 1, 2; k = D, F$) is derived in Appendix A (see (A1) and (A2)). To facilitate the following analysis, we illustrate $\Delta\Pi_i^k = 0$ in Figures 2 and 3. Figure 2 shows the case where $\Delta c_1 > \Delta c_2$ holds and Figure 3 the case where $\Delta c_1 < \Delta c_2$. When $f^* = 0$, $\Delta\Pi_i^k = 0$ holds at $t = \Delta c_i$ (see (13)). Moreover, when $f^* > 0$, $\Delta\Pi_i^k = 0$ holds at some t which is less than Δc_i; and $\Delta\Pi_i^k = 0$ is downward sloping.[18] By noting

$$\Delta\Pi_i^D - \Delta\Pi_i^F = \frac{4\,(\Delta c_i - t)\,(\Delta c_j - t)}{9a}, \quad j = 1, 2; i \neq j, \tag{14}$$

$\Delta\Pi_i^D = 0$ and $\Delta\Pi_i^F = 0$ intersect with each other at $t = \Delta c_j$ as well as at $t = \Delta c_i$. At $t = \Delta c_j$, the effective MC of firm j in the foreign country is identical with that in the domestic country. This implies $\Pi_1^{DD} = \Pi_1^{DF}$ and $\Pi_1^{FD} = \Pi_1^{FF}$ with $j = 2$ and $\Pi_2^{DD} = \Pi_2^{FD}$ and $\Pi_2^{FF} = \Pi_2^{DF}$ with $j = 1$. Thus, the location decision of firm i does not depend on the rival firm's decision. In Figure 2 (Figure 3), $\Delta\Pi_i^D = 0$ is located above $\Delta\Pi_i^F = 0$ when $0 \leq t < \Delta c_2$ ($0 \leq t < \Delta c_1$) and vice versa when $\Delta c_2 \leq t < \Delta c_1$ ($\Delta c_1 \leq t < \Delta c_2$).

The following lemma is immediate.

Lemma 1 *Regardless of the rival's location, firm i produces in the domestic country when* $t \geq \max\{t_i^D, t_i^F\}$ *but in the foreign county when* $t < \min\{t_i^D, t_i^F\}$. *When* $t_i^D \leq t < t_i^F$ ($t_i^F \leq t < t_i^D$), *firm i is located in the domestic (foreign) country if the rival produces in the domestic country, but in the foreign (domestic) country if the rival produces in the foreign country. Moreover,* $t_i^D < \Delta c_i$ *and* $t_i^F < \Delta c_i$ *when* $f^* > 0$, *while* $t_i^D = t_i^F = \Delta c_i$ *in the absence of FCs (i.e.,* $f^* = 0$*).*

[16] This type of FC may include monitoring costs.
[17] Neary (2006) refers to $\Delta\Pi_i^D$ and $\Delta\Pi_i^F$ as the offshoring gain.
[18] $t < \Delta c_i$ is necessary for firm i to undertake FDI.

Depending on the relative sizes of t_i^D and t_i^F $(i = 1, 2)$, we have different location patterns. Since there are four critical values, there are 24 possible orders. However, some are not relevant. The following Lemmas are useful for eliminating the irrelevant cases.

Lemma 2 *If* $t_i^D < t_i^F$, *then* $t_j^F < t_j^D < \Delta c_j < t_i^D < t_i^F$.

Proof. See Appendix B. ■

Lemma 3 *If* $t_2^D \leq t_1^D$, *then* $t_2^F < t_1^F$.

Proof. See Appendix B. ■

Using Lemma 2, we eliminate 16 cases. And using Lemma 3, we eliminate an additional case (i.e., $t_1^F < t_2^F < t_2^D < t_1^D$). That is, the following seven cases are possible: $t_j^F < t_j^D < t_i^D < t_i^F$, $t_j^F < t_j^D < t_i^F < t_i^D$, $t_j^F < t_i^F < t_j^D < t_i^D$ $(i, j = 1, 2; i \neq j)$, and $t_2^F < t_1^F < t_1^D < t_2^D$.[19]

Invoking Lemma 1, we examine the plant locations determined by Nash equilibrium. For example, suppose $t_2^F < t_2^D < t_1^D < t_1^F$. We first consider the strategy of firm 1. Recalling the definition of t_1^D and t_1^F, firm 1 produces in the domestic country if $t \geq t_1^F$ and in the foreign country if $t < t_1^D$ regardless of firm 2's strategy. If $t_1^D \leq t < t_1^F$, firm 1 chooses the same location as firm 2. The strategy of firm 2 is as follows. Regardless of firm 1's strategy, firm 2 produces in the domestic country if $t \geq t_2^D$ and in the foreign country if $t < t_2^F$. Given firm 1's location, firm 2 chooses a different location if $t_2^F \leq t < t_2^D$. This is summarized in Case I in Table 1. Thus, we obtain the following Nash equilibrium. If $t \geq t_1^D$, both firms produce in the domestic country. If $t_2^F \leq t < t_1^D$, firm 1 produces in the foreign country while firm 2 produces in the domestic country. If $t < t_2^F$, both firms produce in the foreign country. Thus, a lower t leads to a greater incentive for the more efficient firm (i.e., firm 1) to undertake FDI. In this manner, we can find the Nash equilibrium.

In view of Table 1, we can summarize the location patterns as follows:

1. Cases I and II. $t_j^F < t_j^D < t_i^D < t_i^F$ $(i, j = 1, 2; i \neq j)$ or $t_j^F < t_j^D < t_i^F < t_i^D$ $(i, j = 1, 2; i \neq j)$: In these cases, if $t \geq t_i^D$ $(t < t_j^F)$, both firms produce in the domestic (foreign) country. If $t_j^F \leq t < t_i^D$, firm i produces in the foreign country while firm j produces in the domestic country.[20]

2. Case III. $t_j^F < t_i^F < t_j^D < t_i^D$ $(i, j = 1, 2; i \neq j)$: As in Cases I and II, both firms produce in the domestic (foreign) country if $t \geq t_i^D$ $(t < t_j^F)$. If either $t_j^F \leq t < t_i^F$ or $t_j^D \leq t < t_i^D$, firm i produces in the foreign country while firm j produces in the domestic country. However, if $t_i^F \leq t < t_j^D$, there are two possible equilibria. In one, firm i produces in the foreign country while firm j produces in the domestic country, and vice versa in the other.

[19] In Appendix A, we verify that these seven cases actually exist.

