Trade Costs, Wage Rates, Technologies,

and Reverse Imports*

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Abstract

This papers explores the effects of transport costs, tariffs, and foreign wage rates on the domestic economy in the presence of reverse imports, with special emphasis on inter-firm cost asymmetry in an international oligopoly model. To serve the domestic market, a foreign firm produces in the foreign country, while two domestic firms produce either at home or abroad. Surprisingly, an increase in the foreign wage rate may increase the profits of a firm producing in the foreign country. Even if all firms produce in the foreign country, an increase in the foreign wage rate may improve domestic welfare.

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1 Introduction

Over the last decade, a great number of firms in developed countries have made foreign direct investment (FDI) in developing countries. It is widely observed that outputs of such FDI are exported to other countries. When products are exported back to the source country, they are called "reverse imports" from the viewpoint of the source country.[1] For example, many Japanese firms have invested in Asian countries to serve the Japanese market.[2] 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 regions and the share of reverse imports for industrial machinery has been high in China and the ASEAN 4.[3]

<Figure 1 here>

Moreover, according to Liu and Huang (2005), Taiwanese reverse imports comprise about 40% of their foreign affiliate production. Many Taiwanese firms invest in China for reverse imports. Ekholm et al. (2007) argue that while overall export sales to the US by US manufacturing affiliates amounted to only 13% of sales in 2003, they exceeded 30% for US manufacturing affiliates in Malaysia, the Philippines, Canada, and Mexico.

We can attribute an increase in reverse imports to several factors: rising domestic production costs such as wages, falling trade costs including transport costs, communications costs, and tariffs, and increasing productivity in developing countries. In particular, recent improvements in transportation and communications technology as well as trade liberalization allow firms to locate their plants all over the world in order to lower production costs.[4] In host countries, however, the production costs have recently started rising. In particular, upward pressure has been exerted on wages.[5]

It has been observed that the surge in reverse imports has upset firms operating at home. An interesting feature is that this trade friction exists among domestic firms rather than between

domestic and foreign firms. For example, an increase in towel imports from China and Vietnam led the Japan Towel Industry Association to petition the Ministry of Economy, Trade and Industry (METI) to impose textile safeguards in 2001. On the other hand, a group of Japanese towel makers with production bases in China and Vietnam asked the government not to impose them, claiming that such measures would ruin their efforts to lower costs. The METI conducted a probe into whether to impose safeguards and eventually decided not to introduce them.

The existing trade literature is not very useful in evaluating such a decision, because, with the exception of Greaney (2003), Xing and Zhao (2006), and Yomogida (2007), no theoretical study explicitly explores reverse imports.[6] The purpose of this paper is to contribute toward a better understanding of reverse imports. To this end, we investigate reverse imports in an international oligopoly model in which two domestic firms and a foreign firm produce a homogeneous good by using labor to serve the domestic market. The domestic firms choose their plant locations either at home or abroad. We consider three possible cases with respect to domestic firms' locations. In the first case, the domestic firms produce at home and the foreign firm produces abroad. This is a standard case in the trade literature and serves as the benchmark case in our analysis. In the second case, one domestic firm produces in the domestic country while the other domestic firm and the foreign firm produce in the foreign country. In the last case, all three firms locate themselves in the foreign country.

It is quite natural to conjecture that the plant location is strongly affected by cost structures. In fact, the relationship between firm heterogeneity and FDI has recently attracted considerable attention in the international trade literature. However, most studies are based on monopolistically competitive models, as originally developed by Montagna (1995) and Melitz (2003).[7] In our analysis, we introduce cost asymmetry among domestic firms into an international oligopoly model. This generates some interesting strategic environments that do not arise in monopolistically competitive models.

In Ishikawa and Komoriya (2006), a companion to the present paper, we have theoretically examined the relationship between location choices and trade costs in the presence of inter-firm cost asymmetry. We have found that cost structures are indeed crucial to plant location and location patterns may not be unique. Since Ishikawa and Komoriya (2006) highlight endogenous location choices, the present study focuses on the effects of transport costs, tariffs, and foreign wage rates on the domestic economy with given plant locations. To examine the effects of foreign wage rates, we specifically decompose the marginal cost (MC) into the wage rate and the labor coefficient. This decomposition, as well as the inter-firm cost asymmetry, gives us new insights into reverse imports.

In the framework of international oligopoly, few studies take into account cost asymmetries within a country.[8] Long and Soubeyran (1997) show that when firms are heterogeneous, the Herfindahl index and the elasticity of the slope of the demand curve play crucial roles in determining optimal export policies. Lahiri and Ono (1997) examine the welfare effects of entry and exit policies (in particular, the elimination of a minor firm) in a multi-country model of international oligopoly with inter-firm cost asymmetry.

The rest of the paper is organized as follows. In Section 2, we set out the basic model. In Section 3, we investigate the location choices. Since Ishikawa and Komoriya (2006) explore this issue, we briefly consider a case without fixed costs. In Section 4, we analyze the effects of transport costs, tariffs, and foreign wage rates on outputs, profits, and domestic welfare in the presence of reverse imports. Section 5 concludes the paper.

2 Basic Model

We consider an international oligopoly model where there are two countries (domestic and foreign), and where two domestic firms (firms 1 and 2) and one foreign firm (firm 3) produce a homogeneous good and engage in Cournot competition in the domestic market. 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 $\epsilon(X) < 1$, which implies that goods produced by the firms are always strategic substitutes (i.e., $P' + P''x_i < 0$, where x_i is the output of firm i ($i = 1, 2, 3$), always holds).[9]

Each domestic firm produces either at home or abroad, while the foreign firm always produces in the foreign country. When producing in the foreign country, the profits of firm i ($i = 1, 2, 3$) are given by

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

where t and τ are, respectively, a specific transport cost and a specific tariff, and $C_i(\cdot)$ is the cost function.[10] When firm i ($i = 1, 2$) produces in the domestic country, the profits equal $P(X)x_i - C_i(x_i)$. The domestic firms incur both t and τ in the case of foreign production.

Specifically, we assume that labor is a single production factor and the cost functions are given by

$$C_i(x_i) = \begin{cases} c_i x_i + f_i = a_i w x_i + f_i \\ c_i^* x_i + f_i^* = a_i^* w^* x_i + f_i^* \end{cases} \quad (i = 1, 2); \; C_3(x_3) = c_3^* x_3 + f_3^* = a_3^* w^* x_3 + f_3^* \tag{3}$$

where a_i, w, and f_i are, respectively, the labor coefficient, the wage rate, and a plant-specific fixed cost (FC), which are exogenously given and constant. Since FC does not play a crucial

role in our main analysis, we assume $f_i = f_i^* = 0$ $(i = 1, 2)$ and $f_3^* = 0.$[11] An asterisk denotes parameters in the foreign country. The "effective" MC is $a_i w$ in the case of domestic production and is $a_i^* w^* + t + \tau$ in the case of foreign production. Without loss of generality, firm 1 is assumed to be more efficient than firm 2 (i.e., $a_1 w < a_2 w$ and $a_1^* w^* < a_2^* w^*$). There is no restriction on a_3^* and thus the foreign firm can be more efficient or inefficient than the domestic firms. Only one or two firms may operate in equilibrium, but in the following analysis we focus on the case in which all firms always serve the market.

