Intraindustry Trade, Intraindustry Investment, and Welfare

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Abstract

This paper examines how two international firms compete non-cooperatively by choosing domestic sale, export, and overseas investment, and investigates conditions for the existence of simultaneous intraindustry trade and intraindustry investment. The roles of transport costs, market disadvantage, and tariff, and whether intraindustry trade and intraindustry are substitutes are explicitly analyzed. This paper determines the possibility of gains from trade and investment, and shows that in the presence of free trade, further allowing free investment is always beneficial. Competition between the firms in the long run in terms of input advantage is analyzed in a three-stage game.

1 Introduction

The phenomenon of simultaneous intraindustry trade and intraindustry investment has long drawn a lot of attention from trade theorists. While would a country find simultaneous import and export of products in the same industry and simultaneous inflow and outflow of capital within the same industry?

In the trade literature, intraindustry trade and intraindustry investment are usually handled separately. Following the work of Grubel and Lloyd (1975), which shows the importance of intraindustry trade, Brander (1981) and Brander and Krugman (1983) analyze intraindustry trade in oligopolistic markets while Krugman (1979, 1980, 1981), Lancaster (1980), and Helpman (1981) show how intraindustry trade may exist in the presence of monopolistic competition. Earlier work on cross-hauling of the capital flow focuses on inflow and outflow of capital into different sectors.[1] More recent work such as Clegg (1990) considers intraindustry capital movements.[2] Rowthorn (1992) is more successful work on intraindustry trade and intraindustry investment. However, his work suffers some drawbacks. First, his model is very special, with linear demand and identical countries. Second, his model predicts either trade or investment for each firm, a result not compatible with the fact that many firms do export to and invest in the industry in another country.

This paper develops a model to analyze the phenomenon of intraindustry trade and intraindustry investment. It extends the work of Brander (1981) and Brander and Krugman (1983) by considering two oligopolistic firms, one in each country, producing a homogeneous product.[3] Our model differs from theirs becasue we allow export and investment by a firm. A similar approach has also been used by Rowthorn (1992) but our model is more general because we do not assume linear demands or identical countries, and our model includes cases in which export and investment can exist at the same time.

[1] See, for example, Wong (1995, Chapter 4) for a discussion.

[2] Some work such as Helpman (1984 and 1985) and Ethier (1996) considers investment in the presence of intraindustry trade using a monopolistic competition model, but they are not looking at intraindustry trade and intraindustry investment explicitly.

[3] The assumption of a homogeneous product is not essential for the results. It would be easier to explain intraindustry trade and investment by assuming instead that the firms produce differentiated product.

To model foreign direct investment, we extend the theory of multinational corporation developed by Hymer (1960), Aliber (1970), Hirsch (1976), Dunning (1977, 1981), and many others. The theory postulates that a firm will try to exploit the local market and the foreign market through the activities of domestic sale, export, and investment to maximise its own profit. In the present model, both firms are competing as oligopolistic firms. It is shown that there are cases in which a firm would want to carry out the activities of domestic sale, export, and investment simultaneously, and then the phenomenon of intraindustry trade and intraindustry investment may exist. Many features of this phenomenon are analyzed in the present paper. For example, we examine how trade and investment may be affected by trade policies, transport cost, market disadvantage, and input advantage. We also investigate how the two firms compete in terms of quantity in the short run and in input advantage in the long run, and whether intraindustry trade and intraindustry investment are substitutes. Whether trade and investment are beneficial to a country is also analzyed in the present paper.

The rest of this paper is organized as follows. In section 2, we present the model and identify several ownership advantages of a firm. How two international firms compete in the short-run is examined. Section 3 provides an examination of the roles of transport costs and market disadvantage. The analysis of tariff-jumping foreign investment is given in section 4. Section 5 examines whether intraindustry trade and investment are substitutes or complements. In section 6, we examine the gains from (or costs of) trade and investment. In section 7, the assumption of fixed input advantages in the short-run is relaxed, and how the firms compete in terms of input advantages is analyzed. Section 8 concludes.

2 The Model

Consider a small industry producing a homogeneous product in two countries, which are labeled "home" and "foreign." There is one single firm in the industry in each country, conveniently named after the country: the home and the foreign firms. Each firm serves one or two of the markets. To serve an overseas market it may choose to export, to invest, or both. If it invests in another country, the production unit that remains in its own country is called the *parent* and its affiliate abroad is called *subsidiary*. Denote the supply of the home firm to the home market, that to the foreign market through export, and that to the foreign market by its subsidiary by x, e, and v, respectively. Similarly, denote the supply of the foreign firm to the foreign market, its supply to the home market through export, and the supply of its subsidiary to the home market by X, E, and V, respectively.

