# Trade Costs, Wage Rates, Technologies, and Offshore Outsourcing*

Jota Ishikawa†
Hitotsubashi University and
University of New South Wales

Yoshimasa Komoriya
Hitotsubashi University

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**Abstract**

In a two-country model, we examine offshore outsourcing decisions by two domestic firms which are heterogeneous due to different marginal costs (MCs) of production. We specifically decompose the MC into the wage rate and the labor coefficient. Both lower foreign wage rate and lower trade costs make outsourcing more attractive, though they may generate different effects. When both firms use outsourcing, a decrease in the transport and communications costs improves domestic welfare. Surprisingly, however, an increase in the foreign wage rate as well as an increase in the domestic tariff rate may enhance domestic welfare.

*Keywords*: outsourcing; oligopoly; heterogeneous firms; trade costs; wage rates, technologies

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†*Corresponding author*: Faculty of Economics, Hitotsubashi University, Kunitachi, Tokyo 186-8601, Japan; Fax: +81-42-580-8882; E-mail: jota@econ.hit-u.ac.jp

# 1 Introduction

Over the last decade or so, a great number of firms in developed countries have moved part of operations in manufacture to developing countries. For instance, many of electronic components are manufactured in Taiwan and many of labor-intensive consumer goods such as apparel are produced in China. The proliferation of this phenomenon, dubbed "offshoring" or "hollowing out", can be attributed to several factors: rising domestic production costs such as wages and falling trade costs such as transport costs, tariffs and communications costs. Recent improvements in transportation and communications technology allow firms to allocate operations all over the world to lower production costs. In particular, offshoring has facilitated trade in intermediate inputs including both goods and services.[1]

There are two types of offshoring: foreign direct investment (FDI) and outsourcing. In this paper, we investigate offshore outsourcing. In particular, we examine offshore outsourcing decisions by two domestic firms which are heterogeneous due to different marginal costs (MCs) of production. We specifically decompose the MC into the wage rate and the labor coefficient, which enables us to obtain some more insight into outsourcing. The labor coefficients may be different not only across firms but also across production locations. The wage rates may also be different between countries.

We analyze how trade costs, wage rates, and labor coefficients affect firms' outsourcing decisions. The inter-firm cost asymmetry enables us to investigate which firm has more incentive to utilize outsourcing, a more efficient firm or a less efficient one. We also examine the effects of trade costs and wage rates on domestic welfare. When both firms make use of outsourcing, a decrease in the transport and communications costs improves domestic welfare. Surprisingly, however, an increase in the foreign wage rate as well as an increase in the tariff rate may enhance domestic welfare. This interesting result stems from firm heterogeneity.

Recently firm heterogeneity has attracted considerable attention in the trade literature. However, the most studies are on the basis of the monopolistic competition model originally developed by Melitz (2003), who considers the coexistence of exporting firms and non-exporting firms.[2] In the framework of oligopoly, the technology asymmetry among firms with the same nationality has been paid little attention.

The recent development of theory on offshoring is broadly based on two approaches. The first approach is the analysis of fragmentation in the framework of traditional trade theories.[3] In those models, the production process exogenously fragments into a few processes and the effects of such fragmentation on factor prices and welfare are investigated.[4] Another approach is the analysis of the choice of organizational form across countries.[5] That is, the choice between internal and

[1] Examples of such services include software and hardware engineering, R&D, accounting, call centers, etc.

[2] See, for example, Helpman et al. (2004) and Grossman et al. (2006).

[3] See, for example, Jones (2000), Jones and Kierzkowski (2001), and Deardorff (2001).

[4] Grossman and Ross-Hansberg (2006) have built a more sophisticated model to examine the effects of offshoring on domestic factor prices.

[5] See, for example, McLaren (2000), Grossman and Helpman (2002, 2005), and Antràs and Helpman (2004).

external production is explored in the context of contract and organization theories.

In contrast to these approaches, our focus is on the effects of trade costs and wage rates on outsourcing in the presence of the inter-firm cost asymmetry in the framework of oligopoly. By using an oligopolistic model, Chen et al. (2004) examine the relationship between trade liberalization and outsourcing. However, their interest is in the strategic aspect between domestic and foreign firms. Whereas outsourcing arises even if outsourcing is more costly than in-house production due to the strategic aspect in their model, outsourcing is purely motivated by cost saving in our model.

In Ishikawa and Komoriya (2006), we examine plant location choices among heterogeneous firms in the presence of fixed costs associated with FDI. Once FCs are present, the analysis becomes quite messy. Ishikawa and Komoriya (2006) show that multiple equilibria may exist and a small change in trade costs may reverse plant locations. In the present study, FCs are absent, though the MC is decomposed into the wage rate and the labor coefficient. Furthermore, Ishikawa and Miyagiwa (2005) extend our static analysis to a dynamic framework. They specifically investigate the relationship between the inter-firm cost asymmetry and the timing of offshore outsourcing. In particular, they show that a more efficient firm does not always start outsourcing before a less efficient one.

The rest of the paper is organized as follows. Section 2 examines the offshore outsourcing decisions when two domestic firms serve only the domestic market. Section 3 analyzes the welfare effects of both transport and communications costs and foreign wage rates. We investigate tariffs in Section 4. Since tariffs generate government revenue, the effects of tariffs are different from those of transport and communications costs. Section 5 takes the foreign market into account. We analyze the case where only the foreign market is served as well as the case where both domestic and foreign markets are served. Section 6 concludes the paper. Mathematical derivation of the results is provided in the appendix.

## 2 Basic Model

We consider a model where there are two countries (domestic and foreign) and two domestic firms (firms 1 and 2). Both firms supply a homogeneous good to the domestic market. Each firm produces the good with or without offshore outsourcing. For simplicity, we assume that in the case of outsourcing, all manufacturing processes are done in the foreign country. The model involves two stages of decision. In stage 1, both firms simultaneously choose whether to use outsourcing. In stage 2, the firms compete in quantities with Cournot conjectures.[6] The game is solved by backward induction.

Spencer (2005) surveys the literature.

[6] As we shall see later, whether to use outsourcing is independent of the mode of competition unless there is a bang-bang solution such as in the case of price competition along with perfect substitutability.

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 two firms are strategic substitutes (i.e., $P' + P''x_i < 0$ where $x_i$ is the output of firm $i$ $(i = 1, 2)$).[7]

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

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

where $t$ and $\tau$ are, respectively, a specific transport and/or communications cost and a specific tariff and $C_i(\cdot)$ is the cost function. The domestic firm incurs both $t$ and $\tau$ in the case of outsourcing.[8] Specifically, we assume that labor is the only production factor and the cost function of firm $i$ $(i = 1, 2)$ is given by

$$C_i(x_i) = \begin{cases} c_i x_i = a_i w x_i \\ c_i^* x_i = a_i^* w^* x_i \end{cases} \tag{3}$$

where $a_i$ and $w$ are, respectively, labor coefficient and the wage rate, which are exogenously given and constant.[9] An asterisk denotes foreign variables or parameters. In the case of outsourcing, the domestic firm has to transfer its technology to a foreign firm and let them produce the good. Without technology transfer, the foreign firm cannot produce it. For simplicity, we assume that the domestic firms can design the license fees such that all rent associated with technology transfer accrues to the domestic firms and hence the cost of outsourcing for firm $i$ is only $a_i^* w^*$.[10] We also assume $w > w^*$ and $a_i \leq a_i^*$. $a_i \leq a_i^*$ reflects the cost of outsourcing such as the cost of international technology transfer and the managerial inefficiency of the foreign firm. Without loss of generality, firm 1 is assumed to be more efficient than firm 2 (i.e., $a_1 w < a_2 w$ and $a_1^* w^* < a_2^* w^*$)

When $a_i w > a_i^* w^*$ $(i = 1, 2)$, the benefit lies in lower MC in the case of outsourcing, but there are trade costs. A firm manufactures in the country where the "effective" MC is lower. The effective MC includes the trade costs. That is, the effective MC of firm $i$ is $c_i$ (i.e., the real MC) under in-house production and $c_i^* + t + \tau$ under outsourcing. Thus, firm $i$ $(i = 1, 2)$ uses outsourcing if and only if

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

[8] In fact, it may be technically difficult to charge tariffs when outsourcing is made through the Internet.