[20] In Cases I, II, and III, (F,D) ((D,F)) means that firm i produces abroad (at home) and firm j produces at home (abroad) $(i, j = 1, 2; i \neq j)$. This should be distinguished from the above defined FD (DF), which means that firm 1 produces abroad (at home) and firm 2 produces at home (abroad).

Case I. $t_j^F < t_j^D < t_i^D < t_i^F$	$t < t_j^F$	$t_j^F < t < t_j^D$	$t_j^D < t < t_i^D$	$t_i^D < t < t_i^F$	$t_i^F < t$
Best response of firm i ($R_i(D)$, $R_i(F)$)	(F,F)	(F,F)	(F,F)	(D,F)	(D,D)
Best response of firm j ($R_j(D)$, $R_j(F)$)	(F,F)	(F,D)	(D,D)	(D,D)	(D,D)
Nash equilibrium (firm i, firm j)	(F,F)	(F,D)	(F,D)	(D,D)	(D,D)

Case II. $t_j^F < t_j^D < t_i^F < t_i^D$	$t < t_j^F$	$t_j^F < t < t_j^D$	$t_j^D < t < t_i^F$	$t_i^F < t < t_i^D$	$t_i^D < t$
Best response of firm i ($R_i(D)$, $R_i(F)$)	(F,F)	(F,F)	(F,F)	(F,D)	(D,D)
Best response of firm j ($R_j(D)$, $R_j(F)$)	(F,F)	(F,D)	(D,D)	(D,D)	(D,D)
Nash equilibrium (firm i, firm j)	(F,F)	(F,D)	(F,D)	(F,D)	(D,D)

Case III. $t_j^F < t_i^F < t_j^D < t_i^D$	$t < t_j^F$	$t_j^F < t < t_i^F$	$t_i^F < t < t_j^D$	$t_j^D < t < t_i^D$	$t_i^D < t$
Best response of firm i ($R_i(D)$, $R_i(F)$)	(F,F)	(F,F)	(F,D)	(F,D)	(D,D)
Best response of firm j ($R_j(D)$, $R_j(F)$)	(F,F)	(F,D)	(F,D)	(D,D)	(D,D)
Nash equilibrium (firm i, firm j)	(F,F)	(F,D)	(F,D) or (D,F)	(F,D)	(D,D)

Case IV. $t_2^F < t_1^F < t_1^D < t_2^D$	$t < t_2^F$	$t_2^F < t < t_1^F$	$t_1^F < t < t_1^D$	$t_1^D < t < t_2^D$	$t_2^D < t$
Best response of firm 1 ($R_1(D)$, $R_1(F)$)	(F,F)	(F,F)	(F,D)	(D,D)	(D,D)
Best response of firm 2 ($R_2(D)$, $R_2(F)$)	(F,F)	(F,D)	(F,D)	(F,D)	(D,D)
Nash equilibrium (firm 1, firm 2)	(F,F)	(F,D)	(F,D) or (D,F)	(D,F)	(D,D)

Table 1: Best response of each firm and Nash equilibrium

3. Case IV. $t_2^F < t_1^F < t_1^D < t_2^D$: If $t \geq t_2^D$ ($t < t_2^F$), both firms produce in the domestic (foreign) country. If $t_1^D \leq t < t_2^D$ ($t_2^F \leq t < t_1^F$), firm 1 produces in the domestic (foreign) country while firm 2 produces in the foreign (domestic) country. If $t_1^F \leq t < t_1^D$, there are two possible equilibria.

The following should be mentioned. First, in all cases, both firms produce in the domestic country if $t \geq \max\{t_1^D, t_2^D\}$ but in the foreign country if $t < \min\{t_1^F, t_2^F\}$.

Second, in the first four cases (i.e., in Cases I and II), the location patterns are similar to those in the case without FCs. That is, as t falls, the regime shifts from DD to DF and then to FF, or from DD to FD and then to FF. This similarity arises in those four cases, because the two critical values of firm i are greater than those of firm j, that is, $\max\{t_j^D, t_j^F\} < \min\{t_i^D, t_i^F\}$ holds. This is likely to arise when the difference between Δc_j and Δc_i is large ($\Delta c_j < \Delta c_i$) and the FCs are small. A small FC of firm i (j) implies that the gap between Δc_i (Δc_j) and t_i^D (t_j^D) or t_i^F (t_j^F) is small.

Third, multiple equilibria arise when neither firm has a dominant strategy. The intuition for multiple equilibria is as follows. For both firms, the effective MCs are lower if they produce in the foreign country. However, if both firms produce in the foreign country, competition becomes so intense that the profits become very small. It is possible that neither firm can cover its FC. Therefore, one of them would rather stay in the domestic country. Thus, only one firm is located in the foreign country. The presence of FCs plays a crucial role here. Relatively high FCs lead to a relatively large gap between t_i^D (t_j^D) and t_i^F (t_j^F). In addition, if the gap between Δc_j and

Δc_i is small, multiple equilibria are likely to arise.

Fourth, because of multiple equilibria, a complete reversal of location patterns may occur between t_i^F and t_j^D in Case III, and does occur between t_1^F and t_1^D in Case IV. It should be noted that all orders of Cases III and IV (i.e., $t_2^F < t_1^F < t_2^D < t_1^D$, $t_1^F < t_2^F < t_1^D < t_2^D$ and $t_2^F < t_1^F < t_1^D < t_2^D$) are possible if $\Delta c_1 < \Delta c_2$, while only $t_2^F < t_1^F < t_2^D < t_1^D$ is possible if $\Delta c_1 > \Delta c_2$. This is because firm 1 always has a greater incentive for FDI if both $\Delta c_1 > \Delta c_2$ and $f_1^* = f_2^* (\equiv f)$ hold.

Fifth, multiple equilibria can arise, even without inter-firm cost asymmetry. In the case of identical firms, however, regimes DF and FD are only possible in multiple equilibria. That is, neither DF nor FD arises as a result of dominant strategies. Thus, in the absence of cost heterogeneity, we cannot claim that the complete reversal of location patterns necessarily occurs.

Lastly, if there exists no inter-firm difference in MC savings, that is, if $\Delta c_1 = \Delta c_2$, only two cases are possible: $t_2^F < t_2^D < t_1^F < t_1^D$ and $t_2^F < t_1^F < t_2^D < t_1^D$. This implies that the more efficient firm (i.e. firm 1) has more incentive for FDI. In addition, the inter-firm difference is not a necessary condition for complete reversal, because complete reversal may occur in the latter case. The firm that can save its real MC more through foreign production has a greater incentive for FDI. Thus, if $\Delta c_1 < \Delta c_2$, firm 2 may have a greater incentive for FDI and $t_2^F < t_1^F < t_1^D < t_2^D$ is possible. In the case of $t_2^F < t_1^F < t_1^D < t_2^D$, when t is relatively high (low), the inter-firm difference in MC savings is important (unimportant) relative to the difference in MCs between the firms. Thus, the less (more) efficient firm has more incentive to invest. If Δc_2 is sufficiently large relative to Δc_1, only firm 2 has a strong incentive for FDI.