To explain the production and investment decisions of the firms, we focus on the following ownership advantages possessed by a firm: (1) *technological advantage*, which is not market specific and has a public-good nature (Johnson, 1970); (2) *input advantage*, which is not market-specific but has a limited public-good nature; and (3) *market disadvantage*, which is due to the firm's being an alien firm in an overseas market.[4]

The input advantage of a firm is represented by an amount m of an input called M (for manager) while the foreign firm has an amount M of the same input. This input is essential to the production process (production needs managers), although other inputs (such as workers and capital) are also needed. For simplicity, we assume that each unit of the output requires one unit of input M and that changing the amount of input M possessed takes time so that in the short run m and M are taken as given. (Training managers takes time.) How firms choose input advantages in the long run will be analyzed later.

Let the variable cost functions (other than the cost of the input M) of the home firm in the local market and foreign market (when investing) be $c(x + e)$ and $\theta c^*(v)$, respectively, where $\theta \geq 1$ is a measure of the home firm's market disadvantage when producing in the foreign market.[5] The cost function has positive and strictly increasing marginal costs, i.e., c', c'', $c^{*\prime}$, $c^{*\prime\prime} > 0$ for non-negative production, where primes represent derivatives, and $c(0) = c^*(0) = 0$. The parent firm and its subsidiary have to pay fixed costs of f and f^*, respectively, in additional to the variable costs. The cost functions of the foreign firms are similarly defined. Specifically, its variable cost functions in the home market (when investing) and foreign market are denoted by $\Theta C(V)$ and $C^*(X + E)$, respectively, where $\Theta \geq 1$ is the market disadvantage of the foreign firm when producing in the home market. It is also assumed that C', C'', $C^{*\prime}$, $C^{*\prime\prime} > 0$ for non-negative production, and $C(0) = C^*(0) = 0$.[6] The fixed costs of the foreign parent firm and its

[4] For more discussion of various ownership advantages of a firm, see Wong (1995, Chapter 13).

[5] In the special case in which $\theta = 1$, no market disadvantage exists.

[6] The following hierarchy of notation is adopted: Variables of the home firm are represented by lower case letters while those of the foreign firm by upper case letters, possibly

subsidiary in the home country are F^* and F, respectively. To focus on the incentives to invest abroad, the fixed costs of subsidiaries, f^* and F, are assumed to be sufficiently small.

When firms invest in another country, they have to transfer certain amount of input M. (Production requires managers.) Because of the fixed input-output relationship between output and input M, the outputs of the firms are subject to the following short-run constraints:[7]

$$\begin{aligned} x + e + v &= m && \text{(1a)} \\ X + E + V &= M. && \text{(1b)} \end{aligned}$$

When given the short-run supplies of input M, the home and foreign firms compete in a Cournot fashion. Denote the inverse demand function in the home country by $p = p(q)$, where p is the price of the good and q is the aggregate demand, and that in the foreign country by $p^* = p^*(q^*)$ where p^* is the foreign price and q^* is the foreign aggregate demand. Both demand curves are downward sloping, i.e., $p' < 0$ and $p^{*\prime} < 0$. To ensure a falling marginal revenue curve, it is assumed that p'', $p^{*\prime\prime} \leq 0$ or are of small magnitudes if positive. The markets are segmented, implying that the equilibrium values of p and p^* may not be the same even with no transport costs. The market-clearing conditions for the two markets are

$$\begin{aligned} q &= x + E + V && \text{(2a)} \\ q^* &= X + e + v. && \text{(2b)} \end{aligned}$$

The home government imposes a tariff with a specific rate of $t \geq 0$ while the foreign government is passive in setting policies. The per unit transport cost is denoted by $\tau \geq 0$, which is independent of the direction of the flow of product.

The profits of the home and the foreign firms are respectively defined as

$$\begin{aligned} \pi &= xp(q) + (e+v)p^*(q^*) - c(x+e) - \tau e - \theta c^*(v) - f - f^* && \text{(3a)} \\ \Pi &= (E+V)p(q) + Xp^*(q^*) - C^*(X+E) - (t+\tau)E \\ &\quad - \Theta C(V) - F - F^*. && \text{(3b)} \end{aligned}$$

with an asterisk.