[9] Using a general equilibrium model, Grossman and Rossi-Hansberg (2006) examine the effects of offshoring on factor prices in the source country.

[10] For example, this is possible under a fixed fee contract.

$$a_i w > a_i^* w^* + t + \tau. \quad (4)$$

We should note that a particular firm's outsourcing choice is independent of the other firm's. Thus, there does not exist any strategic relationship between the firms in stage 1.

In the following, we focus on the case in which both firms operate.[11] We normalize $w = 1$. We also set $\tau = 0$ for the moment. Figure 1 illustrates (4). Firm 1 produces without (with) outsourcing in the region above (below) line 1, while firm 2 produces without (with) outsourcing in the region above (below) line 2. The outsourcing decisions depend on the relative size of the labor-coefficient ratio, $a_i/a_i^*$ $(i = 1, 2)$. Whereas Panel (a) shows the case where $a_1/a_1^* < a_2/a_2^*$ holds, Panel (b) shows the case where $a_1/a_1^* > a_2/a_2^*$. For example, $a_1/a_1^* < a_2/a_2^*$ $(a_1/a_1^* > a_2/a_2^*)$ is the case if it is relatively difficult (easy) to transfer more efficient technology to the foreign country.

There are three regions in Panel (a) and four regions in Panel (b). Both firms choose in-house production (outsourcing) when $w^*$ is relatively high (low) and/or $t$ is relatively high (low), that is, $(t, w)$ is in region $DD$ (region $FF$). Firms 1 and 2, respectively, choose in-house production and outsourcing in region $DF$ and vice versa in region $FD$. We should note that region $FD$ never appears in Panel (a).

To obtain economic intuition for the difference between Panels (a) and (b), we first consider an extreme case where $a_i^* = a_i$ $(i = 1, 2)$, that is, the foreign and the domestic production of firm $i$ share the identical technology. Since both firms face the same trade costs in the case of outsourcing, the share of trade cost 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 utilize outsourcing. In this case, therefore, firm 2 always has more incentive for outsourcing (see Figure 1 (a)). 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 relatively a high trade cost and relatively more efficient foreign technology. Thus, if the trade cost is low enough, firm 1 has more incentive to outsource its product in the foreign country.

Thus, we obtain the following proposition.

**Proposition 1** *When $a_1/a_1^* < a_2/a_2^*$, firm 2 (i.e., the less efficient firm) always has more incentive to outsource its product abroad than firm 1 (i.e., the more efficient firm). If only one firm utilizes outsourcing in equilibrium, it is the less efficient firm. When $a_1/a_1^* > a_2/a_2^*$, on the other hand, the less efficient firm (the more efficient firm) has more incentive for outsourcing if both $t$ is relatively high (low) but $w^*$ is relatively low (high).*

When either $t$ or $w^*$ falls, outsourcing becomes more attractive.[12] In this sense, the effect of a decrease in $w^*$ on outsourcing incentive seems similar to that of a decrease in $t$. However,

[11] If the firm 2's effective MC is greater than or equal to the monopoly price charged by firm 1, then firm 1 becomes the monopolist.

[12] Since we normalize $w = 1$, a decrease in $w^*$ does not necessarily imply that the foreign wage rate actually falls.

there is a distinction between them. Suppose that the initial $(t, w^*)$ is located to the northeast of point $S$, in Figure 1 (b). If $t$ falls, the region shifts from $DD$ to $FD$. If $w^*$ falls, on the other hand, the region shifts from $DD$ to $DF$. This distinction stems from the differential effects on the MCs between changes in $t$ and $w^*$. When $t$ falls, the MCs of outsourcing lower by the same amount between two firms. However, when $w^*$ falls, a decrease in the firm 1's MC of outsourcing is smaller than the firm 2's, that is, firm 2 benefits more from a lower $w^*$ than firm 1 when both utilize outsourcing.

Thus, the following proposition is established.

**Proposition 2** *If $a_1/a_1^* < a_2/a_2^*$, a decrease in $t$ as well as a decrease in $w^*$ lead the less efficient firm to have higher incentive for outsourcing. If $a_1/a_1^* > a_2/a_2^*$ and if $t$ and $w^*$ are relatively high, a decrease in $w^*$ provides the less efficient firm higher incentive for outsourcing, but a decrease in $t$ provides the more efficient firm higher incentive.*

# 3 Transport and Communications Costs and Wage Rates

In this section, we examine the effects of changes in $t$ and $w^*$ on domestic welfare, measured by the sum of consumer surplus and firms' profits:

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

where $dU/dX = P$.

Obviously, any change in $t$ does not affect welfare in region $DD$. In region $FF$, the appendix shows that both firms lose from an increase in $t$.[13] Consumers also lose from a higher $t$, because the price rises. Thus, a lower $t$ leads to higher welfare in region $FF$. In region $DF$, a decrease in $t$ hurts firm 1 and benefits firm 2, and vice versa in region $FD$.

The appendix shows that when firm $i$ produces in the domestic country and firm $j$ produces in the foreign country $(i, j = 1, 2; i \neq j)$, the following holds: when $\epsilon \neq 0$, $dW/dt < 0$ if and only if $\sigma_i < \widehat{\sigma}_i \equiv \left(-\sqrt{-10\epsilon + 2\epsilon^2 + 9} + 3\right)/2\epsilon$, where $\sigma_i$ is the market share of firm $i$; and when $\epsilon = 0$, $dW/dt < 0$ if and only if $\sigma_i < 5/6$.[14] Thus, if $x_i$ is not very large, then $dW/dt < 0$ holds. In particular, the appendix shows $1/2 < \widehat{\sigma}_i < 1$. Thus, $dW/dt < 0$ holds if $\sigma_i \leq 1/2$, which always holds with $i = 2$.

Intuitively, a lower $t$ is beneficial, because the total supply rises and the domestic consumers gain. However, as pointed out by Lahiri and Ono (1988), an increase in the output of the less efficient firm at the expense of the more efficient firm is detrimental. When the latter effect dominates the former, domestic welfare deteriorates. In Figure 1, therefore, a decrease in $t$ reduces domestic welfare only if $(t, w^*)$ is in region $DF$.

Thus, the following proposition is established.

[13] Although a higher $t$ harms both firms, the output of the more efficient firm may rise (see the appendix).

[14] Assuming linear demand: $P(X) = \alpha - \beta X$, $w^* < (4\alpha + 7a_i)/11a_j^* - t/11a_j^*$ is equivalent to $\sigma_i < 5/6$.