The first-order conditions (FOCs) for profit maximization are $(i = 1, 2, 3)$

$$\frac{\partial \Pi_i}{\partial x_i} = P + P' x_i - C_i^{'}(x_i) = 0. \tag{4}$$

With $\epsilon(X) < 1$, the second-order sufficient conditions (SOCs) $(i = 1, 2, 3)$:

$$2P' + P'' x_i = P'(2 - \epsilon \sigma_i) < 0$$

and the stability conditions:

$$|\Omega_{ij}| > 0 \ (i, j = 1, 2, 3; i \neq j), |\Omega| = (P')^2(4P' + P'' X) = (P')^3(4 - \epsilon) < 0$$

where $\sigma_i \equiv x_i/X$ and

$$\Omega_{ij} \equiv \begin{pmatrix} 2P' + P'' x_i & P' + P'' x_i \\ P' + P'' x_j & 2P' + P'' x_j \end{pmatrix}, \Omega \equiv \begin{pmatrix} 2P' + P'' x_1 & P' + P'' x_1 & P' + P'' x_1 \\ P' + P'' x_2 & 2P' + P'' x_2 & P' + P'' x_2 \\ P' + P'' x_3 & P' + P'' x_3 & 2P' + P'' x_3 \end{pmatrix}$$

are satisfied.

3   Location Choices

In this section, we consider the location choices of domestic firms.[12] It is obvious that in the absence of FCs, the firm's location decision does not depend on the other firms' locations. That is, in stage 1, there exist dominant strategies for both domestic firms. Each domestic firm chooses its location that results in a lower effective MC. Firm i ($i = 1, 2$) produces in the domestic country if and only if $a_i w \leq a_i^* w^* + T$, where $T \equiv t + \tau$. Figure 2 illustrates this condition by normalizing $w = 1$. Firm 1 produces in the domestic (foreign) country in the region above (below) line 1, while firm 2 produces in the domestic (foreign) country in the region above (below) line 2. Whereas Panel (a) shows the case where $a_1/a_1^* < a_2/a_2^*$ holds, Panel (b) shows the case where $a_1/a_1^* > a_2/a_2^*$ holds. $a_1/a_1^* < a_2/a_2^*$ ($a_1/a_1^* > a_2/a_2^*$) could be the case if it is relatively difficult (easy) to transfer more efficient technology to the foreign country.

<**Figure 2 here**>

There are three regions in Panel (a) and four regions in Panel (b). Both firms produce in the domestic (foreign) country when w^* is relatively high (low) and/or T is relatively high (low), that is, (T, w^*) is in region DD (region FF). Whereas firms 1 and 2, respectively, produce at home and abroad in region DF, firms 1 and 2, respectively, produce abroad and at home in region FD. We should note that region FD never appears in Panel (a).

The location choice depends on the relative size of the labor-coefficient ratio, a_i/a_i^* ($i = 1, 2$). If $a_1/a_1^* < a_2/a_2^*$, then firm 2 (i.e., the less efficient firm) always has a greater incentive to undertake FDI than firm 1 (i.e., the more efficient firm). In the case where $a_1/a_1^* > a_2/a_2^*$ holds, however, firm 1 (firm 2) has a greater incentive to engage in FDI if T is relatively low (high) but w^* is relatively high (low).

To obtain economic intuition, we first consider an extreme case where $a_i^* = a_i$ ($i = 1, 2$), that is, foreign and domestic production of firm i share the same technology. When they invest in the foreign country, both firms face the same trade costs T, and hence the share of trade costs

in the "effective" MC is larger for firm 1 (i.e., the more efficient firm) than for firm 2 (i.e., the less efficient firm). Thus, the advantage of firm 1 is relatively small when both firms produce abroad. In this case, therefore, firm 2 always has a greater incentive to undertake FDI than firm 1. As long as $a_1/a_1^* < a_2/a_2^*$, the same economic intuition goes through. If $a_1/a_1^* > a_2/a_2^*$, on the other hand, firm 1 faces a trade-off between a relatively high share of trade costs and relatively more efficient foreign technology. Moreover, as the foreign wage becomes higher, the share of trade costs in the "effective" MC becomes smaller. Thus, if trade costs are relatively low and the foreign wage is relatively high (i.e., in region FD), firm 1 has a greater incentive to undertake FDI than firm 2.

4   Effects of Trade Costs and Foreign Wage Rates

In this section, we consider the effects of transport costs, tariffs, and foreign wage rates on the domestic economy with given plant locations. The formal derivation of the results is given in the appendix. In the text below, we focus on the linear-demand case (i.e., the case with $\epsilon(X) = 0$).

4.1   Benchmark Case: Case A

As a benchmark, we consider a case where the domestic firms produce in the domestic country and the foreign firm produces in the foreign country. First, we consider the effect of a change in transport costs, t, on profits and economic welfare. As shown in the appendix, when t falls, the outputs and profits of the domestic firms decrease but those of the foreign firm increase. The total output also rises. The effect of a change in t on domestic welfare, which is measured by the sum of consumer surplus and domestic firms' profits:

$$W \equiv U(X) - P(X)X + \Pi_1 + \Pi_2, \tag{5}$$

is not monotonic. A reduction of t improves domestic welfare if and only if the market share of the foreign firm is greater than a critical level. With linear demand, the critical level is 50% (see also Ono, 1990). When t falls, there are two conflicting effects on domestic welfare. Although consumers gain from a lower t, the domestic firms lose. The former effect dominates the latter when the market share of the domestic firms is small.

Next we examine the effects of a small tariff, τ. It is obvious that the effects of a tariff on outputs and profits are the same as those of transport costs. A tariff benefits the domestic firms at the cost of the foreign firm and consumers. In the welfare analysis of tariffs, we have to take the tariff revenue into account. A tariff protects the domestic firms. Besides, a rent is shifted from the foreign firm to the domestic government, which exceeds consumers' loss from the higher consumer price. That is, a small tariff enhances domestic welfare (see also Furusawa et al., 2003).

The effects of a change in the foreign wage rate, w^*, are the same as those of a change in transport costs, t. This is because only the foreign firm is affected by changes in w^* in the benchmark case. Thus, as w^* rises, the outputs and profits of the domestic firms increase but those of the foreign firm decrease. Moreover, an increase in w^* improves domestic welfare if and only if the market share of the foreign firm is less than 50%.