[7]Note that because input M is always productive, the firms will use up all available input M in the short run to produce the good.

Each firm chooses the optimal outputs for its parent and subsidiary, taking the outputs of the other firm as given and being subject to its input constraint (1a) and (1b). The Lagrangian functions of the two firms can be defined as

$$\begin{aligned} \mathcal{L} &= \pi + \lambda(m - x - e - v) && \text{(4a)} \\ \mathcal{L}^* &= \Pi + \lambda^*(M - X - E - V). && \text{(4b)} \end{aligned}$$

The first-order conditions for profit maximization of the firms are:

$$\begin{aligned} p(q) + xp'(q) - c'(x+e) - \lambda &\leq 0 && \text{(5a)} \\ p^*(q^*) + (e+v)p^{*\prime}(q^*) - c'(x+e) - \lambda &\leq 0 && \text{(5b)} \\ p^*(q^*) + (e+v)p^{*\prime}(q^*) - \theta c^{*\prime}(v) - \lambda &\leq 0 && \text{(5c)} \\ p^*(q^*) + Xp^{*\prime}(q^*) - C^{*\prime}(X+E) - \lambda^* &\leq 0 && \text{(5d)} \\ p(q) + (E+V)p'(q) - C^{*\prime}(X+E) - (t+\tau) - \lambda^* &\leq 0 && \text{(5e)} \\ p(q) + (E+V)p'(q) - \Theta C'(V) - \lambda^* &\leq 0. && \text{(5f)} \end{aligned}$$

Intraindustry trade and investment means the existence of an interior solution. For the time being, we assume an interior solution and leave the analysis of its existence later. Replacing the weak inequalities in conditions (5) by equalities, and including conditions (2) and (1), we have ten equations to solve for the ten unknowns: q, q^*, x, e, v, X, E, V, λ, and λ^*. The derivation of the equilibrium is explained in terms of two conditions: the *Marginal Revenue Equalization* (MRE) condition and the *Marginal Cost Equalization* (MCE) condition.

2.1 Marginal Revenue Equalization (MRE) Condition

Conditions (5a) and (5b), with equalities, conditions (2) and the input constraint (1a) are combined together to give the home firm's MRE condition:

$$p(x+M-X)+xp'(x+M-X) = p^*(X+m-x)+(m-x)p^{*\prime}(X+m-x)-\tau. \quad (6)$$

The left-hand side of (6) is the marginal revenue received from the home market while the right-hand side is the (net) marginal revenue from the foreign market through export. If the parent firm supplies the good to both markets, (6) is a necessary condition for optimal allocation. The equation can be used to derive the best response function of the home firm, which is illustrated in Figure 1 by schedule hh. The slope of the schedule, which is obtained by differentiating (6) and rearranging terms, is equal to:

$$\left.\frac{\mathrm{d}X}{\mathrm{d}x}\right|_{\mathrm{hh}} = \frac{\phi+\gamma}{\phi} > 1, \tag{7}$$

where $\phi \equiv \gamma + xp'' + (m-x)p^{*\prime\prime} < 0$ and $\gamma \equiv p' + p^{*\prime} < 0$.

The same technique can be applied to the foreign firm. Conditions (5d) and (5e) (with equality) are combined to give the foreign firm's MRE condition:

$$p(x+M-X)+(M-X)p'(x+M-X)-t-\tau = p^*(X+m-x)+Xp^{*\prime}(X+m-x). \tag{8}$$

The left-hand side of (8) is the (net) marginal revenue the foreign parent firm receives from the home market, and the right-hand side is the marginal revenue it gets from its local market.

Treating m, M, t, and τ as parameters, condition (8) gives the best response function of the foreign firm, which is illustrated graphically in Figure 1 by schedule ff. Its slope is equal to

$$\left.\frac{\mathrm{d}X}{\mathrm{d}x}\right|_{\mathrm{ff}} = \frac{\Phi}{\Phi+\gamma} > 0, \tag{9}$$

where $\Phi \equiv \gamma + (M-X)p'' + Xp^{*\prime\prime} < 0$. The slope is less than unity, a case shown in Figure 1.

The supply of the firms to their own markets, x and X, can be obtained by solving equations (6) and (8), and is depicted by the intersecting point, A, between schedule hh and schedule ff. A solution exists under the normal assumption that a firm produces a positive output to the local market if the other firm is not producing, and it is unique. Given the input constraints, the supply of each firm to the other market can also be derived. How the overseas supply is divided between export and foreign investment is derived using the following condition.