**Proposition 3** *When both firms utilize outsourcing, a decrease in $t$ improves domestic welfare. A lower $t$ raises domestic welfare if only the more efficient firm utilizes outsourcing, but reduces it if only the less efficient firm utilizes outsourcing and its market share is sufficiently small.*

We next consider the effects of changes in $w^*$. Any change in $w^*$ does not affect welfare in region $DD$. In region $FF$, consumers lose from a higher $w^*$. However, the appendix proves that it is possible an increase in $w^*$ benefits the more efficient firm at the expense of the less efficient firm and improves economic welfare. In the appendix, we obtain

$$\frac{d\Pi_1}{dw^*} > 0 \Leftrightarrow \frac{a_2^*}{a_1^*} > \frac{4 - 2\epsilon + \epsilon\sigma_1}{2 - \epsilon\sigma_1}, \tag{6}$$

and if $5 - \epsilon - 6\sigma_1 + 2\epsilon\sigma_1^2 < 0$,

$$\frac{dW}{dw^*} > 0 \Leftrightarrow \frac{a_2^*}{a_1^*} > \frac{-\left(5 - \varepsilon - 6\sigma_2 + 2\varepsilon\sigma_2^2\right)}{5 - \epsilon - 6\sigma_1 + 2\epsilon\sigma_1^2} = \frac{1 - \epsilon - 6\sigma_1 + 4\epsilon\sigma_1 - 2\epsilon\sigma_1^2}{5 - \epsilon - 6\sigma_1 + 2\epsilon\sigma_1^2} > 1.$$

In the case of linear demand (i.e., $\epsilon = 0$), therefore, $dx_1/dw^* > 0$ and $d\Pi_1/dw^* > 0$ if and only if $a_2^*/a_1^* > 2$; and $dW/dw^* > 0$ if and only if $a_2^*/a_1^* > (6\sigma_1 - 1)/(6\sigma_1 - 5) > 1$.

In region $DF$, an increase in $w^*$ hurts firm 2 and benefits firm 1, and vice versa in region $FD$. The appendix shows that when firm $i$ produces in the domestic country and firm $j$ produces in the foreign country ($i, j = 1, 2; i \neq j$), the following holds: when $\epsilon \neq 0$, $dW/dw^* > 0$ if and only if $\sigma_i > \sigma_i^* \equiv \left(-\sqrt{-10\epsilon + 2\epsilon^2 + 9} + 3\right)/2\epsilon$; and when $\epsilon = 0$, $dW/dw^* > 0$ if and only if $\sigma_i > 5/6$.

Thus, the following proposition is established.

**Proposition 4** *When both firms use outsourcing, an increase in $w^*$ improves domestic welfare if the market share of the less efficient firm is sufficiently small. A higher $w^*$ raises domestic welfare if only the less efficient firm utilizes outsourcing and its market share is sufficiently small.*

We should note that there is asymmetry between the effects of $t$ and $w^*$ on profits and welfare. That is, when both firms utilize outsourcing, they lose from an increase in $t$ but the more efficient firm may gain from an increase in $w^*$. This is because an increase in $t$ raises the effective MCs of both firms, $a_i^* w^* + t$ $(i = 1, 2)$, by the same amount, while an increase in $w^*$ raises the effective MC of the less efficient firm, $a_2^* w^* + t$, more than that of the more efficient firm, $a_1^* w^* + t$. Intuitively, when the difference between $a_1^*$ and $a_2^*$ is large, an increase in $w^*$ expands the output of the more efficient firm at the cost of the less efficient firm and may benefit the more efficient firm. If this gain dominates the loss of consumers as well as that of the less efficient firm, then welfare improves.

# 4 Tariffs

In this section, we consider tariffs. In particular, we focus on the welfare effects of tariffs, $\tau (> 0)$,[15] because the effects on outputs and profits are the same as those of $t$. In the welfare analysis of

[15] We focus on positive tariffs.

tariffs, we have to take tariff revenue into account. We first examine the case where both firms utilize outsourcing. The following proposition is proved in the appendix.

**Proposition 5** *When both firms utilize outsourcing, the domestic government has no incentive to impose a tariff if* $-1 \leq \epsilon < 1$ *but has such incentive if* $\epsilon < -1$ *and* $1/2 - \sqrt{-\epsilon}/2\epsilon < \sigma_1 \leq 1$.

The reason why a tariff may enhance domestic welfare is as follows. In view of the appendix, the welfare effect of a tariff is given by

$$\frac{dW}{d\tau}|_{\tau=0} = -XP'\frac{dX}{d\tau} + \frac{d\Pi_i}{d\tau} + \frac{d\Pi_j}{d\tau} + X.$$

The effects of a tariff on firm $i$'s profits are decomposed into two terms:

$$\frac{d\Pi_i}{d\tau} = -x_i + \frac{\partial \Pi_i}{\partial x_j}\frac{\partial x_j}{\partial \tau} = -x_i + P'x_i\frac{P' + P''(x_i - x_j)}{|\Omega|},$$

where $|\Omega| \equiv (P')^2(3-\epsilon) > 0$ (see the appendix). The first term is the direct effect of a tariff (i.e., the loss from the tariff payment), while the second is the indirect effect generated by the presence of the rival firm. The second term is positive for the more efficient firm when $\epsilon \leq 0$. The tariff payments are a transfer from the firms to the government. Thus, domestic welfare improves if the second term of the more efficient firm dominates the sum of a decrease in consumer surplus and the second term of the less efficient firm. This is likely to occur when $(x_1 - x_2)$ (or the share of firm 1) is very large and $P''$ (or $\epsilon$) is very small. That is,

$$\frac{dW}{d\tau}|_{\tau=0} > 0 \Leftrightarrow P'x_1\frac{P' + P''(x_1 - x_2)}{|\Omega|} > XP'\frac{dX}{d\tau} - P'x_2\frac{P' + P''(x_2 - x_1)}{|\Omega|}.$$

We should note that in the case of transport and communications costs, the costs cannot be recovered and hence an increase in $t$ always deteriorates welfare.

We next investigate the case where firms $i$ and $j$, respectively, choose in-house production and outsourcing. The appendix shows

**Proposition 6** *The domestic government has no incentive to impose a tariff if only the more efficient firm uses outsourcing but may have such incentive if only the less efficient firm uses outsourcing.*

To obtain some more insight in the case where only firm 2 uses outsourcing, suppose linear demand: $P(X) = \alpha - \beta X$. Then, as shown in the appendix, a tariff enhances welfare if and only if $\sigma_1 > 2/3$ (i.e., $x_1 > 2x_2$). The (local) optimal tariff rate set by the domestic government is zero if $\tau_{DF}(\equiv -\alpha - 4a_1 + 5a_2^*w^* + 5t) \leq 0$, $\tau_{DF}$ if $0 < \tau_{DF} < a_2 - a_2^*w^* - t$, and $a_2 - a_2^*w^* - t$ if $\tau_{DF} \geq a_2 - a_2^*w^* - t$.[16] Thus, as long as only firm 2 utilizes outsourcing, there are three cases. The government does not impose any tariff in the first case, imposes a relatively small tariff in the second case, and imposes a relatively large tariff so that firm 2 becomes indifferent between outsourcing and in-house production in the third case.

[16] When $\tau = a_2 - a_2^*w^* - t$, firm 2 is indifferent between outsourcing and in-house production.

On the basis of the above analysis, we consider the global optimal tariff (i.e., the optimal tariff when production locations are allowed to change). To this end, we relabel the horizontal axis as $t + \tau (\equiv T)$ in Figure 1. Keeping the initial $t$ and $w^*$ constant, we find the optimal tariff. A tariff shifts the initial point horizontally to the right. Since a tariff may change production locations, we first compare welfare on the borders of regions. Suppose $(T, w^*)$ is on line 1 or line 2 as a result of a tariff. On line 1, $DF$ ($FD$) and $FF$ ($DD$) lead to the same consumer price and profits but $FF$ ($FD$) generates the tariff revenue. Similarly, on line 2, $DF$ ($FF$) and $DD$ ($FD$) result in the same consumer price and profits but $DF$ ($FF$) generates the tariff revenue. Thus, the following lemma holds.