4.2 Reverse Imports: Case B

In this subsection, we examine the case in which one domestic firm produces in the domestic country but the other domestic firm and the foreign firm produce in the foreign country. First, we consider the effects of a change in transport costs, t, on profits and domestic welfare. As in the benchmark case, a reduction in t decreases the profits of the firm producing in the domestic country and increases those of firms producing in the foreign country.

The welfare effect is different from that in the benchmark case, because here the domestic firm producing abroad benefits from a reduction in t. First, suppose that firm 2 produces in the foreign country. Then, by recalling $\sigma_i \equiv x_i/X$ $(i = 1, 2, 3)$, the welfare effect with linear demand

is given by

$$\frac{dW}{dt} > 0 \Leftrightarrow \sigma_1 - \sigma_2 > \frac{1}{2} \Leftrightarrow 2\sigma_2 + \sigma_3 < \frac{1}{2}. \tag{6}$$

Thus, a decrease in t reduces domestic welfare if firm 1 is very efficient relative to firms 2 and 3. When firm 3 is as efficient as firm 2 (i.e., $a_2^* = a_3^*$), for example, then domestic welfare deteriorates if and only if $\sigma_1 > 2/3$. If firm 1 produces in the foreign country, on the other hand, subscripts 1 and 2 in (6) are switched and hence a decrease in t always enhances domestic welfare. Intuitively, a lower t is beneficial for consumers as well as for the firms producing in the foreign country but is harmful for the firm producing in the domestic country.[13] When the latter effect dominates the former, domestic welfare deteriorates. As the market share of the firm producing in the domestic country becomes larger, the gains for consumers and the domestic firm producing in the foreign country become smaller and the loss for the firm producing in the domestic country becomes larger. Thus, when the share of the firm producing in the domestic country is sufficiently large, the loss exceeds the gains.

Thus, the welfare effect of a decrease in t is as follows:

Proposition 1 *Suppose that only one domestic firm engages in reverse imports. Then a decrease in transport costs could reduce domestic welfare if the market share of the firm producing in the domestic country is large.*

We next consider the effects of a small tariff. Again, the effects of τ on outputs and profits are the same as those of t. When firms 1 and 2, respectively, produce at home and abroad, the welfare effect is given by

$$\frac{dW}{d\tau}\Big|_{\tau=0} = \frac{X}{2}\left(1 - 2\sigma_2\right) > 0 \Leftrightarrow \sigma_2 < \frac{1}{2}$$

and the optimal tariff is given by $\tau = -XP'\left(1 - 2\sigma_2\right)/2$. Since $\sigma_2 < 1/2$, a tariff raises domestic welfare. It is worth noting that this result holds even if the share of firm 1 is not large because

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of rent-shifting from the foreign firm (i.e., firm 3) to the domestic government.[14] This contrasts with the case of a change in transport costs. When firm 1 chooses foreign production instead, a tariff reduces domestic welfare if and only if $\sigma_1 > 1/2$. When $\sigma_1 > 1/2$, the losses for firm 1 and consumers dominate the gains for firm 2 and the domestic government.

Thus, we obtain:

Proposition 2 *Suppose that only one domestic firm engages in reverse imports. Then a small tariff could reduce domestic welfare if the market share of the domestic firm producing abroad is large.*

Next we examine the effects of an increase in the foreign wage rate. It should be noted that the effects of a change in the foreign wage rate on outputs and profits are now no longer the same as those of transport costs. Suppose that firms i and j $(i, j = 1, 2; i \neq j)$, respectively, produce at home and abroad. Then, as expected, an increase in w^* raises the output and profits of firm i but lowers the total supply. However, the effects on the firms producing in the foreign country are not simple. We have

$$\frac{dx_j}{dw^*} > 0 \Leftrightarrow \frac{d\pi_j}{dw^*} > 0 \Leftrightarrow a_j^* < \frac{a_3^*}{3}, \quad \frac{dx_3}{dw^*} > 0 \Leftrightarrow \frac{d\pi_3}{dw^*} > 0 \Leftrightarrow a_3^* < \frac{a_j^*}{3}. \tag{7}$$

Interestingly, an increase in w^* could raise the profits and output of firm j (firm 3) if it is more efficient than firm 3 (firm j). This result contrasts with the case of an increase in transport costs. In particular, it seems counter-intuitive for a firm producing in the foreign country to benefit from an increase in w^*. The economic intuition, however, is as follows. An increase in t raises the effective MC of both firm j and firm 3 by the same amount, while an increase in w^* raises firm 3's effective MC more than firm j's when $a_j^* < a_3^*$. That is, the cost of an increase in w^* is asymmetric between firm j and firm 3, and firm 3 is affected more than firm j when $a_j^* < a_3^*$. A reduction of firm 3's output generates the force to increase the outputs of the other firms (i.e. firms 1 and 2), because the outputs are strategic substitutes. When a_3^* is large, firm 3

decreases its output by a large amount and hence the force to reduce firm j's output due to an increase in w^* could be dominated by the force to raise it.

An increase in the foreign wage rate basically discourages an incentive to produce in the foreign country. However, this could be mitigated when the foreign firm is very inefficient. When the foreign firm is very efficient, on the other hand, it may welcome the domestic firm's FDI.

The welfare effect is given by

$$
\frac{dW}{dw^*} > 0 \Leftrightarrow \frac{\sigma_1 + \sigma_2 - \sigma_3}{8} > \frac{\sigma_j a_j^*}{a_j^* + a_3^*} \Leftrightarrow \frac{x_i - x_3}{x_j} > \frac{7a_j^* - a_3^*}{a_j^* + a_3^*}. \tag{8}
$$

Thus, an increase in w^* is likely to improve domestic welfare if firm 3 is very inefficient relative to the domestic firms. Although an increase in w^* hurts consumers, the domestic firms could gain if firm 3 is very inefficient relative to the domestic firms and hence domestic welfare could improve.

The above analysis establishes the following proposition:

Proposition 3 *Suppose that only one domestic firm engages in reverse imports. Then an increase in the foreign wage rate could benefit both domestic firms and the domestic country if the foreign firm is less efficient than the domestic firm producing in the foreign country.*

4.3   Reverse Imports: Case C

In this subsection, we examine the case in which all firms produce in the foreign country. With linear demand, the effects of a change in transport costs, t, on profits and domestic welfare are as follows. Not only do the outputs and profits of all firms rise but domestic welfare also rises as t falls.