2.2 Marginal Cost Equalization (MCE) Condition

To determine how the home firm chooses between export and invest, we now derive its MCE condition, which is obtained by combining conditions (5b) and (5c) together:

$$c'(x+e) + \tau = \theta c^{*\prime}(v). \tag{10}$$

When x is known, condition (10), which is illustrated by schedule EV in Figure 2, describes the home firm's optimal combinations of export and investment to serve the foreign market. The left-hand side of (10) measures the (effective) marginal cost of export and the right-hand side is the marginal cost of investment. If the home firm exports and invests simultaneously, these marginal costs must be the same. The slope of schedule EV is equal to

$$\left.\frac{\mathrm{d}v}{\mathrm{d}e}\right|_{\mathrm{ff}} = \frac{c''(x+e)}{\theta c^{*\prime\prime}(v)} > 0. \tag{11}$$

To determine the optimal export and investment, we have to make use of the input constraint as given by equation (1a), which, when given x, is illustrated by the negatively-sloped line MM. The intersecting point of the schedules gives the optimal export and investment of the home firm.

The same technique can be used to determine the optimal export and investment of the foreign firm, with its MCE condition given by

$$C^{*\prime}(X+E) + (t+\tau) = \Theta C'. \tag{12}$$

3 The Roles of Transport Costs and Market Disadvantage

The present model is now used to analyze the roles of transport costs τ and market disadvantages (θ and Θ) in the firms' allocational decisions. The analysis will help us derive conditions for existence of intraindustry trade and investment, and investigate possible gains from trade and investment.

With given input advantages of the firms and assuming an interior solution, totally differentiate conditions (6) and (8) and rearrange terms to give

$$\begin{bmatrix} \phi+\gamma & -\phi \\ -\Phi & \Phi+\gamma \end{bmatrix} \begin{bmatrix} \mathrm{d}x \\ \mathrm{d}X \end{bmatrix} = -\begin{bmatrix} 0 \\ 1 \end{bmatrix} \mathrm{d}t - \begin{bmatrix} 1 \\ 1 \end{bmatrix} \mathrm{d}\tau. \tag{13}$$

For simplicity, no government intervention is assumed in this section, i.e., $t = \mathrm{d}t = 0$. Condition (13) is then solved for

$$\mathrm{d}x = -\frac{1}{\gamma}\mathrm{d}\tau \tag{14a}$$

$$\mathrm{d}X = -\frac{1}{p'+p^{*\prime}}\mathrm{d}\tau. \tag{14b}$$

Conditions (14) immediately give an interesting result: the supply of each firm to its own market depends on the transport costs but not on the market disadvantage. We will have more discussion of this result later.

Turning to the effects on export and investment, totally differentiate the home firm's MCE condition (10) and a similar MCE condition for the foreign firm, making use of their input-advantage constraints, to give

$$
\begin{aligned}
\mathrm{d}e &= \left(\frac{1}{\gamma} - \frac{1}{c'' + \theta c^{*\prime\prime}}\right)\mathrm{d}\tau + \frac{c^{*\prime}}{c'' + \theta c^{*\prime\prime}}\mathrm{d}\theta && \text{(15a)}\\
\mathrm{d}v &= \frac{\mathrm{d}\tau - c^{*\prime}\mathrm{d}\theta}{c'' + \theta c^{*\prime\prime}} && \text{(15b)}\\
\mathrm{d}E &= \left(\frac{1}{\gamma} - \frac{1}{C^{*\prime\prime} + \Theta C''}\right)\mathrm{d}\tau + \frac{C'}{C^{*\prime\prime} + \Theta C''}\mathrm{d}\Theta && \text{(15c)}\\
\mathrm{d}V &= \frac{\mathrm{d}\tau - C'\mathrm{d}\Theta}{C^{*\prime\prime} + \Theta C''}. && \text{(15d)}
\end{aligned}
$$

We now make use of these conditions to examine the roles of transport costs and market disadvantage and derive some intuition behind the phenomena of intraindustry trade and intraindustry investment.

3.1 Transport Costs

To focus on the role of transport costs, for the time being it is supposed that $\mathrm{d}\theta = \mathrm{d}\Theta = 0$. By conditions (14), an increase in τ increases the equilibrium values of x and X, meaning that when it is more costly to ship goods abroad, firms supply more of their products to their local markets. A mirror image of this result, as provided by conditions (15), is that an increase in τ discourages export of the firms. These results are intuitive and do not require further explanation. A related result is given by conditions (15b) and (15d), which state that an increase in τ encourages the firms to invest more abroad. This is intuitive: When transport costs are higher, investment becomes a cheaper way for each firm to supply to the other market. Furthermore, according to the input-advantage constraint, an increase in a firm's supply to its own market must be at the expense of its supply to the other market, meaning that the decrease in each firm's export in magnitude must be more than the increase in the production of its subsidiary.