**Lemma 1** *On line 1, welfare in region $FF$ ($FD$) is larger than that in region $DF$ ($DD$). On line 2, welfare in region $DF$ ($FF$) is larger than that in region $DD$ ($FD$).*

We are now ready to find the optimal tariff. First, suppose that the initial $(t, w^*)$ is in region $DF$. A tariff may shift the region from $DF$ to $DD$ . In view of Lemma 1, a tariff which shifts the region from $DF$ to $DD$ is not optimal. Then we can infer from the local optimal tariff in region $DF$ above that there are two cases. In the first case, a tariff in region $DF$ reduces welfare and hence the optimal tariff is zero. In the second case, the optimal tariff is positive.

Second, suppose that the initial $(t, w^*)$ is in region $FD$. In view of Proposition 6, the government has no incentive to impose a tariff as long as $(T, w^*)$ remains in region $FD$. A tariff may shifts the region from $FD$ to $DD$. However, by noting Lemma 1, such tariff is welfare-reducing. Thus, the optimal tariff is zero.

Lastly, suppose that the initial $(t, w^*)$ is in region $FF$. If $-1 \leq \epsilon < 1$, the government has no incentive to impose a tariff which leads $(T, w^*)$ to remain in region $FF$. A tariff which shifts the region from $FF$ to $FD$ cannot be optimal. If a tariff shifts the region from $FF$ to $DF$, on the other hand, we need to compare the initial welfare with the welfare in region $DF$. The optimal tariff is zero if the initial welfare is higher than the welfare in region $DF$ and is positive otherwise. If both $\epsilon < -1$ and $1/2 - \sqrt{-\epsilon}/2\epsilon < \sigma_1 \leq 1$ hold, on the other hand, the government has incentive to impose a tariff in region $FF$. Under the optimal tariff which is positive, either $FF$ or $DF$ arises.

The domestic government can strategically utilize tariffs not to reduce domestic welfare. For example, Proposition 3 implies that in region $DF$, domestic welfare may deteriorate as $t$ falls. If this is the case, the domestic government can prevent such welfare deterioration by imposing a tariff so that firm 2 chooses in-house production. The government may have incentive to lift the tariff, once $t$ becomes so low that outsourcing improves domestic welfare.

# 5 Foreign Market

## 5.1 Foreign Market Alone

In this subsection, we consider the decision of outsourcing when two firms serve the foreign market alone. Firms incur the transport cost only when they choose domestic production and export to the foreign country.

Firm $i$ ($i = 1, 2$) produces in the domestic country if and only if

$$a_i w + t \leq a_i^* w^*,$$

that is,

$$a_i^* w^* \geq a_i w + t. \tag{7}$$

Figure 2 illustrates (7). Both lines have positive slopes in Figure 2 in contrast to those in Figure 1. Whereas Panel (a) shows the case where $a_1/a_1^* < a_2/a_2^*$ holds, Panel (b) shows the case where $a_1/a_1^* > a_2/a_2^*$. There are four regions in Panel (a) and three regions in Panel (b). Both firms choose in-house production (outsourcing) when $w^*$ is relatively high (low) but $t$ is relatively low (high), i.e., in region $DD$ (region $FF$). Whereas firm 1 chooses in-house production and firm 2 chooses outsourcing in region $DF$, firm 1 chooses outsourcing and firm 2 chooses in-house production in region $FD$. We should note that region $DF$ never appears in Panel (b). Thus, the more efficient firm always has more incentive to utilize outsourcing when $a_1/a_1^* > a_2/a_2^*$.

Economic intuition is similar to that in section 2. Suppose $a_i^* = a_i$ ($i = 1, 2$). When they outsource their products in the foreign country, both firms can save the transport cost. Since $a_1^* w^* < a_2^* w^*$, an advantage of outsourcing stemming from saving the same transport cost is relatively large for firm 1 than for firm 2. Therefore, firm 1 always has more incentive for outsourcing than firm 2. 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 relatively a high reduction of the transport cost and relatively less efficient foreign technology. Thus, firm 1 has more incentive for outsourcing only when the transport cost is high enough.

We thus obtain the following propositions.

**Proposition 7** *When $a_1/a_1^* > a_2/a_2^*$, firm 1 (i.e., the more efficient firm) always has more incentive for outsourcing than firm 2 (i.e., the less efficient firm). If only one firm utilizes outsourcing in equilibrium, it is the more efficient firm. When $a_1/a_1^* < a_2/a_2^*$, on the other hand, the more efficient firm (the less efficient firm) has more incentive for outsourcing if $t$ and $w^*$ are relatively high (low).*

With respect to the effects of changes in $t$ or $w^*$ on domestic welfare, measured by firms' profits: $W \equiv \Pi_1 + \Pi_2$, the results are similar to Propositions 3 and 4. First, suppose that both firms produce without outsourcing. A lower $t$ benefits both firms and hence domestic welfare improves. Second, suppose that both firms outsource their products in the foreign country. Regarding a change in $w^*$, (6) holds. Thus, a higher $w^*$ may enhance welfare.[17] When firms $i$ and $j$, respectively, produces at home and abroad ($i, j = 1, 2; i \neq j$), we can say that if $x_j$ ($x_i$) is sufficiently small, $dW/dt < 0$ ($dW/dt > 0$) holds, that is, a decrease in $t$ improves (reduces) domestic welfare.[18] Moreover, if only the less efficient firm utilizes outsourcing and its market share is small, $dW/dw^* > 0$ holds.[19]

### 5.2 Both Domestic and Foreign Markets

We now consider outsourcing decisions when both domestic and foreign markets are served. We assume that the transport and communications costs from the domestic country to the foreign country is the same with those from the foreign country to the domestic country and no tariffs are imposed. We combine Figures 1 and 2 to examine the two-market case (see Figure 3). In Figure 3, the first (last) two letters show where two firms produce their products to serve the domestic (foreign) market. For example, $(DD, DF)$ means that both firms choose in-house production to serve the domestic market, and firms 1 and 2, respectively, choose in-house production and outsourcing to serve the foreign market.

There are seven regions in each panel. Regions ($DF$, $DF$) and ($DD$, $DF$) are observed only in Panel (a), while ($FD$, $FF$) and ($FD$, $FD$) are only in Panel (b).

## 6 Concluding Remarks

Using a simple, two-country, duopoly model, we have analyzed outsourcing decisions by the domestic firms whose MCs are different. Specifically, we have decomposed the MC into the wage rate and the labor coefficient. Whether the firm which has higher incentive for outsourcing is more efficient or less efficient than the other crucially depends on the difference in their relative technology gap between two countries. Depending on the gap, a reduction of trade costs and a reduction of the foreign wage rate can affect the outsourcing decisions differently. When both firms use outsourcing, a decrease in the transport and communications costs improves domestic welfare. Surprisingly, however, an increase in the foreign wage rate as well as an increase in the tariff rate may enhance welfare. The inter-firm cost asymmetry is crucial to derive this surprising result.

To present our point clearly, we have assumed that labor is the 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, the whole production process has been assumed to be outsourced to the foreign country. Even if some processes remain in the domestic country, the essence of our results is still valid.

[17] In the case of linear demand (i.e., $\epsilon = 0$), $dW/dw^* > 0$ if and only if $a_2^*/a_1^* > (3\sigma_1 - 1)/(3\sigma_1 - 2) > 1$.
[18] When $\epsilon = 0$, $dW/dt < 0$ if $\sigma_i > 1/3$ which always holds with $i = 1$.
[19] When $\epsilon = 0$, $dW/dw^* > 0$ if $\sigma_j < 1/3$.

In our model, the motive of outsourcing is simply factor-cost saving. An interesting extension would be combining this with the organizational approach in the presence of heterogeneous firms. This is left for the future research.