The effects of a tariff on outputs and profits are the same as those of transport costs. The

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welfare effect of a small tariff is given by

$$\frac{dW}{d\tau}\Big|_{\tau=0} = -\frac{X}{4}(1 - 2\sigma_3) > 0 \Leftrightarrow \sigma_3 > \frac{1}{2}$$

and the optimal tariff is given by $\tau = XP'(1 - 2\sigma_3)/3$. Thus, a small tariff makes the domestic country worse off unless firm 3 is very efficient. A tariff hurts consumers as well as the domestic firms but shifts rent from firm 3 to the domestic country. When firm 3's share is large, the gain from the rent shifting dominates the loss.

Thus, we obtain the following proposition:

Proposition 4 *Suppose that both domestic firms engage in reverse imports. Then a small tariff could improve domestic welfare if the market share of the foreign firm is large.*

Next we analyze the effects of an increase in the foreign wage rate. We obtain

$$\frac{dx_i}{dw^*} > 0 \Leftrightarrow \frac{d\pi_i}{dw^*} > 0 \Leftrightarrow a_i^* < \frac{a_j^* + a_k^*}{3}, \quad (i, j, k = 1, 2, 3; i \neq j, i \neq k, j \neq k).$$

As in Case B, an increase in w^* could raise the profits and outputs of both firms 1 and 2 if firm 3 is inefficient. This is because the cost of an increase in w^* is not uniform among the three firms. It is possible that only firm 1 gains from an increase in w^*.

The welfare effect is

$$\frac{dW}{dw^*} > 0 \Leftrightarrow \frac{\sigma_1 + \sigma_2 - \sigma_3}{8} > \frac{\sigma_1 a_1^* + \sigma_2 a_2^*}{a_1^* + a_2^* + a_3^*}. \tag{9}$$

Again, as in Case B, an increase in w^* could enhance domestic welfare.[15]

Thus, we have the following proposition:

Proposition 5 *Suppose that both domestic firms engage in reverse imports. An increase in the foreign wage rate could benefit both domestic firms and the domestic country if the foreign firm*

is less efficient than the domestic firms.

5 Concluding Remarks

We have explored the effects of trade costs (i.e., transport costs and tariffs) and foreign wage rates on the domestic economy in the presence of reverse imports. To this end, we have constructed a simple Cournot model with two domestic firms and a foreign firm. The two domestic firms, whose MCs are different, produce either at home or abroad. In the presence of reverse imports, the effects of trade costs and foreign wages are different from those without reverse imports. In particular, the effects of a change in the foreign wage rate are noteworthy. A firm producing in the foreign country may gain from an increase in the foreign wage rate. Moreover, even if all firms produce in the foreign country, an increase in the foreign wage rate may improve domestic welfare. Not only the inter-firm cost asymmetry but also the decomposition of the MC into the wage rate and the labor coefficient plays a crucial role in obtaining the results.

If there is only one domestic firm in our model, there are only two possible cases. When the domestic firm produces at home, the situation is similar to the benchmark case. When it produces abroad, on the other hand, the situation is similar to Case C. However, we cannot analyze Case B with a single domestic firm. If, however, there is no foreign firm in our model, we find that some results are still valid. For example, the domestic country could gain from an increase in the foreign wage rate. This result could hold even if both firms engage in reverse imports. Furthermore, an earlier version of this paper shows that even if both firms engage in reverse imports, a tariff could raise domestic welfare when the demand is non-linear.[16] That is, the domestic country may gain from a tariff even without rent-shifting from the foreign country.

Four final remarks are in order. First, to present our point as clearly as possible in the analysis of foreign wage rates we have assumed that labor is a single factor of production. Even if other factors are involved, however, our point would not change as long as the effect of trade costs on

the effective MC is different from that of the factor prices. Moreover, it is assumed the entire production process takes place in the foreign country when a domestic firm locates abroad. Even if some processes remain in the domestic country, the essence of our results is still valid.

Second, decomposing the MC into the wage rate and the labor coefficient, we can deal with foreign technology improvements as well. There are many ways in which foreign technologies improve. A possibility is that all foreign labor coefficients decrease proportionally. In this case, we can easily verify that the effects are similar to those of a decrease in the foreign wage rate. It is possible that foreign technology improvements reduce domestic welfare.

Third, we can easily analyze the effects of third-country export-platform FDI. In this case, the effects on outputs and profits are the same as those under reverse imports. However, the welfare effect is different because the good is consumed not in the domestic country but in a third country.

Lastly, in our analysis, the number of firms is fixed and there is no entry and exit. However, both entry and exit could be induced by, for example, a tariff. As is conjectured from Lahiri and Ono (1988,1997), the exit (entry) of a very inefficient firm is likely to raise (reduce) welfare. Entry and exit are also related to location choices and many cases could arise. A complete analysis incorporating entry and exit is beyond the scope of the present paper and is left for future research.

Appendix A

In this appendix, we examine the effects in the benchmark case. The profits of the three firms are given by $\pi_1 = Px_1 - a_1wx_1$, $\pi_2 = Px_2 - a_2wx_2$, and $\pi_3 = (P - t - \tau)x_3 - a_3^*w^*x_3$.

Effects of a change in transport costs

From the FOCs, we obtain

$$
\begin{pmatrix} \frac{dx_1}{dt} \\ \frac{dx_2}{dt} \\ \frac{dx_3}{dt} \end{pmatrix} = \frac{P'}{|\Omega|} \begin{pmatrix} 3P' + P'' (x_2 + x_3) & -(P' + P'' x_1) & -(P' + P'' x_1) \\ -(P' + P'' x_2) & 3P' + P'' (x_1 + x_3) & -(P' + P'' x_2) \\ -(P' + P'' x_3) & -(P' + P'' x_3) & 3P' + P'' (x_1 + x_2) \end{pmatrix} \begin{pmatrix} 0 \\ 0 \\ 1 \end{pmatrix}.
$$

The effects on the outputs are given by

$$
\frac{dx_1}{dt} = -\frac{(P')^2}{|\Omega|} (1 - \epsilon \sigma_1) > 0, \frac{dx_2}{dt} = -\frac{(P')^2}{|\Omega|} (1 - \epsilon \sigma_2) > 0, \frac{dx_3}{dt} = \frac{(P')^2}{|\Omega|} \{3 - \epsilon (1 - \sigma_3)\} < 0,
$$
$$
\frac{dX}{dt} = \frac{(P')^2}{|\Omega|} < 0.
$$

The effects on the profits are given by

$$
\frac{d\pi_1}{dt} = \frac{(P')^3 x_1}{|\Omega|} (2 - \epsilon \sigma_1) > 0, \frac{d\pi_2}{dt} = \frac{(P')^3 x_2}{|\Omega|} (2 - \epsilon \sigma_2) > 0, \frac{d\pi_3}{dt} = -\frac{(P')^3 x_3}{|\Omega|} \{6 - \epsilon (2 - \sigma_3)\} < 0.
$$