Conditions (14) and (15) can be combined to give the effect of an increase in τ on the total supply to the home market:

$$\frac{\mathrm{d}q}{\mathrm{d}\tau} = \frac{\mathrm{d}x}{\mathrm{d}\tau} + \frac{\mathrm{d}E}{\mathrm{d}\tau} + \frac{\mathrm{d}V}{\mathrm{d}\tau} = 0, \tag{16}$$

which says that a change in transport costs does not affect the total supply to the home market. As a result, the price of the good and thus the welfare of consumers in the home market are independent of the transport costs. The same argument can be extended to the foreign market.

The above results can be summarized by the following proposition:

Proposition 1. *An increase in transport costs encourages each firm to supply more to its own market, export less but invest more. The total supply to each market by both firms, however, is not affected by a change in the transport costs.*

3.2 Market Disadvantage

Let us now assume instead $\tau = d\tau = 0$ and analyze the effects of changes in θ and Θ. Three results can be obtained immediately from conditions (14) and (15): (i) Supplies x and X are independent of θ and Θ; (ii) Supplies e and v are affected by θ but not by Θ, while E and V are affected by Θ but not by θ; (iii) An increase in market disadvantage encourages each firm to export more but invest less.

These three results can easily be explained by the MRE and the MCE conditions. The market disadvantage of a firm, which affects directly the cost of production of a firm's subsidiary in another country, appears only in the firm's MCE condition but not in its MRE condition. This means that the direct effect of a change in a firm's market disadvantage is on the firm's export-invest decision, but not on its supply to its own market. Thus when its market disadvantage becomes more severe, it lowers its investment abroad but increases its export by the same amount. Conditions (15) further reveal that a change in θ or Θ does not affect each firm's supply to either market, meaning that the total supply to each market is not affected by the market disadvantages. This result is partly due to the short-run input-advantage constraint, and partly due to the effect of the market disadvantage on export and investment.

Summarizing the above results, we have

Proposition 2. *An increase in a firm's market disadvantage in an overseas market encourages the firm to export more but invest less, while its supply to its own market is not affected. The total supply to each market by the firms is not affected by the firms' market disadvantages.*

3.3 Simultaneous Existence of Export and Investment

The above analysis is now applied to get an intuition behind the existence of simultaneous export and investment. Let us begin with a special case with both countries and firms being identical, meaning that the two markets have the same demand functions, that the two firms have identical cost structures and identical input-advantage constraints, that the parent firm and subsidiary have the same cost function, and that there are no market disadvantages and no trade restrictions ($\theta = \Theta = 1$, $t = 0$). We further assume that transport costs are zero, $\tau = 0$.

To see why the firms would want to mutually penetrate into each other's market, let us imagine that initially both markets stay closed. Because of symmetry the two markets share the same autarkic equilibrium, with each firm supplying the same amount of good to its own market. Let us now allow free trade and investment. With segmented markets, both firms have incentives to sell the good to the other market. This can be explained in terms of the MRE and MCE conditions. When free trade is first allowed, each firm supplies nothing to the other market, implying that the marginal revenue from an overseas market is equal to the autarkic price, which, by symmetry, is equal to the domestic price and is greater than the marginal revenue in the local market. Thus by the MRE condition, at least the first unit to the other market is profitable for both firms. In equilibrium, each firm must supply the same amount of the good to each market.

As mentioned, there are two alternatives for a firm to serve its overseas market: export and investment. Which alternative would each firm choose? Because the marginal cost is increasing and with sufficiently small fixed costs, in equilibrium both the parent firm and the subsidiary must be producing the same output, supplying the output to each market. In other words, the parent firm produces for its local market only and while its subsidiary produces the same output for the foreign market. In this special case, trade is not necessary and only intraindustry investment exists.[8]

Let us slightly modify the above case. Suppose that both firms have the same positive, but small, market disadvantage when investing overseas, i.e., $\theta = \Theta > 1$. As conditions (15) show, an increase in θ and Θ will encourage both firms to export but discourage them to invest. Thus at low levels of θ and Θ with no transport costs, both firms export and invest at the same time.[9]