The location choices in the multiple equilibria cases are summarized in the following proposition.

Proposition 1 *When $t_j^F < t_i^F < t_j^D < t_i^D$ $(i, j = 1, 2; i \neq j)$, a small change in t may completely reverse the location choices between t_i^F and t_j^D. When $t_2^F < t_1^F < t_1^D < t_2^D$, only the less efficient firm has an incentive to invest if $t_1^D < t < t_2^D$ and only the more efficient firm has an incentive to invest if $t_2^F < t < t_1^F$. Thus, complete reversal does occur between t_1^F and t_1^D.*

4 Welfare effects of transport costs

In this section, we examine the relationship between transport and/or communications costs and domestic welfare as measured by the sum of consumer surplus and firms' profits:[21]

$$W \equiv U(X) - P(X)X + \Pi_1 + \Pi_2, \tag{15}$$

where $dU/dX = P$. Obviously, a change in t does not affect welfare in region DD. In region FF, both firms gain from a decrease in t (see (12)). Consumers also benefit from a lower t, because the price falls. As a result, a lower t leads to higher welfare in region FF. In region DF (region

[21] Ishikawa and Komoriya (2008) examine other welfare effects, including tariffs.

FD), a decrease in t benefits firm 2 (firm 1) and hurts firm 1 (firm 2) (see (7) and (8)). To investigate the case where firm i produces in the domestic country and firm j produces in the foreign country ($i, j = 1, 2; i \neq j$), we differentiate (15) with respect to t and obtain:

$$\begin{aligned} \frac{dW}{dt} &= -XP'\frac{dX}{dt} + \frac{d\Pi_i}{dt} + \frac{d\Pi_j}{dt} = \frac{(P')^2}{|\Omega|}(6\sigma_i - 5), \\ \frac{dW}{dt} &< 0 \Leftrightarrow \sigma_i < 5/6. \end{aligned}$$

Thus, a lower t raises domestic welfare if only the more efficient firm produces in the foreign country, but reduces it if only the less efficient firm produces in the foreign country and its market share is less than 1/6.[22]

Intuitively, a lower t is beneficial, because total supply increases and domestic consumers gain. As pointed out in Lahiri and Ono (1988), however, an increase in the output of the less efficient firm at the expense of the more efficient firm can be detrimental. When the latter effect dominates the former, domestic welfare deteriorates. This is likely the case when the market share of the less efficient firm is small, because the gains for the less efficient firm and consumers become smaller as the share of the less efficient firm becomes smaller. Therefore, a decrease in t reduces domestic welfare only if the plant locations are given by DF.

Next, we consider the welfare effects of a change in t that causes plant-location switches in the presence of FCs. At t_i^D (t_i^F), firm i is indifferent between domestic and foreign production, given that firm j stays in the domestic (foreign) country ($i, j = 1, 2; i \neq j$). However, the profits of firm j discontinuously fall if firm i invests abroad. This is because the effective MC of firm i becomes lower, which in turn decreases the price. In particular, Appendix B proves the following proposition.

Proposition 2 *At critical levels of t, domestic welfare jumps up if only the more efficient firm switches its plant location from the domestic country to the foreign country but goes down if only the less efficient firm switches its plant location from the domestic country to the foreign country.*

Therefore, domestic welfare improves if a decrease in t leads only the more efficient firm to switch its plant location from the domestic country to the foreign country, but may deteriorate if a decrease in t leads only the less efficient firm to switch its plant location from the domestic country to the foreign country.

Moreover, Appendix B proves the following proposition in the case of complete reversal.

Proposition 3 *When plant locations are completely reversed, consumer surplus jumps up if FDI is undertaken by the firm whose FDI can save its real MC more than its rival and the profits of the investing firm become larger. The effects of a complete reversal on domestic welfare are generally ambiguous. However, if $\Delta c_1 > \Delta c_2$, then complete reversal, under which the more efficient firm switches its location from the domestic country to the foreign country and vice versa for the less efficient firm, improves domestic welfare.*

[22] The welfare analysis assumes full employment in the domestic country. In the presence of unemployment, a lower t raises unemployment and may reduce welfare, even if this condition does not hold.

5 Concluding Remarks

Using a simple, two-country, duopoly model, we have analyzed location choices by firms. More specifically, both firms are domestic; they are heterogeneous in the sense that their MCs differ; and they serve only the domestic market. When trade costs are neither very high nor very low, one of the firms has an incentive to engage in FDI. In the absence of FCs, the difference between domestic and foreign MCs is crucial. It should be emphasized that what is crucial is not the cost difference between firms but the cost difference between domestic and foreign production within a firm. In the presence of FCs, we may have multiple equilibria. Moreover, the production location may not monotonically change as trade costs change. However, the difference between domestic and foreign MCs still plays an important role. We have also shown that a decrease in transport and/or communications costs may reduce domestic welfare.

The domestic government may be able to affect trade costs. For instance, this is the case if part of the trade cost are non-tariff barriers (NTBs). In this case, the government may intervene to improve domestic welfare. When the less efficient firm has an incentive to engage in FDI, for example, the government may keep NTBs high to discourage this incentive. In addition, it may lift barriers once the transport cost becomes so low that both firms are willing to undertake FDI.

We have explored location choices in the case of reverse imports. We can regard our analysis as a case of third-country export-platform FDI as long as the trade costs between the domestic country and the third country are negligible. This could be the case if the two countries conclude a regional trade agreement such as an FTA.

We have focused on the case where firms choose to produce either at home or abroad. A firm may shift only a part of its production facilities to the foreign country. Although a complete analysis is left for future research, we believe that the basic insight is the same as in the present study.