By assuming $\tau = 0$, the welfare effect is given by

$$
\frac{dW}{dt} = -XP'\frac{dX}{dt} + \frac{d\pi_1}{dt} + \frac{d\pi_2}{dt} = \frac{X(P')^3}{|\Omega|} \left\{ -\epsilon \left(\sigma_1^2 + \sigma_2^2 \right) + 1 - 2\sigma_3 \right\}.
$$

Thus,

$$
\frac{dW}{dt} > 0 \Leftrightarrow -\epsilon \left(\sigma_1^2 + \sigma_2^2 \right) + 1 - 2\sigma_3 > 0 \Leftrightarrow \sigma_3 < \frac{1}{2} \left\{ 1 - \epsilon \left(\sigma_1^2 + \sigma_2^2 \right) \right\}.
$$

When $\epsilon = 0$,

$$
\frac{dW}{dt} = \frac{X}{4} (1 - 2\sigma_3) > 0 \Leftrightarrow \sigma_3 < \frac{1}{2}.
$$

With linear demand, therefore, a decrease in transport costs raises domestic welfare if and only if the market share of the foreign firm is greater than 1/2.

Effects of a small tariff

Since the effects on outputs and profits of a change in τ are the same as those of a change in t, we consider only the welfare effect. It is given by

$$
\begin{aligned}
\frac{dW}{d\tau} &= -XP'\frac{dX}{d\tau} + \frac{d\pi_1}{d\tau} + \frac{d\pi_2}{d\tau} + x_3 + \tau\frac{dx_3}{d\tau} \\
&= \frac{X(P')^3}{|\Omega|}\left\{-\epsilon\left(\sigma_1^2 + \sigma_2^2 + \sigma_3\right) + 1 + 2\sigma_3\right\} + \tau\frac{dx_3}{d\tau}.
\end{aligned}
$$

To examine the effect of a small tariff, we evaluate this at $\tau = 0$. Since $\epsilon < 1$ and $\sigma_1^2 + \sigma_2^2 + \sigma_3 < 1$, we have

$$
\frac{dW}{d\tau}\Big|_{\tau=0} > 0.
$$

Thus, a small tariff always improves welfare.

Appendix B

In this appendix, we explore the effects in Case B. Suppose that firms i and j $(i, j = 1, 2; i \neq j)$, respectively, produce at home and abroad. Then the profits of the three firms are given by $\pi_i = Px_i - a_i wx_i$, $\pi_j = (P - t - \tau)x_j - a_j^* w^* x_j$, and $\pi_3 = (P - t - \tau)x_3 - a_3^* w^* x_3$.

Effects of a change in transport costs

From the FOCs, we have

$$
\begin{pmatrix} \frac{dx_i}{dt} \\ \frac{dx_j}{dt} \\ \frac{dx_3}{dt} \end{pmatrix} = \frac{P'}{|\Omega|} \begin{pmatrix} 3P' + P''(x_j + x_3) & -(P' + P''x_i) & -(P' + P''x_i) \\ -(P' + P''x_j) & 3P' + P''(x_i + x_3) & -(P' + P''x_j) \\ -(P' + P''x_3) & -(P' + P''x_3) & 3P' + P''(x_i + x_j) \end{pmatrix} \begin{pmatrix} 0 \\ 1 \\ 1 \end{pmatrix}.
$$

The effects on the outputs are given by

$$\frac{dx_i}{dt} = -\frac{2\left(P'\right)^2}{|\Omega|}\left(1 - \epsilon\sigma_i\right) > 0, \frac{dx_j}{dt} = \frac{\left(P'\right)^2}{|\Omega|}\left\{2 - \epsilon\left(1 - 2\sigma_j\right)\right\}, \frac{dx_3}{dt} = \frac{\left(P'\right)^2}{|\Omega|}\left\{2 - \epsilon\left(1 - 2\sigma_3\right)\right\},$$

$$\frac{dX}{dt} = \frac{2(P')^2}{|\Omega|} < 0.$$

The effects on the profits are given by

$$\frac{d\pi_i}{dt} = \frac{2\left(P'\right)^3 x_i}{|\Omega|}\left(2 - \epsilon\sigma_i\right) > 0, \quad \frac{d\pi_j}{dt} = -\frac{2\left(P'\right)^3 x_j}{|\Omega|}\left\{2 - \epsilon\left(1 - \sigma_j\right)\right\} < 0,$$

$$\frac{d\pi_3}{dt} = -\frac{2\left(P'\right)^3 x_3}{|\Omega|}\left\{2 - \epsilon\left(1 - \sigma_3\right)\right\} < 0.$$

The welfare effect is given by

$$\frac{dW}{dt} = -XP'\frac{dX}{dt} + \frac{d\pi_i}{dt} + \frac{d\pi_j}{dt} = \frac{2X(P')^3}{|\Omega|}\left\{-\epsilon\left(-\sigma_j + \sigma_i^2 + \sigma_j^2\right) - 1 + 2\sigma_i - 2\sigma_j\right\}.$$

Thus,

$$\frac{dW}{dt} > 0 \Leftrightarrow -\epsilon\left(-\sigma_j + \sigma_i^2 + \sigma_j^2\right) - 1 + 2\sigma_i - 2\sigma_j > 0.$$

When $\epsilon = 0$, we have

$$\frac{dW}{dt} = -\frac{X}{2}\left(1 - 2\sigma_i + 2\sigma_j\right) > 0 \Leftrightarrow \sigma_i - \sigma_j > \frac{1}{2} \Leftrightarrow 2\sigma_j + \sigma_3 < \frac{1}{2}.$$

Effects of a small tariff

The effects on outputs and profits of a change in τ are the same as those of a change in t. Thus, we examine only the welfare effect, which is given by

$$
\begin{aligned}
\frac{dW}{d\tau} &= -XP'\frac{dX}{d\tau} + \frac{d\pi_i}{d\tau} + \frac{d\pi_j}{d\tau} + x_j + x_3 + \tau\left(\frac{dx_j}{d\tau} + \frac{dx_3}{d\tau}\right) \\
&= \frac{X(P')^3}{|\Omega|}\left\{-\epsilon\left(1 - \sigma_i - 2\sigma_j + 2\sigma_i^2 + 2\sigma_j^2\right) + 2 - 4\sigma_j\right\} + \tau\left(\frac{dx_j}{d\tau} + \frac{dx_3}{d\tau}\right).
\end{aligned}
$$

Thus, evaluating this at $\tau = 0$, we have

$$
\frac{dW}{d\tau}\Big|_{\tau=0} > 0 \Leftrightarrow -\epsilon\left(1 - \sigma_i - 2\sigma_j + 2\sigma_i^2 + 2\sigma_j^2\right) + 2 - 4\sigma_j > 0.
$$

When $\epsilon = 0$,

$$
\frac{dW}{d\tau} = \frac{X}{2}\left(1 - 2\sigma_j\right) + \frac{\tau}{P'}.
$$

Thus,

$$
\frac{dW}{d\tau}\Big|_{\tau=0} = \frac{X}{2}\left(1 - 2\sigma_j\right) > 0 \Leftrightarrow \sigma_j < \frac{1}{2}
$$

and the optimal tariff is given by $\tau = -XP'\left(1 - 2\sigma_j\right)/2 > 0$.