3.4 Further Analysis

The above analysis shows that the transport costs and market disadvantages play important roles in determining whether a firm exports and invests simultaneously. To investigate their roles further, let us relax the assumption of identical technologies and market demands, and consider explicitly the effects of τ and θ on the choice of the home firm while Θ is kept constant and t is set at 0. Conditions (15a) and (15b) then imply that e and v are functions of τ and θ. Express these functions as $e = e(\tau, \theta)$ and $v = v(\tau, \theta)$. Condition $e = e(\tau, \theta) = 0$ can be illustrated by the schedule labeled $e = 0$ in Figure 3. The slope of this schedule, by condition (15a), with $e = \mathrm{d}e = 0$, is equal to

$$\left.\frac{\mathrm{d}\theta}{\mathrm{d}\tau}\right|_{e=0} = \frac{1}{c^{*\prime}} - \frac{c'' + \theta c^{*\prime\prime}}{\gamma c^{*\prime}} > 0. \tag{17}$$

We then turn to condition $v(\tau, \theta) = 0$, which determines locus (τ, θ) that corresponds to zero investment. This locus is depicted by the schedule labeled $v = 0$ in Figure 3. The slope of this schedule, which can be obtained from condition (15b) with $v = \mathrm{d}v = 0$, is equal to

$$\left.\frac{\mathrm{d}\theta}{\mathrm{d}\tau}\right|_{v=0} = \frac{1}{c^{*\prime}(0)} > 0. \tag{18}$$

Conditions (17) and (18) show that both schedules are positively sloped, with schedule $e = 0$ being steeper than schedule $v = 0$ at the point of intersection,

[8] Strictly speaking, because there are no transport costs, it is possible that trade exists in the form that a parent firm exports part of its output while imports the same quantity. However, this form of trade is not necessary and is not considered here.

[9] Simultaneous export and investment, two different ways of serving an overseas market, is an application of the theory of a multi-plant firm.

A, as Figure 3 shows. These schedules divide the space in the diagram into four regions labeled I, II, III, and IV. Using the above analysis, we can see that region III contains values of τ and θ that imply simultaneous export and investment by the home firm. The values of τ and θ in other regions imply that at least one of e and v is negative, and thus they are prohibitive for the home country in terms of trade, investment, or both. In terms of Figure 3, the values of τ and θ at point A, $(\bar{\tau}, \bar{\theta})$, give the prohibitive levels of transport costs and market disadvantage for the home firm. In drawing Figure 3, it is assumed that the home firm exports and invests simultaneously when $\tau = \theta = 0$.[10]

The above analysis applies also to the foreign firm.

4 Tariff-jumping Direct Investment

Suppose now that with both firms exporting and investing initially, the home government imposes a small tariff on the good the economy imports from the foreign firm. Keeping the transport costs and market disadvantages constant, condition (13) can be solved to give the effects of an increase in the home tariff

$$\frac{\mathrm{d}x}{\mathrm{d}t} = -\frac{\phi}{\Delta} > 0 \tag{19a}$$

$$\frac{\mathrm{d}X}{\mathrm{d}t} = -\frac{\phi+\gamma}{\Delta} > 0, \tag{19b}$$

where $\Delta \equiv \gamma(\phi + \Phi + \gamma) > 0$. The MCE condition (10) of the home firm and a similar one for the foreign firm are differentiated to give

$$\frac{\mathrm{d}e}{\mathrm{d}t} = \frac{\phi}{\Delta} < 0 \tag{20a}$$

$$\frac{\mathrm{d}v}{\mathrm{d}t} = 0 \tag{20b}$$

$$\frac{\mathrm{d}E}{\mathrm{d}t} = \left(\frac{\phi+\gamma}{\Delta} - \frac{1}{C^{*\prime\prime} + \Theta C^{\prime\prime}}\right) < 0 \tag{20c}$$

$$\frac{\mathrm{d}V}{\mathrm{d}t} = \frac{1}{C^{*\prime\prime} + \Theta C^{\prime\prime}} > 0. \tag{20d}$$

[10] In the special symmetric case analyzed above, export is not necessary when $\tau = \theta = 0$. This means that schedule $e = 0$ passes through the origin.

Let us now explain these results. We first focus on the foreign firm. The most straighforward effect of the tariff is a dampening effect on the foreign firm's export, as given by (20c). Tariff-jumping foreign investment is shown by condition (20d). The impact of the tariff on foreign investment is interesting to note, because, unlike in a general equilibrium model, it does not depend on the factor intensity ranking of sectors.[11] The changes in the firm's export and investment can be explained in terms of its MCE condition: Because of the tariff, export is more expensive for the foreign firm than investment is as a way to supply to the home market.