Appendix A

In this appendix, we show that seven location patterns obtained with FCs actually exist. In the following equations, $i, j = 1, 2; i \neq j$. The profits are given by

$$\begin{aligned}
\Pi_i^{DD} &= a\left(\frac{A - 2c_i + c_j}{3a}\right)^2, \\
\Pi_1^{FD} &= a\left(\frac{A - 2c_1^* + c_2 - 2t}{3a}\right)^2 - f_1^*, \quad \Pi_2^{FD} = a\left(\frac{A - 2c_2 + c_1^* + t}{3a}\right)^2, \\
\Pi_1^{DF} &= a\left(\frac{A - 2c_1 + c_2^* + t}{3a}\right)^2, \quad \Pi_2^{DF} = a\left(\frac{A - 2c_2^* + c_1 - 2t}{3a}\right)^2 - f_2^*, \\
\Pi_i^{FF} &= a\left(\frac{A - 2c_i^* + c_j^* - t}{3a}\right)^2 - f_i^*.
\end{aligned}$$

The firm i's incentive to undertake FDI is determined by

$$\Delta\Pi_i^D = a\left(\frac{A-2c_i^*+c_j-2t}{3a}\right)^2 - a\left(\frac{A-2c_i+c_j}{3a}\right)^2 - f_i^*, \tag{A1}$$

$$\Delta\Pi_i^F = a\left(\frac{A-2c_i^*+c_j^*-t}{3a}\right)^2 - a\left(\frac{A-2c_i+c_j^*+t}{3a}\right)^2 - f_i^*. \tag{A2}$$

Differentiating the above equations with respect to t, we obtain

$$\frac{d\Delta\Pi_i^D}{dt} = -\frac{4}{9a}\left(A-2c_i^*+c_j-2t\right) < 0, \tag{A3}$$

$$\frac{d\Delta\Pi_i^F}{dt} = -\frac{4}{9a}\left(A-c_i-c_i^*+c_j^*\right) < 0. \tag{A4}$$

Given that firm j produces in the domestic country, firm i will undertake FDI if the following condition holds:

$$\Delta\Pi_i^D > 0 \Leftrightarrow t < \frac{1}{2}\left\{(A-2c_i^*+c_j) - \sqrt{(A-2c_i+c_j)^2+9af_i^*}\right\} \equiv t_i^D. \tag{A5}$$

Similarly, given that firm j produces in the foreign country, firm i will undertake FDI if the following holds:

$$\Delta\Pi_i^F > 0 \Leftrightarrow t < (c_i-c_i^*) - \frac{9af_i^*}{4\left(A-c_i-c_i^*+c_j^*\right)} \equiv t_i^F. \tag{A6}$$

We can easily verify that $t_i^D < \Delta c_i$ and $t_i^F < \Delta c_i$ when $f_i^* > 0$, while $t_i^D = t_i^F = \Delta c_i$ in the absence of FCs (i.e., $f_i^* = 0$).

Suppose $A = 20$, $a = 2$, $c_1 = 4$, $c_2 = 5$, $c_2^* = 3$, and $f_1^* = f_2^* = 3$. Then,

1. $t_2^F < t_2^D < t_1^D < t_1^F$ ($t_1^D = 2.240$, $t_1^F = 2.250$, $t_2^D = 1.094$, $t_2^F = 0.962$) holds when c_1^*=1.00; and $t_1^F < t_1^D < t_2^D < t_2^F$ ($t_1^D = 0.290$, $t_1^F = 0.209$, $t_2^D = 1.094$, $t_2^F = 1.097$) when $c_1^* = 2.95$.

2. $t_2^F < t_2^D < t_1^F < t_1^D$ ($t_1^D = 1.740$, $t_1^F = 1.729$, $t_2^D = 1.094$, $t_2^F = 1.000$) when $c_1^* = 1.50$; and $t_1^F < t_1^D < t_2^F < t_2^D$ ($t_1^D = 0.740$, $t_1^F = 0.682$, $t_2^D = 1.094$, $t_2^F = 1.069$) when $c_1^* = 2.50$.

3. $t_2^F < t_1^F < t_2^D < t_1^D$ ($t_1^D = 1.120$, $t_1^F = 1.080$, $t_2^D = 1.094$, $t_2^F = 1.044$) when $c_1^* = 2.12$; and $t_1^F < t_2^F < t_1^D < t_2^D$ ($t_1^D = 1.060$, $t_1^F = 1.017$, $t_2^D = 1.094$, $t_2^F = 1.048$) when $c_1^* = 2.18$.

4. $t_2^F < t_1^F < t_1^D < t_2^D$ ($t_1^D = 1.090$, $t_1^F = 1.049$, $t_2^D = 1.094$, $t_2^F = 1.046$) when $c_1^* = 2.15$

Appendix B

Proof of Lemma 2. First, we prove $\Delta c_j < t_i^D < t_i^F$. In Figures 2 and 3, $t_i^D < t_i^F$ at some $f_i^*(> 0)$ implies that $\Delta\Pi_i^F = 0$ is located to the right of $\Delta\Pi_i^D = 0$, which holds if and only if $\Delta c_j < t < \Delta c_i$. Thus, $\Delta c_j < t_i^D < t_i^F$ must be the case when $t_i^D < t_i^F$.

Next, we prove $t_j^F < t_j^D < \Delta c_j$. Since $\max\{t_j^D, t_j^F\} < \Delta c_j$, either $t_j^F < t_j^D$ or $t_j^D < t_j^F$ holds. Suppose $t_j^D < t_j^F$. Then, in view of the first part of the proof, $\Delta c_i < t_j^D < t_j^F$ is necessary. This is a contradiction because $\Delta c_j < t_i^D < t_i^F < \Delta c_i$. Thus, $t_j^F < t_j^D < \Delta c_j$. ■

Proof of Lemma 3. First, suppose that a combination of FCs (f_1^* and f_2^*) under which $t_2^D = t_1^D$ holds. Because $t_i^D < \Delta c_i$ $(i = 1, 2)$, $t_1^D = t_2^D < \min\{\Delta c_1, \Delta c_2\}$ holds. Using (14), we find $\Delta\Pi_1^D - \Delta\Pi_1^F = \Delta\Pi_2^D - \Delta\Pi_2^F > 0$ when $t = t_1^D = t_2^D$. Because $\Delta\Pi_1^D = \Delta\Pi_2^D = 0$ at t_1^D (t_2^D), we find $\Delta\Pi_1^F = \Delta\Pi_2^F < 0$. Differentiating $\Delta\Pi_1^F$ and $\Delta\Pi_2^F$ with respect to t and rearranging those, we obtain:

$$\left|\frac{d\Delta\Pi_1^F}{dt}\right| = \left|\frac{d\Delta\Pi_2^F}{dt}\right| + \frac{4}{9a}\left\{2\left(c_2^* - c_1^*\right) + \left(c_2 - c_1\right)\right\}. \tag{A7}$$

Since $c_1 < c_2$ and $c_1^* < c_2^*$, (A7) means that the absolute value of the slope of $\Delta\Pi_1^F$ is greater than that of $\Delta\Pi_2^F$. This implies that the required additional reduction of t for $\Delta\Pi_1^F = 0$ is smaller than that for $\Delta\Pi_2^F = 0$. Thus, $t_2^F < t_1^F$ holds.