Effects of a change in the foreign wage rate

From the FOCs, we have

$$
\begin{pmatrix} \frac{dx_i}{dw^*} \\ \frac{dx_j}{dw^*} \\ \frac{dx_3}{dw^*} \end{pmatrix} = \frac{P'}{|\Omega|} \begin{pmatrix} 3P' + P''\left(x_j + x_3\right) & -\left(P' + P''x_i\right) & -\left(P' + P''x_i\right) \\ -\left(P' + P''x_j\right) & 3P' + P''\left(x_i + x_3\right) & -\left(P' + P''x_j\right) \\ -\left(P' + P''x_3\right) & -\left(P' + P''x_3\right) & 3P' + P''\left(x_i + x_j\right) \end{pmatrix} \begin{pmatrix} 0 \\ a_j^* \\ a_3^* \end{pmatrix}.
$$

The effects on the outputs are given by

$$
\begin{aligned}
\frac{dx_i}{dw^*} &= -\frac{(P')^2}{|\Omega|}\left(a_j^* + a_3^*\right)\left(1 - \epsilon\sigma_i\right) > 0, \quad \frac{dx_j}{dw^*} = \frac{(P')^2}{|\Omega|}\left[3a_j^* - a_3^* - \epsilon\left\{a_j^* - \sigma_j\left(a_j^* + a_3^*\right)\right\}\right], \\
\frac{dx_3}{dw^*} &= \frac{(P')^2}{|\Omega|}\left[-a_j^* + 3a_3^* - \epsilon\left\{a_3^* - \sigma_3\left(a_j^* + a_3^*\right)\right\}\right], \quad \frac{dX}{dw^*} = \frac{(P')^2}{|\Omega|}\left(a_j^* + a_3^*\right) < 0.
\end{aligned}
$$

The condition for $dx_k/dw^* > 0$ $(k, l = j, 3; k \neq l)$ is

$$
\frac{dx_k}{dw^*} > 0 \Leftrightarrow 3a_k^* - a_l^* < \epsilon\left\{a_k^* - \sigma_k\left(a_k^* + a_l^*\right)\right\}.
$$

When $\epsilon = 0$,

$$
\frac{dx_i}{dw^*} = -\frac{1}{4P'}\left(a_j^* + a_3^*\right) > 0, \frac{dx_j}{dw^*} = \frac{1}{4P'}\left(3a_j^* - a_3^*\right), \frac{dx_3}{dw^*} = \frac{1}{4P'}\left(-a_j^* + 3a_3^*\right), \frac{dX}{dw^*} = \frac{1}{4P'}\left(a_j^* + a_3^*\right) < 0.
$$

Thus, we obtain

$$
\frac{dx_k}{dw^*} > 0 \Leftrightarrow a_k^* < \frac{a_l^*}{3}.
$$

The effects on the profits are given by

$$
\begin{aligned}
\frac{d\pi_i}{dw^*} &= \frac{(P')^3 x_i}{|\Omega|}\left(a_j^* + a_3^*\right)\left(2 - \epsilon\sigma_i\right) > 0, \\
\frac{d\pi_j}{dw^*} &= -\frac{(P')^3 x_j}{|\Omega|}\left[2\left(3a_j^* - a_3^*\right) - \epsilon\left\{2a_j^* - \sigma_j\left(a_j^* + a_3^*\right)\right\}\right], \\
\frac{d\pi_3}{dw^*} &= -\frac{(P')^3 x_3}{|\Omega|}\left[2\left(-a_j^* + 3a_3^*\right) - \epsilon\left\{2a_3^* - \sigma_3\left(a_j^* + a_3^*\right)\right\}\right].
\end{aligned}
$$

The condition for $d\pi_k/dw^* > 0$ $(k, l = j, 3; k \neq l)$ is

$$
\frac{d\pi_k}{dw^*} > 0 \Leftrightarrow 3a_k^* - a_l^* < \frac{\epsilon}{2}\left\{2a_k^* - \sigma_k\left(a_k^* + a_j^*\right)\right\}.
$$

When $\epsilon = 0$,

$$\frac{d\pi_i}{dw^*} = \frac{x_i}{2}\left(a_j^* + a_3^*\right) > 0, \quad \frac{d\pi_j}{dw^*} = -\frac{x_j}{2}\left(3a_j^* - a_3^*\right), \quad \frac{d\pi_3}{dw^*} = -\frac{x_3}{2}\left(-a_j^* + 3a_3^*\right)$$

and hence

$$\frac{d\pi_k}{dw^*} > 0 \Leftrightarrow a_k^* < \frac{a_l^*}{3}.$$

This condition is the same as that for $dx_k/dw^* > 0$ $(k, l = j, 3; k \neq l)$.

The welfare effect is given by

$$\begin{aligned}
\frac{dW}{dw^*} &= -XP'\frac{dX}{dw^*} + \frac{d\pi_i}{dw^*} + \frac{d\pi_j}{dw^*} \\
&= \frac{X(P')^3}{|\Omega|}\left[\left(-1 + 2\sigma_i + 2\sigma_j\right)\left(a_j^* + a_3^*\right) - 8a_j^*\sigma_j - \epsilon\left\{a_j^*\left(\sigma_i^2 + \sigma_j^2 - 2\sigma_j\right) + a_3^*\left(\sigma_i^2 + \sigma_j^2\right)\right\}\right].
\end{aligned}$$

Thus,

$$\frac{dW}{dw^*} > 0 \Leftrightarrow \left(-1 + 2\sigma_i + 2\sigma_j\right)\left(a_j^* + a_3^*\right) - 8a_j^*\sigma_j > \epsilon\left\{a_j^*\left(\sigma_i^2 + \sigma_j^2 - 2\sigma_j\right) + a_3^*\left(\sigma_i^2 + \sigma_j^2\right)\right\}.$$

When $\epsilon = 0$, noting $\sigma_i + \sigma_j = 1 - \sigma_3$, we have

$$\frac{dW}{dw^*} > 0 \Leftrightarrow \frac{\sigma_i + \sigma_j - \sigma_3}{8\sigma_j} > \frac{a_j^*}{a_j^* + a_3^*} \Leftrightarrow \frac{x_i - x_3}{x_j} > \frac{7a_j^* - a_3^*}{a_j^* + a_3^*}.$$

Appendix C

In this appendix, we explore the effects in Case C. The profits of firm i $(i = 1, 2, 3)$ are given by $\pi_i = (P - t - \tau)x_i - a_i^* w^* x_i$.