# Appendix

## Effects of transport and communications costs

We examine the effects of transport and communications costs. The first-order conditions for profit maximization are ($i = 1, 2$)

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

The second-order sufficient conditions ($i = 1, 2$):

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

and

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

where $\sigma_i \equiv x_i / X$ 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 with $\epsilon(X) < 1$.

We first consider the effects of a change in $t$ on outputs. When firms $i$ and $j$, respectively, choose in-house production and outsourcing, 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

$$\frac{dx_i}{dt} = -\frac{P' + P''x_i}{|\Omega|} > 0, \quad \frac{dx_j}{dt} = \frac{2P' + P''x_i}{|\Omega|} < 0, \ \frac{dX}{dt} = \frac{P'}{|\Omega|} < 0. \tag{A1}$$

A decrease in $t$ reduces the output of firm $i$ and raises the output of firm $j$ and the total output.

Using the first-order condition and (A1), we can obtain the effects on the profits:

$$\frac{d\Pi_i}{dt} = \frac{P'x_i}{|\Omega|}(2P' + P''x_i) > 0, \frac{d\Pi_j}{dt} = -\frac{(P')^2 x_j}{|\Omega|}(4 - \epsilon - \epsilon\sigma_i) < 0.$$

When $t$ falls, the profits of firm $i$ decrease and those of firm $j$ increase.

When both firms utilize outsourcing, 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

$$\begin{aligned}\frac{dx_i}{dt} &= \frac{P' + P''(x_j - x_i)}{|\Omega|} = \frac{P'}{|\Omega|}(1 - \epsilon + 2\epsilon\sigma_i), \qquad \text{(A2)}\\ \frac{dX}{dt} &= \frac{2P'}{|\Omega|} < 0.\end{aligned}$$

In view of (8), we have

$$\frac{dx_i}{dt} < 0 \Leftrightarrow 1 - \epsilon + 2\epsilon\sigma_i > 0.$$

If $-1 \leq \epsilon < 1$, $1 - \epsilon + 2\epsilon\sigma_i \geq 0$ holds for $\sigma_i \in [0, 1]$ (the equality holds when $\epsilon = -1$ and $\sigma_i = 1$). If $\epsilon < -1$, however, $1 - \epsilon + 2\epsilon\sigma_i < 0$ hods for $\sigma_i \in [(\epsilon - 1)/2\epsilon, 1]$ (where $(\epsilon - 1)/2\epsilon > 1/2$ when $\epsilon < -1$). Thus, when $t$ falls, the output of the less efficient firm always increases but that of the more efficient firm may decrease under $\epsilon < -1$. This is likely to be the case when $a_2^*$ is sufficiently larger than $a_1^*$.

Using the first-order condition and (8), we can obtain ($i = 1, 2$)

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

Therefore, when both firms utilize outsourcing, they gain from a lower $t$. This is the case even if the output of the more efficient firm falls. The welfare effect is given by

$$\frac{dW}{dt} = -XP'\frac{dX}{dt} + \frac{d\Pi_i}{dt} + \frac{d\Pi_j}{dt}. \qquad \text{(A3)}$$

When both firms use outsourcing, all terms in the RHS are negative. Thus, a decrease in $t$ improves domestic welfare.

When firms $i$ and $j$, respectively, employ in-house production and outsourcing, we can rewrite (A3) as follows:

$$\frac{dW}{dt} = -\frac{(P')^2 X}{|\Omega|}(2\epsilon\sigma_i^2 - 6\sigma_i + 5 - \epsilon).$$

$h(\sigma_i) \equiv 2\epsilon\sigma_i^2 - 6\sigma_i + 5 - \epsilon = 0$ holds at

$$\widehat{\sigma}_i \equiv \frac{-\sqrt{-10\epsilon + 2\epsilon^2 + 9} + 3}{2\epsilon} \text{ and } \widetilde{\sigma}_i \equiv \frac{\sqrt{-10\epsilon + 2\epsilon^2 + 9} + 3}{2\epsilon}.$$

Since $h(0) > 0$ , $h(1/2) > 0$ and $h(1) < 0$, we have $1/2 < \widehat{\sigma}_i < 1$ and $\widetilde{\sigma}_i < 0$ if $\epsilon < 0$ and $1/2 < \widehat{\sigma}_i < 1$ and $\widetilde{\sigma}_i > 1$ if $0 < \epsilon < 1$. Thus, noting $0 < \sigma_i < 1$, we have

$$\frac{dW}{dt} < 0 \Leftrightarrow \begin{cases} \sigma_i < \widehat{\sigma}_i \equiv \frac{-\sqrt{-10\epsilon+2\epsilon^2+9}+3}{2\epsilon} \text{ if } \epsilon \neq 0 \\ \sigma_i < \frac{5}{6} \text{ if } \epsilon = 0 \end{cases}$$

## Effects of wage rates

We examine the effects of a change in the foreign wage rate. When both firms utilize outsourcing, the profits of firm $i$ ($i = 1, 2$) are

$$\Pi_i = P(X)\,x_i - (a_i^* w^* + t)\,x_i.$$

The first-order conditions for profit maximization are

$$\frac{\partial \Pi_i}{\partial x_i} = P + P' x_i - a_i^* w^* - t = 0.$$

We have

$$\begin{pmatrix} \frac{dx_i}{dw^*} \\ \frac{dx_j}{dw^*} \end{pmatrix} = \frac{1}{|\Omega|} \begin{pmatrix} 2P' + P'' x_j & -(P' + P'' x_i) \\ -(P' + P'' x_j) & 2P' + P'' x_i \end{pmatrix} \begin{pmatrix} a_i^* \\ a_j^* \end{pmatrix}.$$

Thus, the effects on outputs are given by

$$\begin{aligned} \frac{dx_i}{dw^*} &= \frac{a_i^*(2P' + P'' x_j) - a_j^*\,(P' + P'' x_i)}{|\Omega|} = \frac{P'}{|\Omega|} \left\{ a_i^*(2 - \epsilon + \epsilon\sigma_i) - a_j^*\,(1 - \epsilon\sigma_i) \right\}, \\ \frac{dX}{dw^*} &= \frac{\left(a_i^* + a_j^*\right) P'}{|\Omega|} < 0. \end{aligned}$$

Therefore,

$$\frac{dx_i}{dw^*} > 0 \Leftrightarrow \frac{a_j^*}{a_i^*} > \frac{2 - \epsilon + \epsilon\sigma_i}{1 - \epsilon\sigma_i}.$$

$a_j^* > a_i^*$ is necessary for the above condition because $2 - \epsilon + \epsilon\sigma_i > 1 - \epsilon\sigma_i > 0$. Thus, when $w^*$ goes up, the output of the less efficient firm always decreases but that of the more efficient firm may increase.

The effects on profits are

$$\frac{d\Pi_i}{dw^*} = \frac{P' x_i}{|\Omega|} \left\{ -a_i^*\,(P' + P'' x_j) + a_j^*\,(2P' + P'' x_i) \right\} - a_i^* x_i = \frac{(P')^2 x_i}{|\Omega|} \left\{ a_i^*(-4 + 2\epsilon - \epsilon\sigma_i) + a_j^*\,(2 - \epsilon\sigma_i) \right\}.$$

We find

$$\frac{d\Pi_i}{dw^*} > 0 \Leftrightarrow \frac{a_j^*}{a_i^*} > \frac{4 - 2\epsilon + \epsilon\sigma_i}{2 - \epsilon\sigma_i}.$$

$a_j^* > a_i^*$ is necessary for $d\Pi_i/dw^* > 0$. Thus, when $w^*$ rises, the profits of the less efficient firm always decrease but those of the more efficient firm may increase.