Condition (19b) shows another effect of the tariff: it encourages the foreign firm to supply more to the foreign market. This result can be explained by the MRE condition: A home tariff makes the home market less attractive and the foreign firm prefers to supply more of its output to the local market.

We now turn to the effects of the tariff on the home firm. Condition (19a) shows an increase in the home firm's supply to the local market. This is what is usually called the protective effect of a tariff: As the foreign firm lowers its supply to the home market, the home firm "reacts" with a larger supply to the market.

Conditions (20a) and (20b) describe two effects of a home tariff that are rarely analyzed in the literature: Tariff discourages the home firm's export but has no effect on its investment. These effects can be explained by using the home firm's MRE and MCE conditions. Because its MCE condition does not depend on the tariff rate and because τ and θ are constant, the home firm's foreign investment is not affected by a change in the tariff. On the other hand, a decrease in the foreign firm's supply (export plus investment) makes the home market more attractive to the home firm, which will then shift some of its export to local supply.

The effects of a higher home tariff can be shown graphically by Figures 1 and 2. In Figure 1, conditions (6) and (8) imply that an increase in t does not affect schedule hh but shifts schedule ff down to f′f′, which cuts schedule hh at point B, showing an increase in x but a decrease in X. In Figure 2, an increase in x means that schedule EV shifts up to E′V′ while schedule MM shifts down to M′M′. Point B indicates a lower e but a constant v, as conditions (20a) and (20b) suggest. A similar diagram can be used to show

[11] As Wong (1995, Chapter 13) argues, tariff-jumping direct investment is usually a partial equilibrium phenomenon. In a general equilibrium framework with perfect intersectoral factor mobility, the effect of a tariff on foreign investment depends crucially on the factor intensity ranking of the sectors.

the changes in export and overseas investment of the foreign firm.

Comparing conditions(20a) and (20c), we get

$$\frac{\partial E}{\partial t} < \frac{\partial e}{\partial t} < 0, \tag{21}$$

which states that an increase in the home tariff discourages the foreign firm's export more than the home firm's export. This result is easy to understand since the former is directly subject to the tariff. Conditions (20b) and (20d), on the other hand, give

$$\frac{\partial V}{\partial t} > \frac{\partial v}{\partial t} = 0, \tag{22}$$

as the tariff encourages investment by the foreign firm but has no impact on the home firm's investment.

Furthermore, combining conditions (19) and (20) together gives the effects of a home tariff on market supplies:

$$\frac{\partial q}{\partial t} = \frac{1}{\phi + \Phi + \gamma} < 0 \tag{23a}$$

$$\frac{\partial q^*}{\partial t} = -\frac{1}{\phi + \Phi + \gamma} > 0. \tag{23b}$$

Conditions (23) show that an increase in the home tariff has a negative effect on the supply to the home market but a positive effect on the supply to the foreign market. It further implies that a higher home tariff will drive up the domestic price but drive down the foreign price. The above results are summarized by the following proposition:

Proposition 3. *An increase in the home tariff encourages the foreign firm to export less, invest more, and supply more to the foreign market, and encourages the home firm to export less and supply more to the home market. An increase in the home tariff also has a negative impact on the total supply to the home market but a positive one on the foreign market.*

5 Are Intraindustry Trade and Intraindustry Investment Substitutes?

The preceding analysis on the effects of a home tariff helps us answer a question, are intraindustry trade and intraindustry investment substitutes?

To answer this question, let us first define the index of intraindustry trade η^t and the index of intraindustry investment η^i as:

$$\eta^t \equiv 1 - \frac{|e-E|}{e+E} \tag{24a}$$

$$\eta^i = 1 - \frac{|v-V|}{v+V}. \tag{24b}$$

The index of intraindustry trade is commonly used in the trade literature to measure the degree of intraindustry trade. It is now extended to define the index of intraindustry investment. Note that by definition, $0 \leq \eta^t, \eta^i \leq 1$.