Effects of a change in transport costs

From the FOCs, we have

$$
\begin{pmatrix} \frac{dx_1}{dt} \\[2mm] \frac{dx_2}{dt} \\[2mm] \frac{dx_3}{dt} \end{pmatrix} = \frac{P'}{|\Omega|} \begin{pmatrix} 3P' + P''(x_2 + x_3) & -(P' + P''x_1) & -(P' + P''x_1) \\[2mm] -(P' + P''x_2) & 3P' + P''(x_1 + x_3) & -(P' + P''x_2) \\[2mm] -(P' + P''x_3) & -(P' + P''x_3) & 3P' + P''(x_1 + x_2) \end{pmatrix} \begin{pmatrix} 1 \\ 1 \\ 1 \end{pmatrix}.
$$

The effects on the outputs are given by

$$
\frac{dx_i}{dt} = \frac{(P')^2}{|\Omega|} \left\{ 1 - \epsilon(1 - 3\sigma_i) \right\}, \frac{dX}{dt} = \frac{3(P')^2}{|\Omega|} < 0.
$$

The effect on the profits of firm i $(i = 1, 2, 3)$ is

$$
\frac{d\pi_i}{dt} = -\frac{(P')^3 x_i}{|\Omega|} \left\{ 2 - \epsilon(2 - 3\sigma_i) \right\}.
$$

The condition for this to be positive is

$$
\frac{d\pi_i}{dt} > 0 \Leftrightarrow 2 < \epsilon(2 - 3\sigma_i).
$$

When $0 < \epsilon < 1$, $d\pi_i/dt > 0 \Leftrightarrow \sigma_i < 2(1 - 1/\epsilon)/3$. Since $2(1 - 1/\epsilon)/3 < 0$, $d\pi_i/dt < 0$. When $\epsilon < 0$, $d\pi_i/dt > 0 \Leftrightarrow \sigma_i > 2(1 - 1/\epsilon)/3$. When $-2 < \epsilon$, $d\pi_i/dt < 0$ because $2(1 - 1/\epsilon)/3 > 1$. When $\epsilon < -2$, $d\pi_i/dt > 0$ holds if σ_i is sufficiently large. When $\epsilon = 0$,

$$
\frac{d\pi_1}{dt} = -\frac{x_1}{2} < 0, \quad \frac{d\pi_2}{dt} = -\frac{x_2}{2} < 0, \quad \frac{d\pi_3}{dt} = -\frac{x_3}{2} < 0.
$$

The welfare effect is given by

$$
\frac{dW}{dt} = -XP'\left(\frac{dX}{dt}\right) + \frac{d\pi_1}{dt} + \frac{d\pi_2}{dt} = \frac{X(P')^3}{|\Omega|} \left\{ -\epsilon\left(-2\sigma_1 - 2\sigma_2 + 3\sigma_1^2 + 3\sigma_2^2\right) - 5 + 2\sigma_3 \right\}.
$$

Since $\sigma_1 + \sigma_2 = 1 - \sigma_3$, we obtain

$$\frac{dW}{dt} > 0 \Leftrightarrow \sigma_3 > 1 + \frac{3\left\{1 + \epsilon\left(\sigma_1^2 + \sigma_2^2\right)\right\}}{2\left(1 - \epsilon\right)}.$$

When $-1/(\sigma_1^2 + \sigma_2^2) < \epsilon < 1$, $dW/dt < 0$ holds because $1 + 3\left\{1 + \epsilon\left(\sigma_1^2 + \sigma_2^2\right)\right\}/2\left(1 - \epsilon\right) > 1$. When $\epsilon < 5/\left\{2 - 3\left(\sigma_1^2 + \sigma_2^2\right)\right\}$ and $2/3 < \sigma_1^2 + \sigma_2^2 < 1$, $dW/dt > 0$ holds because $1 + 3\left\{1 + \epsilon\left(\sigma_1^2 + \sigma_2^2\right)\right\}/2\left(1 - \epsilon\right) < 0$. When $\epsilon = 0$,

$$\frac{dW}{dt} = -\frac{X}{4}\left(5 - 2\sigma_3\right) < 0.$$

Effects of a small tariff

The effects on outputs and profits of a change in τ are the same as those of a change in t. Thus, we examine only the welfare effect:

$$\begin{aligned}
\frac{dW}{d\tau} &= -XP'\frac{dX}{d\tau} + \frac{d\pi_1}{d\tau} + \frac{d\pi_2}{d\tau} + X + \tau\left(\frac{dX}{d\tau}\right) \\
&= \frac{X\left(P'\right)^3}{|\Omega|}\left\{-\epsilon\left(1 - 2\sigma_1 - 2\sigma_2 + 3\sigma_1^2 + 3\sigma_2^2\right) - 1 + 2\sigma_3\right\} + \tau\left(\frac{dX}{d\tau}\right).
\end{aligned}$$

Since $\sigma_1 + \sigma_2 = 1 - \sigma_3$,
$$\frac{dW}{d\tau}\Big|_{\tau=0} > 0 \Leftrightarrow \sigma_3 > \frac{1}{2} + \frac{3\epsilon\left(\sigma_1^2 + \sigma_2^2\right)}{2\left(1 - \epsilon\right)}.$$

When $1/\left\{1 + 3\left(\sigma_1^2 + \sigma_2^2\right)\right\} < \epsilon < 1$, $(dW/d\tau)|_{\tau=0} < 0$ because $1/2 + 3\epsilon\left(\sigma_1^2 + \sigma_2^2\right)/2\left(1 - \epsilon\right) > 1$. When $\epsilon < 1/\left\{1 - 3\left(\sigma_1^2 + \sigma_2^2\right)\right\}$ and $1/3 < \sigma_1^2 + \sigma_2^2 < 1$, $(dW/d\tau)|_{\tau=0} > 0$ holds because $1/2 + 3\epsilon\left(\sigma_1^2 + \sigma_2^2\right)/2\left(1 - \epsilon\right) < 0$. When $\epsilon = 0$,

$$\frac{dW}{d\tau} = -\frac{X}{4}\left(1 - 2\sigma_3\right) + \frac{3\tau}{4P'}.$$

Thus,

$$\frac{dW}{d\tau}\Big|_{\tau=0} = -\frac{X}{4}(1-2\sigma_3) > 0 \Leftrightarrow \sigma_3 > \frac{1}{2}$$

and the optimal tariff is give by $\tau = XP'(1-2\sigma_3)/3$.