The effect on welfare is

$$\frac{dW}{dw^*} = -XP' \frac{dX}{dw^*} + \frac{d\Pi_i}{dw^*} + \frac{d\Pi_j}{dw^*} = -\frac{(P')^2 X}{|\Omega|} \left\{ a_i^* \left(5 - \epsilon - 6\sigma_j + 2\epsilon\sigma_j^2\right) + a_j^*\left(5 - \epsilon - 6\sigma_i + 2\epsilon\sigma_i^2\right) \right\}.$$

The condition for welfare improvement is

$$\frac{dW}{dw^*} > 0 \Leftrightarrow \frac{a_j^*}{a_i^*} \left(5 - \epsilon - 6\sigma_i + 2\epsilon\sigma_i^2\right) < -\left(5 - \epsilon - 6\sigma_j + 2\epsilon\sigma_j^2\right).$$

To examine this condition, we show the following holds as long as $a_j^*$ is greater than $a_i^*$ (i.e., $\sigma_j < 1/2$):

$$h(\sigma_j) \equiv 5 - \epsilon - 6\sigma_j + 2\epsilon\sigma_j^2 = 2\epsilon(\sigma_j - \frac{3}{2\epsilon})^2 + (5 - \epsilon - \frac{9}{2\epsilon}) > 0.$$

By noting $h(\sigma_j)$ is a quadratic function, $h(\sigma_j)$ reaches its minimum of $5 - \epsilon - 9/2\epsilon$ at $3/2\epsilon$ if $\epsilon$ is positive and its maximum $5 - \epsilon - 9/(2\epsilon)$ at $3/(2\epsilon)$ if $\epsilon$ is negative. Since $3/(2\epsilon) > 1$ when $0 < \epsilon < 1$ and $3/(2\epsilon) < 0$ when $\epsilon < 0$, $h(\sigma_j)$ is monotonically decreasing for $\sigma_j \in [0, 1]$. Since $h(1/2) = 2 - \epsilon/2 > 0$, $h(\sigma_j) > 0$ for $\sigma_j \in [0, 1/2]$.

Therefore, if $5-\epsilon-6\sigma_i+2\epsilon\sigma_i^2<0$,

$$\frac{a_j^*}{a_i^*}>\frac{-\left(5-\epsilon-6\sigma_j+2\epsilon\sigma_j^2\right)}{5-\epsilon-6\sigma_i+2\epsilon\sigma_i^2}=\frac{1-\epsilon-6\sigma_i+4\epsilon\sigma_i-2\epsilon\sigma_i^2}{5-\epsilon-6\sigma_i+2\epsilon\sigma_i^2}>1$$

because $\left(1-\epsilon-6\sigma_i+4\epsilon\sigma_i-2\epsilon\sigma_i^2\right)-\left(5-\epsilon-6\sigma_i+2\epsilon\sigma_i^2\right)=-4\left\{1-\epsilon\sigma_i\left(1-\sigma_i\right)\right\}<0$. This condition is likely to hold when $a_j^*$ is sufficiently larger than $a_i^*$. Thus, when $w^*$ increases, domestic welfare may increase. If $5-\epsilon-6\sigma_i+2\epsilon\sigma_i^2>0$, on the other hand,

$$\frac{a_j^*}{a_i^*}<\frac{1-\epsilon-6\sigma_i+4\epsilon\sigma_i-2\epsilon\sigma_i^2}{5-\epsilon-6\sigma_i+2\epsilon\sigma_i^2}.$$

This condition never holds because the sign of the LHS is positive but that of the RHS is negative. In a linear demand case ($\epsilon=0$), $dx_i/dw^*>0$ and $d\Pi_i/dw^*>0$ if and only if $a_j^*/a_i^*>2$. When $\sigma_i>5/6$, $dW/dw^*>0$ if and only if $a_j^*/a_i^*>(6\sigma_i-1)/(6\sigma_i-5)>1$.

When firm $i$ manufactures without outsourcing and firm $j$ uses outsourcing, the profits are

$$\begin{aligned}\Pi_i\left(x_i;w\right)&=P\left(X\right)x_i-a_ix_i,\\ \Pi_j\left(x_j;t\right)&=P\left(X\right)x_j-\left(a_j^*w^*+t\right)x_j.\end{aligned}$$

Using the first-order conditions for profit maximization, we obtain

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

Thus, the effects on outputs, profits, and welfare are, respectively, given by

$$\begin{aligned}\frac{dx_i}{dw^*}&=\frac{-a_j^*\left(P'+P''x_i\right)}{|\Omega|}>0,\frac{dx_j}{dw^*}=\frac{a_j^*\left(2P'+P''x_i\right)}{|\Omega|}<0,\frac{dX}{dw^*}=\frac{a_j^*P'}{|\Omega|}<0,\\ \frac{d\Pi_i}{dw^*}&=\frac{a_j^*\left(P'\right)^2x_i}{|\Omega|}\left\{2-\epsilon\sigma_i\right\}>0,\frac{d\Pi_j}{dw^*}=\frac{-a_j^*\left(P'\right)^2x_j}{|\Omega|}\left\{4-\epsilon-\epsilon\sigma_i\right\}<0,\\ \frac{dW}{dw^*}&=\frac{-a_j^*\left(P'\right)^2X}{|\Omega|}\left\{2\epsilon\sigma_i^2-6\sigma_i+5-\epsilon\right\}.\end{aligned}$$

We thus obtain

$$\frac{dW}{dw^*}>0\Leftrightarrow\sigma_i>\frac{-\sqrt{-10\epsilon+2\epsilon^2+9}+3}{2\epsilon}.$$

In the linear demand case, $dW/dw^*>0$ if and only if $\sigma_i>5/6$.

## Effects of tariffs

When both firms make use of outsourcing, the profits are

$$\Pi_i=P\left(X\right)x_i-\left(a_i^*w^*+t+\tau\right)x_i.$$

The effects of a tariff on outputs and profits are the same as those of a transport and communications cost:

$$\frac{dx_i}{d\tau}=\frac{P'+P''(x_j-x_i)}{|\Omega|},\frac{dX}{d\tau}=\frac{2P'}{|\Omega|}<0,\frac{d\Pi_i}{d\tau}=-\frac{2P'x_i}{|\Omega|}(P'+P''x_j)<0.$$

As in the case of transport and communications costs, we have

$$\frac{dx_i}{d\tau} < 0 \Leftrightarrow 1 - \epsilon + 2\epsilon\sigma_i > 0.$$

Thus, when a tariff is imposed, the output of the less efficient firm always decreases but that of the more efficient firm may increase under $\epsilon < -1$.