Next, suppose that a combination of FCs under which $t_2^D < t_1^D$ holds. Because $t_2^D < t_1^D$ and $t_i^D < \Delta c_i$ $(i = 1, 2)$, we have three possible orders, $t_2^D < t_1^D < \Delta c_1 < \Delta c_2$, $t_2^D < t_1^D < \Delta c_2 < \Delta c_1$ and $t_2^D < \Delta c_2 < t_1^D < \Delta c_1$. In view of Figure 2, the third order implies $t_1^D < t_1^F$ and hence $t_2^F < t_1^F$ from Lemma 2. Thus, it is sufficient to consider the first two orders. These orders imply $t_2^D < t_1^D < \min\{\Delta c_1, \Delta c_2\}$. Then, $\Delta\Pi_1^D - \Delta\Pi_1^F$ (or $-\Delta\Pi_1^F$) at t_1^D is smaller than $\Delta\Pi_2^D - \Delta\Pi_2^F$ (or $-\Delta\Pi_2^F$) at t_2^D. Thus, we can also prove $t_2^F < t_1^F$ as in the case of $t_2^D = t_1^D$. ■

Proof of Proposition 2. When the effective MCs of two firms are m_i and m_j $(i, j = 1, 2$ and $i \neq j)$, consumer surplus is

$$CS = \frac{a}{2}\left(\frac{2A - m_i - m_j}{3a}\right)^2.$$

Firm i's FDI makes its effective MC lower. The effect of a change in m_i on consumer surplus is

$$\frac{\partial CS}{\partial m_i} = -\left(\frac{2A - m_i - m_j}{9a}\right) < 0,$$

the sign of which is always negative (as long as Cournot interior solutions exist). Since the profits of firm j are

$$\Pi_j = a\left(\frac{A + m_i - 2m_j}{3a}\right)^2,$$

the effect of a change in m_i on the profits is given by

$$\frac{\partial \Pi_j}{\partial m_i} = \frac{2}{3}\left(\frac{A + m_i - 2m_j}{3a}\right) > 0.$$

By noting that firm i's profits are continuous at the critical levels of t: t_i^D and t_i^F, the change in domestic welfare is given by

$$\frac{\partial CS}{\partial m_i} + \frac{\partial \Pi_j}{\partial m_i} = \frac{m_i - m_j}{3a}.$$

Thus, the following condition holds:

$$m_i > m_j \Leftrightarrow \frac{\partial CS}{\partial m_i} + \frac{\partial \Pi_j}{\partial m_i} > 0.$$

This means that FDI undertaken by the firm with the lower effective MC always improves domestic welfare.

Considering this finding, we investigate the following four cases where only one firm changes its location: from DD to FD, from DD to DF, from FD to FF, and from DF to FF. In the first and second cases, since the effective MCs at DD are c_1 and c_2 and $c_1 < c_2$, domestic welfare rises in the first case and falls in the second. In the third case, the effective MCs are $c_1^* + t$ and c_2 at FD. Suppose $c_1^* + t \geq c_2$. Then $c_1^* + t > c_1$ because $c_1 < c_2$. Obviously, firm 1 will not undertake FDI at this trade cost. Thus, $c_1^* + t < c_2$ and domestic welfare deteriorates. In the fourth case, the effective MCs are c_1 and $c_2^* + t$ at DF. Suppose $c_1 \geq c_2^* + t$. Then $c_1 > c_1^* + t$ because $c_1^* < c_2^*$. Obviously, firm 1 will not produce at home at this trade cost. Thus, $c_1 < c_2^* + t$ and domestic welfare improves. ■

Proof of Proposition 3. Complete reversal arises in Cases III and IV. We have two possible cases: from DF to FD, and from FD to DF. The difference of consumer surplus between both regimes is

$$\begin{aligned} CS^{FD} - CS^{DF} &= \frac{a}{2}\left(\frac{2A - c_1^* - c_2 - t}{3a}\right)^2 - \frac{a}{2}\left(\frac{2A - c_1 - c_2^* - t}{3a}\right)^2 \\ &= \frac{1}{18a}\left(c_1 - c_1^* - c_2 + c_2^*\right)\left\{(2A - c_1^* - c_2 - t) + (2A - c_1 - c_2^* - t)\right\}. \end{aligned}$$

Therefore,

$$c_1 - c_1^* > c_2 - c_2^* \Leftrightarrow c_2^* - c_1^* > c_2 - c_1 \Leftrightarrow CS^{FD} > CS^{DF}. \tag{A8}$$

This implies that consumer surplus is larger when the firm that can save its real MC more by FDI switches its production from the domestic country to the foreign country than when the other firm does.

The difference in firm i's profits ($i = 1, 2$) is

$$\begin{aligned} \Pi_1^{FD} - \Pi_1^{DF} &= a\left(\frac{A - 2c_1^* + c_2 - 2t}{3a}\right)^2 - a\left(\frac{A - 2c_1 + c_2^* + t}{3a}\right)^2 - f_1^*, \\ \Pi_2^{FD} - \Pi_2^{DF} &= a\left(\frac{A - 2c_2 + c_1^* + t}{3a}\right)^2 - a\left(\frac{A - 2c_2^* + c_1 - 2t}{3a}\right)^2 + f_2^*. \end{aligned}$$

When $t_2^F < t_1^F < t_2^D < t_1^D$, $\Pi_1^{FD} > \Pi_1^{DD}$ holds at $t \in [t_1^F, t_2^D]$. Because $\Delta c_2 > t_2^D$, the rival's FDI lowers the firm 1's profits ($\Pi_1^{DD} > \Pi_1^{DF}$). Thus, $\Pi_1^{FD} > \Pi_1^{DD} > \Pi_1^{DF}$. Similarly, using $\Pi_2^{DF} \geq \Pi_2^{DD}$ and $\Delta c_1 > t_1^D$, we have $\Pi_2^{DF} \geq \Pi_2^{DD} > \Pi_2^{FD}$. Thus, $\Pi_1^{FD} > \Pi_1^{DF}$ and $\Pi_2^{DF} > \Pi_2^{FD}$. This finding is also applicable when $t_1^F < t_2^F < t_1^D < t_2^D$. When $t_2^F < t_1^F < t_1^D < t_2^D$ (i.e., in Case IV), $\Pi_1^{FD} \geq \Pi_1^{DD}$ holds at $t \in [t_1^F, t_1^D]$. Using $\Delta c_2 > t_2^D$, $\Pi_1^{FD} \geq \Pi_1^{DD} > \Pi_1^{DF}$. Similarly, using $\Pi_2^{DF} > \Pi_2^{DD}$ and $\Delta c_1 > t_1^D$, we have $\Pi_2^{DF} > \Pi_2^{DD} > \Pi_2^{FD}$. Thus, again $\Pi_1^{FD} > \Pi_1^{DF}$ and $\Pi_2^{DF} > \Pi_2^{FD}$ hold. This means that the profits of firm i are larger when it produces abroad and the rival produces at home rather than vice versa.