Effects of a change in the foreign wage rate

From the FOCs, we have

$$\begin{pmatrix} \frac{dx_1}{dw^*} \\ \frac{dx_2}{dw^*} \\ \frac{dx_3}{dw^*} \end{pmatrix} = \frac{P'}{|\Omega|} \begin{pmatrix} 3P' + P''(x_2+x_3) & -(P'+P''x_1) & -(P'+P''x_1) \\ -(P'+P''x_2) & 3P' + P''(x_1+x_3) & -(P'+P''x_2) \\ -(P'+P''x_3) & -(P'+P''x_3) & 3P'+P''(x_1+x_2) \end{pmatrix} \begin{pmatrix} a_1^* \\ a_2^* \\ a_3^* \end{pmatrix}.$$

The effects on outputs are

$$\begin{aligned} \frac{dx_i}{dw^*} &= \frac{(P')^2}{|\Omega|}\left[3a_i^* - a_j^* - a_k^* - \epsilon\left\{a_i^* - \sigma_i\left(a_i^* + a_j^* + a_k^*\right)\right\}\right], \quad (i,j,k=1,2,3; i \neq j, i \neq k, j \neq k), \\ \frac{dX}{dw^*} &= \frac{(P')^2\left(a_1^* + a_2^* + a_3^*\right)}{|\Omega|} < 0. \end{aligned}$$

Thus, we have

$$\frac{dx_i}{dw^*} > 0 \Leftrightarrow 3a_i^* - a_j^* - a_k^* < \epsilon\left\{a_i^* - \sigma_i\left(a_i^* + a_j^* + a_k^*\right)\right\}.$$

When $\epsilon = 0$,

$$\frac{dx_i}{dw^*} = \frac{3a_i^* - a_j^* - a_k^*}{4P'} > 0 \Leftrightarrow a_i^* < \frac{a_j^* + a_k^*}{3}.$$

The effect on firm i's profit is

$$\frac{d\pi_i}{dw^*} = -\frac{(P')^3 x_i}{|\Omega|}\left[2\left(3a_i^* - a_j^* - a_k^*\right) - \epsilon\left\{2a_i^* - \left(a_i^* + a_j^* + a_k^*\right)\sigma_i\right\}\right], \quad (i,j,k=1,2,3; i \neq j, i \neq k, j \neq k).$$

Therefore,

$$\frac{d\pi_i}{dw^*} > 0 \Leftrightarrow 3a_i^* - a_j^* - a_k^* < \frac{\epsilon}{2}\left\{2a_i^* - \left(a_i^* + a_j^* + a_k^*\right)\sigma_i\right\}.$$

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When $\epsilon = 0$,

$$\frac{d\pi_i}{dw^*} = -\frac{x_i}{2}\left(3a_i^* - a_j^* - a_k^*\right) > 0 \Leftrightarrow a_i^* < \frac{a_j^* + a_k^*}{3}.$$

This condition is the same as the condition for $dx_i/dw^* > 0$.

The welfare effect is given by

$$
\begin{aligned}
\frac{dW}{dw^*} &= -XP'\frac{dX}{dw^*} + \frac{d\pi_1}{dw^*} + \frac{d\pi_2}{dw^*} \\
&= \frac{X(P')^3}{|\Omega|}[(-1 + 2\sigma_1 + 2\sigma_2)\left(a_1^* + a_2^* + a_3^*\right) - 8\left(\sigma_1 a_1^* + \sigma_2 a_2^*\right) \\
&\quad - \epsilon\left\{a_1^*\left(\sigma_2^2 - \sigma_1\sigma_2 - \sigma_1\sigma_3 - \sigma_1\right) + a_2^*\left(-\sigma_1\sigma_2 - \sigma_2\sigma_3 + \sigma_1^2 - \sigma_2\right) + a_3^*\left(\sigma_1^2 + \sigma_2^2\right)\right\}].
\end{aligned}
$$

Thus,

$$
\frac{dW}{dw^*} > 0 \Leftrightarrow
\begin{aligned}
&(-1 + 2\sigma_1 + 2\sigma_2)\left(a_1^* + a_2^* + a_3^*\right) - 8\left(\sigma_1 a_1^* + \sigma_2 a_2^*\right) \\
&> \epsilon\left\{\left(\sigma_1^2 + \sigma_2^2\right)\left(a_1^* + a_2^* + a_3^*\right) - 2\left(\sigma_1 a_1^* + \sigma_2 a_2^*\right)\right\}.
\end{aligned}
$$

When $\epsilon = 0$, we have

$$\frac{dW}{dw^*} > 0 \Leftrightarrow \frac{\sigma_1 + \sigma_2 - \sigma_3}{8} > \frac{\sigma_1 a_1^* + \sigma_2 a_2^*}{a_1^* + a_2^* + a_3^*}.$$

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Notes

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

[2]Significant amounts of reverse imports also exist between developed countries. Greaney (2003) finds that "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).

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

[4]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 sectors". For empirical support, see Hanson et al. (2001), for example.

[5]Nikkei (January 30, 2008) reports that the minimum wages in major cities in China have increased more than one and a half times higher in the last seven years. See also http://www.businessweek.com/magazine/content/06_13/b3977049.htm

[6]Greaney (2003) considers reverse imports in the presence of network effects. Xing and Zhao (2006) analyze the relationship among exchange rates, FDI and reverse imports. Yomogida (2007) assumes two identical domestic firms (potential multinational firms) and considers the choice between foreign production and domestic production to serve the domestic market. He shows the possibility of socially undesirable offshoring.

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[7]See, for example, Helpman et al. (2004) and Grossman et al. (2006). In particular, by using firm-level data, Helpman et al. (2004) find that more productive firms engage in FDI. However, Head and Ries (2003) and Yeaple (2005) show that this finding is not necessarily the case. Also Sinn (2004) reports that 60% of small and medium German firms have established plants outside the old EU.

[8]A number of papers such as Neary (1994) and Ishikawa (1998) are concerned with cost asymmetries across countries.

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

[10]Alternatively, we can regard t as a communications cost.

[11]FCs play a crucial role in location choices. For details, see Ishikawa and Komoriya (2006).

[12]By assumption, the foreign firm always produces in the foreign country.

[13]In a closed economy model, Lahiri and Ono (1988) show that an increase in the output of the less efficient firm at the expense of the more efficient firm is detrimental. Here, this welfare-reducing effect is reinforced by the presence of a foreign firm.

[14]A tariff also shifts a rent from the domestic firm producing in the foreign country to the domestic government. However, this is neutral from the viewpoint of domestic welfare.

[15]It can be verified that there actually exist parameter values under which an increase in w^* improves domestic welfare.

[16]The proof is available upon request from the authors.