Since welfare includes the tariff revenue, the welfare effects are different between transport and communications costs and tariffs. The welfare effect is given by

$$\frac{dW}{d\tau} = -XP'\frac{dX}{d\tau} + \frac{d\Pi_i}{d\tau} + \frac{d\Pi_j}{d\tau} + X + \tau\frac{dX}{d\tau} = \frac{(P')^2 X}{|\Omega|}\left(-1 - \epsilon + 4\epsilon\sigma_j - 4\epsilon\sigma_j^2\right) + \tau\frac{dX}{d\tau}.$$

Thus,

$$\frac{dW}{d\tau}|_{\tau=0} \Leftrightarrow -1 - \epsilon + 4\epsilon\sigma_j - 4\epsilon\sigma_j^2 > 0.$$

And the optimal tariff is

$$\tau_{FF} \equiv -\frac{XP'}{2}\left(-1 - \epsilon + 4\epsilon\sigma_j - 4\epsilon\sigma_j^2\right).$$

We examine under what condition $\tau_{FF} > 0$ holds. We have

$$f(\sigma_j) \equiv -1 - \epsilon + 4\epsilon\sigma_j - 4\epsilon\sigma_j^2, f(0) = -1 - \epsilon, f\left(\frac{1}{2}\right) = -1, f(1) \equiv -1 - \epsilon, f'(\sigma_j) = 4\epsilon(1 - 2\sigma_j).$$

When $-1 \leq \epsilon < 1$, $f(\sigma_j) < 0$ and hence the domestic government has no incentive to impose a tariff. When $\epsilon < -1$ and $j = 2$,

$$f(\sigma_2) > 0 \Leftrightarrow 0 < \sigma_2 < \frac{1}{2} + \frac{\sqrt{-\epsilon}}{2\epsilon}.$$

Thus, the domestic government may have incentive to impose a tariff if the difference of MCs between two firms is sufficiently large. For example, if $\epsilon = -4$, then

$$f(\sigma_2) > 0 \Leftrightarrow 0 < \sigma_2 < \frac{1}{4}.$$

When firm $i$ produces without outsourcing but firm $j$ produces with outsourcing, the profits are

$$\begin{aligned}
\Pi_i &= P(X)x_i - a_i x_i, \\
\Pi_j &= P(X)x_j - \left(a_j^* w^* + t + \tau\right)x_j.
\end{aligned}$$

the effects on outputs and profits are

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

$$\frac{d\Pi_i}{d\tau} = \frac{P'x_i}{|\Omega|}(2P' + P''x_i) > 0, \frac{d\Pi_j}{d\tau} = -\frac{(P')^2 x_j}{|\Omega|}(4 - \epsilon - \epsilon\sigma_i) < 0.$$

The welfare effect is

$$\frac{dW}{d\tau} = -XP'\frac{dX}{d\tau} + \frac{d\Pi_i}{d\tau} + \frac{d\Pi_j}{d\tau} + x_j + \tau\frac{dx_j}{d\tau} = \frac{(P')^2 X}{|\Omega|}\left(1 - \epsilon - 3\sigma_j + 3\epsilon\sigma_j - 2\epsilon\sigma_j^2\right) + \tau\frac{dx_j}{d\tau}.$$

Thus,

$$\frac{dW}{d\tau}|_{\tau=0} \Leftrightarrow 1 - \epsilon - 3\sigma_j + 3\epsilon\sigma_j - 2\epsilon\sigma_j^2 > 0,$$

and the optimal tariff is

$$\tau_{DF} \equiv -XP'\frac{\left(1 - \epsilon - 3\sigma_j + 3\epsilon\sigma_j - 2\epsilon\sigma_j^2\right)}{2 - \epsilon + \epsilon\sigma_j}.$$

We examine under what condition $\tau_{DF} > 0$ holds. We have

$$g(\sigma_j) \equiv 1 - \epsilon - 3\sigma_j + 3\epsilon\sigma_j - 2\epsilon\sigma_j^2, g(0) = 1 - \epsilon, g\left(\frac{1}{2}\right) = -\frac{1}{2}, g(1) = -2, g'(\sigma_j) = -3 + 3\epsilon - 4\epsilon\sigma_j.$$

When $\epsilon \neq 0$, $g(\sigma_j)$ is a quadratic function. $g(\sigma_j) = 0$ holds at

$$\widehat{\sigma}_j \equiv \frac{-3\epsilon + 3 - \sqrt{9 - 10\epsilon + \epsilon^2}}{-4\epsilon} \text{ and } \widetilde{\sigma}_j \equiv \frac{-3\epsilon + 3 + \sqrt{9 - 10\epsilon + \epsilon^2}}{-4\epsilon}.$$

Since $g(0) > 0$ , $g(1/2) < 0$ and $g(1) < 0$, we have $0 < \widehat{\sigma}_j < 1/2$ and $\widetilde{\sigma}_j > 1$ if $\epsilon < 0$ and $0 < \widehat{\sigma}_j < 1/2$ and $\widetilde{\sigma}_j < 0$ if $0 < \epsilon < 1$. Noting $0 < \sigma_j < 1$, we have

$$g(\sigma_j) > 0 \Leftrightarrow 0 < \sigma_j < \widehat{\sigma}_j.$$

When $\epsilon = 0$ (assuming $P(X) = \alpha - \beta X$), $g(\sigma_j) = -3\sigma_j + 1$. Thus,

$$g(\sigma_j) > 0 \Leftrightarrow 0 < \sigma_j < \frac{1}{3}$$

$$\tau_{DF} = -X(-\beta)\frac{(1 - 3\sigma_j)}{2} = -\alpha - 4a_i + 5a_j^* w^* + 5t$$

Therefore, when only the less efficient firm utilizes outsourcing, the domestic government may have incentive to impose a tariff. This is likely the case if the difference in MCs between two firms is sufficiently large.

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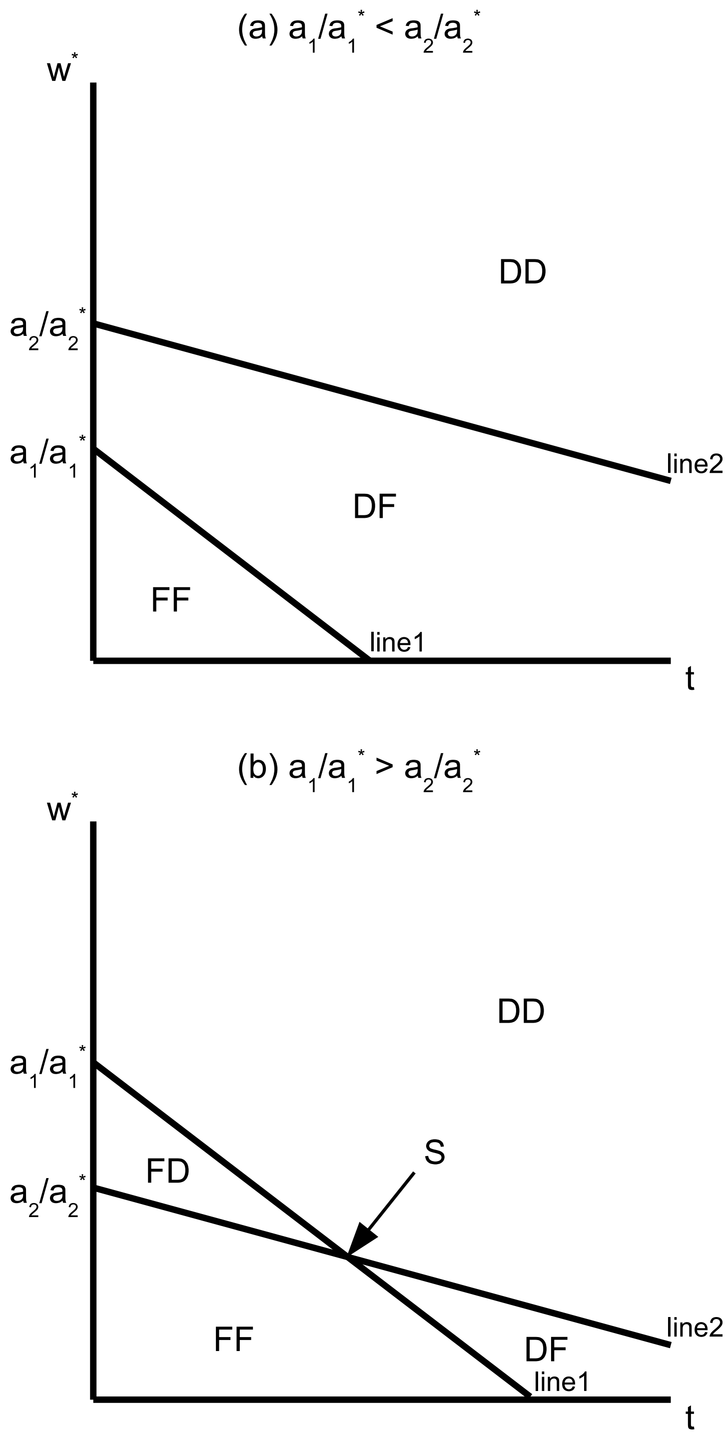