Moreover, with $f_1^* = f_2^*$, we have

$$\begin{aligned} \Pi^{FD} - \Pi^{DF} &\equiv \left(\Pi_1^{FD} + \Pi_2^{FD}\right) - \left(\Pi_1^{DF} + \Pi_2^{DF}\right) \\ &= \{(A - 2c_1 + c_2) + (A - 2c_1^* + c_2^* - t)\}\{2(c_1 - c_1^*) + (c_2 - c_2^*) - 3t\}/9a \\ &\quad - \{(A + c_1 - 2c_2) + (A + c_1^* - 2c_2^* - t)\}\{(c_1 - c_1^*) + 2(c_2 - c_2^*) - 3t\}/9a. \end{aligned}$$

Since $A - 2c_1 + c_2 > A + c_1 - 2c_2$ and $A - 2c_1^* + c_2^* - t > A + c_1^* - 2c_2^* - t$, $\Pi^{FD} - \Pi^{DF} > 0$ if the following holds:

$$2(c_1 - c_1^*) + (c_2 - c_2^*) - 3t > (c_1 - c_1^*) + 2(c_2 - c_2^*) - 3t \Leftrightarrow c_1 - c_1^* > c_2 - c_2^*.$$

Noting (A8), we can claim that $W^{FD} > W^{DF}$ if $c_1 - c_1^* > c_2 - c_2^*$.

Finally, we can verify that the sign of the following equation is generally ambiguous if $c_1 - c_1^* < c_2 - c_2^*$:

$$\begin{aligned} W^{FD} - W^{DF} = \{&8Ac_1 - 11c_1^2 - 8Ac_1^* + 11c_1^{*2} - 8Ac_2 + 11c_2^2 + 8Ac_2^* - 11c_2^{*2} \\ &- 14c_1^*c_2 + 14c_1c_2^* + 14c_1t + 22c_1^*t - 14c_2t - 22c_2^*t\}/18a. \end{aligned}$$

For example, if $A = 20$, $a = 2$, $c_1 = 4$, $c_1^* = 2.915$, $c_2 = 4.1$, $c_2^* = 3$, and $f_1^* = f_2^* = 3$, then $\Pi^{FD} > \Pi^{DF}$, $CS^{FD} < CS^{DF}$, and $W^{FD} > W^{DF}$. If $A = 20$, $a = 2$, $c_1 = 4$, $c_1^* = 2.93$, $c_2 = 4.1$, $c_2^* = 3$, and $f_1^* = f_2^* = 3$, then $\Pi^{FD} > \Pi^{DF}$, $CS^{FD} < CS^{DF}$, and $W^{FD} < W^{DF}$. If $A = 20$, $a = 2$, $c_1 = 4$, $c_1^* = 2.95$, $c_2 = 4.1$, $c_2^* = 3$, and $f_1^* = f_2^* = 3$, then $\Pi^{FD} < \Pi^{DF}$, $CS^{FD} < CS^{DF}$, and $W^{FD} < W^{DF}$. Thus, when complete reversal occurs with $c_1 - c_1^* < c_2 - c_2^*$, domestic welfare may deteriorate regardless of which firm undertakes FDI. ■

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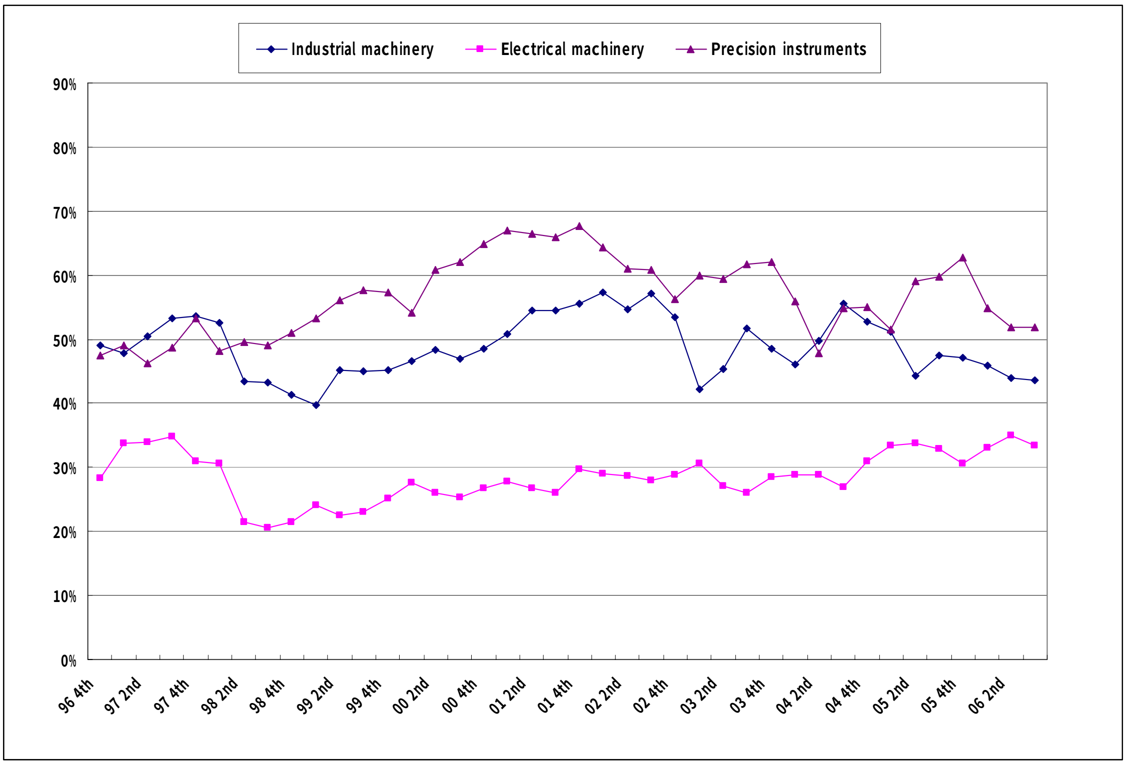
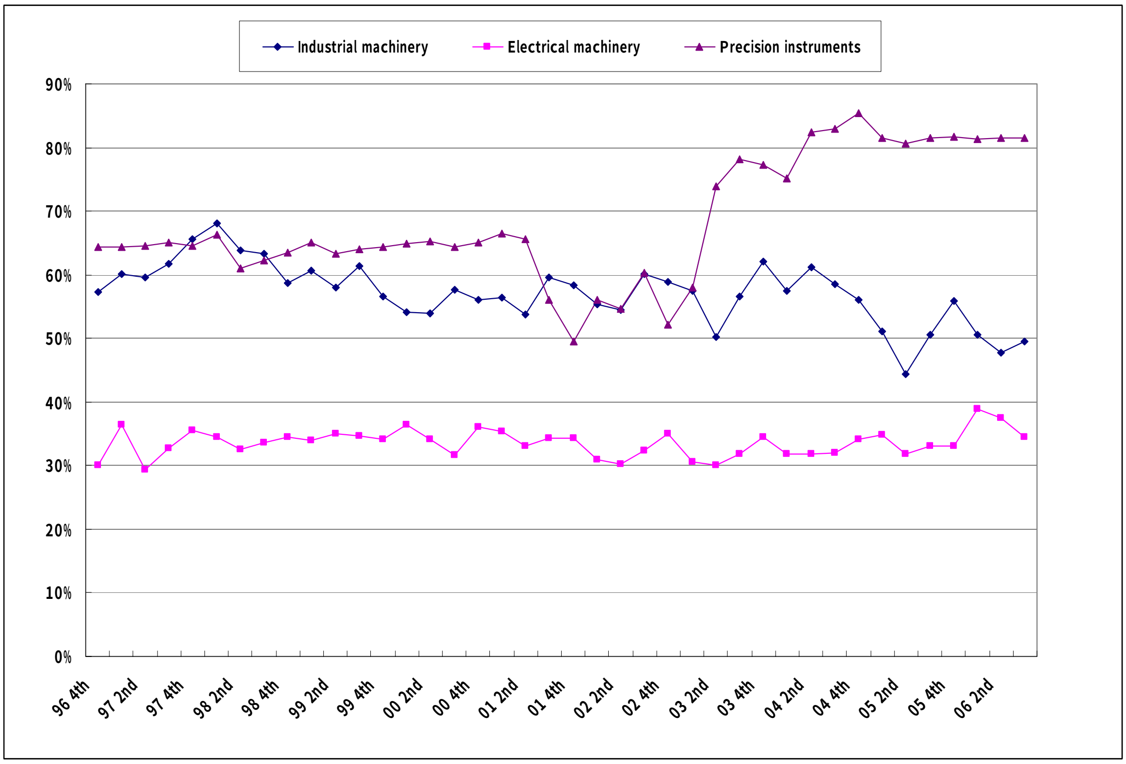
Figure 1. Japanese Reverse Imports

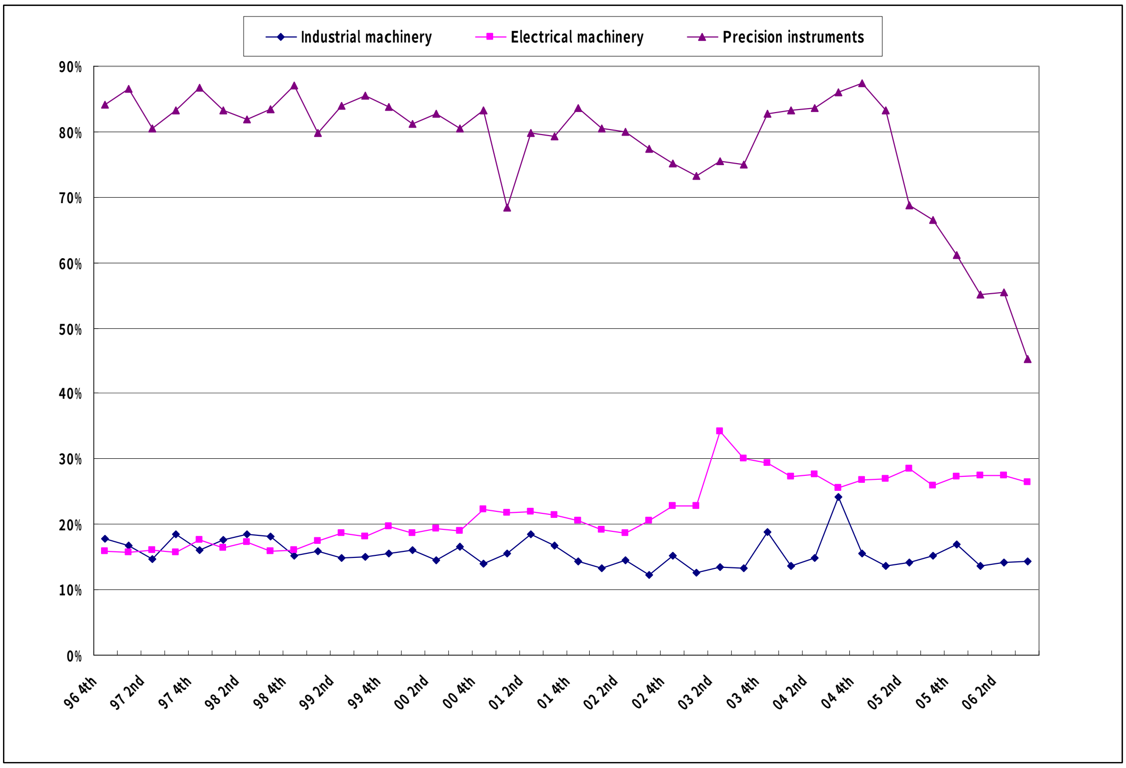
Panel (a) From China (Hong Kong is included)



Panel (b): From ASEAN4



Panel (c): From NIES3



Source: Quarterly Survey of Overseas Subsidiaries, Japanese Ministry of Economy, Trade and Industry