Figure 1: Domestic Market Alone

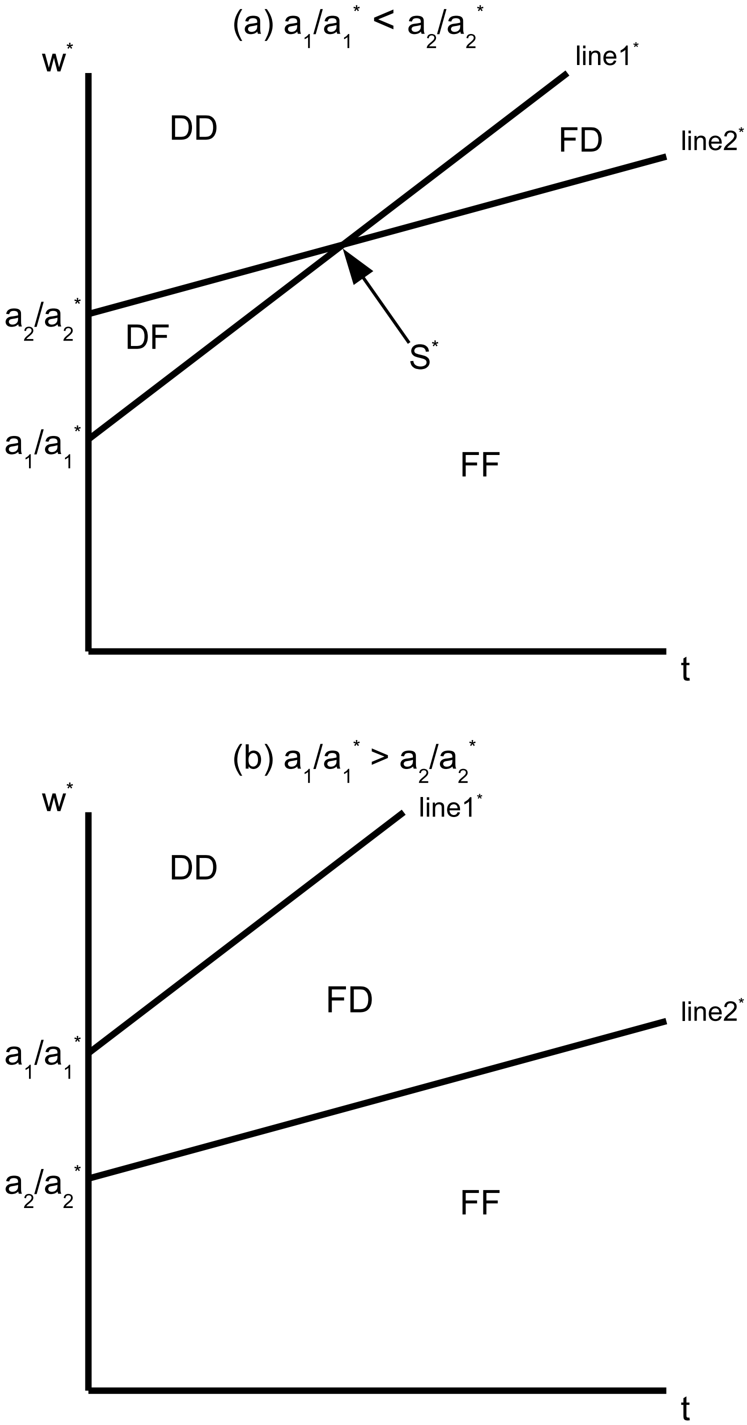


Figure 2: Foreign Market Alone

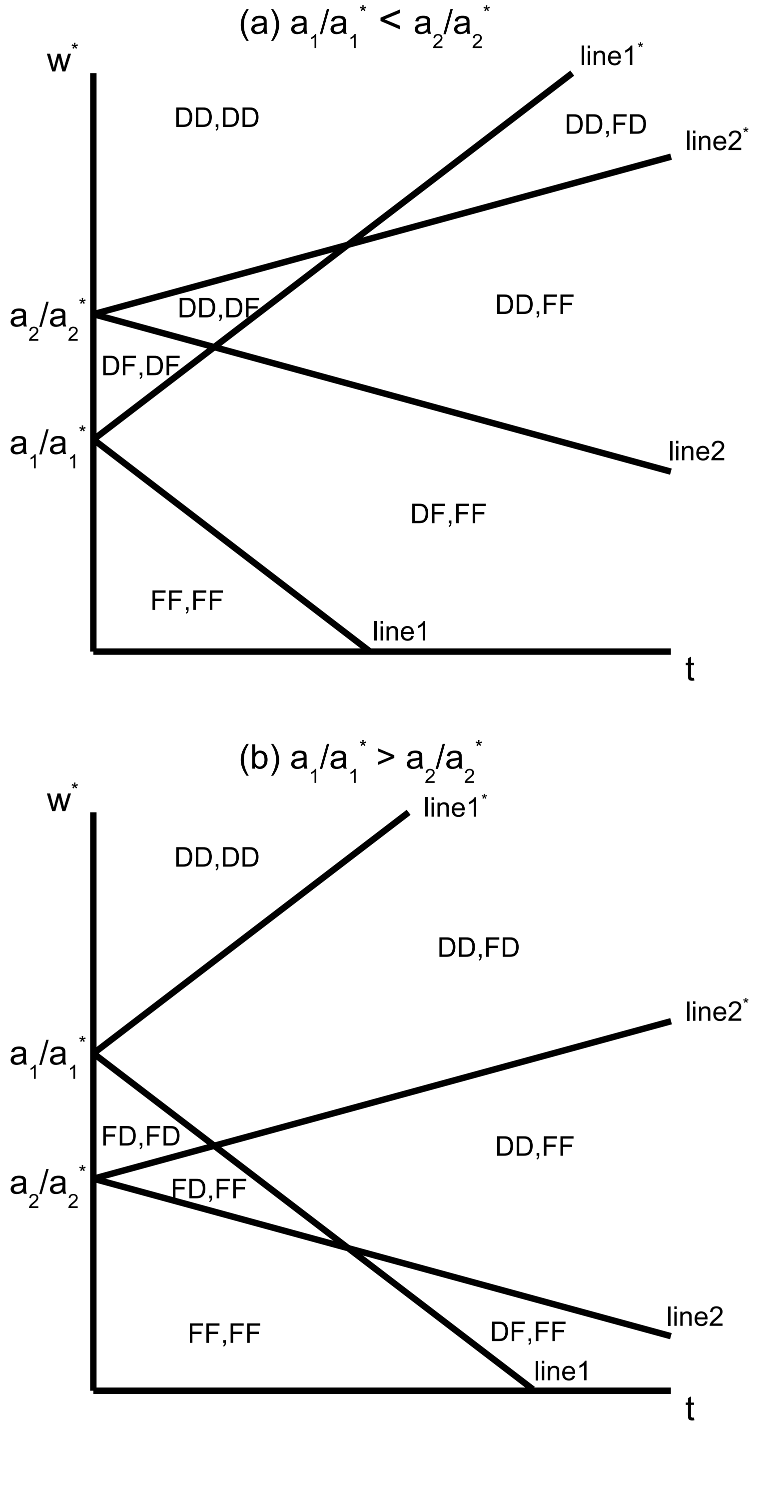


Figure 3: Both Domestic and Foreign Markets