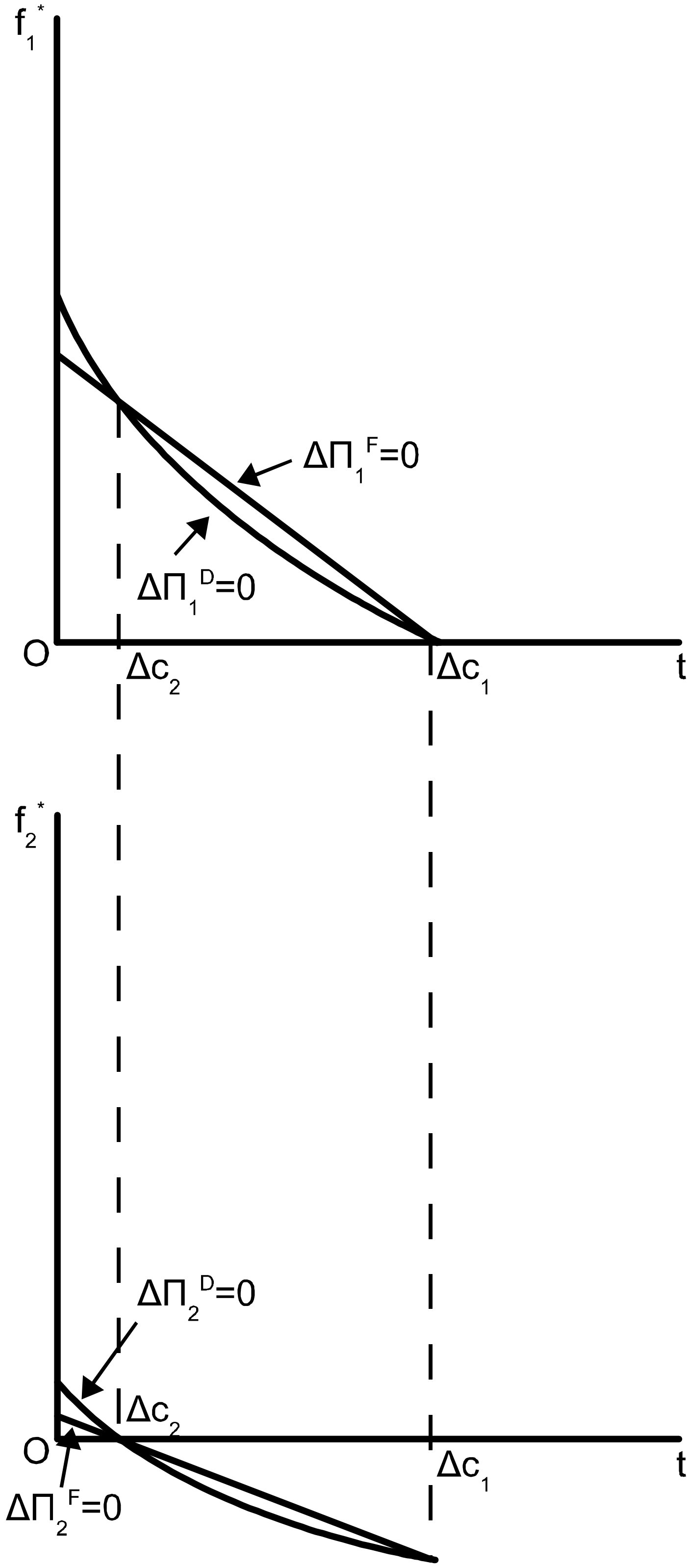


Figure 2: Case with $\Delta c_1 > \Delta c_2$

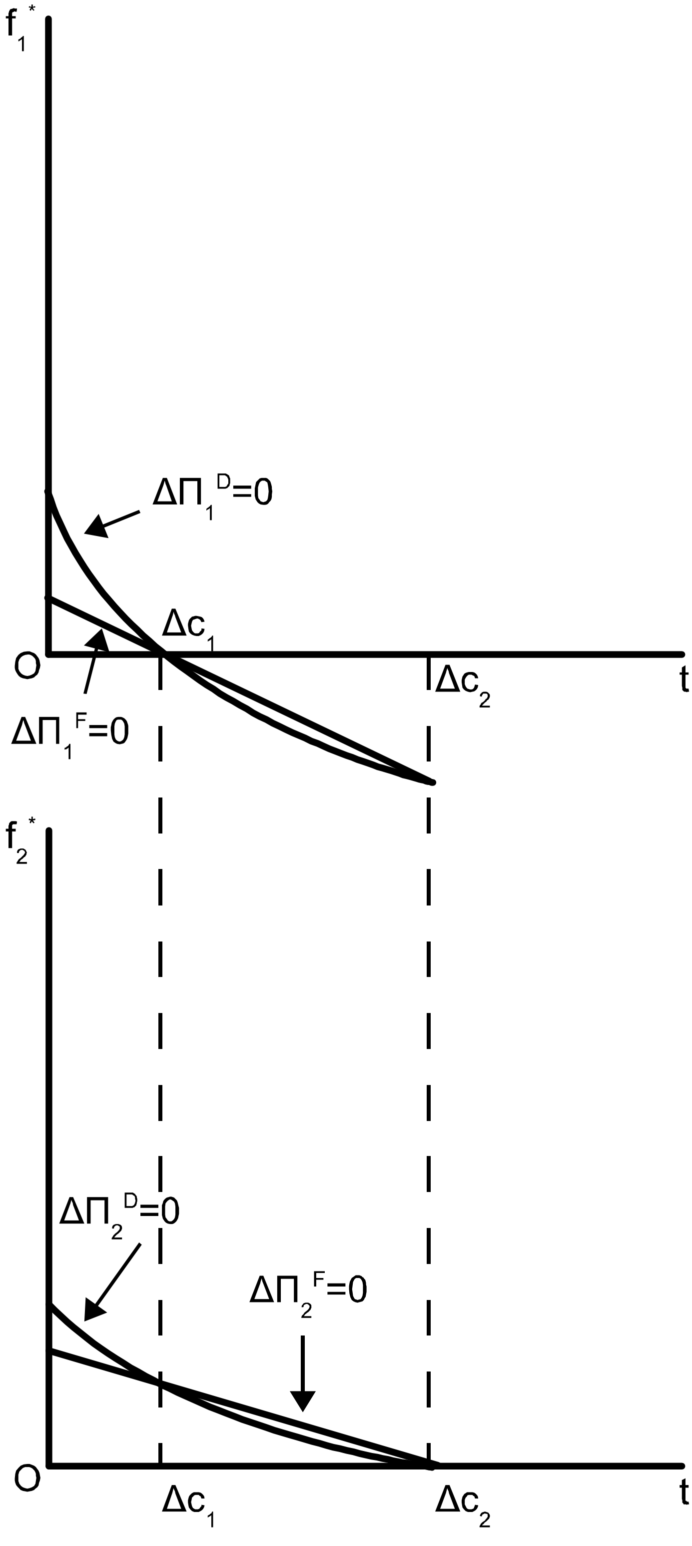


Figure 3: Case with $\Delta c_1 < \Delta c_2$