In this section, we examine the impacts of a home tariff on η^t and η^i when initially there is intraindustry trade and investment. Consider first the case when $e \geq E$. Differentiate equation (24a) to give

$$\frac{\partial \eta^t}{\partial t} = \frac{2eE}{(e+E)^2}\left(\frac{1}{E}\frac{\partial E}{\partial t} - \frac{1}{e}\frac{\partial e}{\partial t}\right) < 0, \tag{25}$$

where condition (21) has been used. If, however, $e < E$, then the sign of $\partial \eta^t / \partial t$ is ambiguous unless e is sufficiently close to E. Now differentiate condition (24b), making use of (22), to yield:

$$\frac{\partial \eta^i}{\partial t} = Z\frac{2vV}{(v+V)^2}\left(\frac{1}{V}\frac{\partial V}{\partial t}\right), \tag{26}$$

where $Z = 1$ if $v > V$, or $Z = -1$ if $V \geq v$.

The relation between the two indices as a result of a change in the home tariff can be expressed as

$$\frac{\mathrm{d}\eta^i}{\mathrm{d}\eta^t} = \frac{\partial \eta^i / \partial t}{\partial \eta^t / \partial t}. \tag{27}$$

The relation can be illustrated graphically by Figure 4. How the two indices vary as a result of a change in the home tariff depends on the initial values of the firms' export and foreign investment. Let us first consider point A, with $e = E$ and $v = V$ (perfect intraindustry trade and intraindustry investment) so that $\eta^t = \eta^i = 1$. Equations (25) and (26) then imply that $\partial \eta^t / \partial t < 0$ and $\partial \eta^i / \partial t < 0$. As the indices drop, $e > E$ and $V > v$. So if the home tariff is lowered further, η^t and η^i will decrease further. As a result, $\mathrm{d}\eta^t / \mathrm{d}\eta^i > 0$, or that intraindustry trade and intraindustry investment are complements. A possible change in the indices as the home tariff increases is shown by curve AK in the diagram.

Consider an alternative initial point, B in Figure 4, where $E > e$ and $v = V$. At this point, $\eta^i = 1$ and $\eta^t < 1$. If E is sufficiently larger than e, then $\partial\eta^t/\partial t > 0$. We still have $\partial\eta^i/\partial t < 0$. Thus the locus of (η^t, η^i) in the neighborhood of point B is negatively sloped. Since E drops more quickly than e as the home tariff goes up, and as long as e drops slowly enough, then sooner or later the point with both E and e dropping at the same rate. Beyond this point, $\partial\eta^t/\partial t < 0$. Thus the locus of the two indices may move along curve BEF as the home tariff increases. Along the portion BE, intraindustry trade and intraindustry investment are substitutes but along portion EF they are complements.

Consider another possibility, point C in the diagram with $e = E$ and $v > V$. At this point, $\partial\eta^t/\partial t < 0$ and $\partial\eta^i/\partial t > 0$. As long as V is not smaller than v by much, when t is raised sufficiently high $V = v$, which corresponds to point G in Figure 4. Beyond this point, $\partial\eta^i/\partial t < 0$. The locus of (η^t, η^i) can be represented by a curve like CGH. Along CG, intraindustry trade and intraindustry investment are substitutes, and beyond point G they are complements.

Summarizing the above results, we have:

Proposition 4. *Suppose that $e \geq E > 0$ and $V \geq v > 0$. An increase in the home tariff decreases both the index of intraindustry trade and the index of intraindustry investment, implying that intraindustry trade and intraindustry investment are complements.*

6 Gains from Trade and Investment

We now analyze the welfare effects of trade and investment. We want to compare the following four regimes in terms of the home welfare: (a) autarky ($e = v = 0$); (b) free trade only ($e > 0$, $v = 0$); (c) free investment only ($v > 0$, $e = 0$); and (d) free trade and investment ($e > 0$, $v > 0$). The welfare of the home country, W, can be defined as the sum of the consumer surplus,

$CS(q)$, and the profit of the firm as given by equation (3a):

$$\begin{aligned} W &= CS(q) + \pi \\ &= \int_0^q p(u)du - qp(q) + xp(q) + (e+v)p^*(q^*) \\ &\quad -c(x+e) - \tau e - \theta c^*(v) - f - f^*. \end{aligned} \tag{28}$$

Assuming no trade restrictions, $t = 0$, and treating τ, θ and Θ as parameters, the home welfare function, W, can be expressed as a function of τ, θ, and Θ; Let us define $W = W(\tau, \theta, \Theta)$. Since our attention is on how various home government's policies affect the home welfare level, Θ is kept constant in this section unless stated otherwise. To facilitate the welfare comparison among the four regimes, we first examine the individual welfare effect of τ and θ. The derivatives of the welfare functions defined in (28) are:

$$\frac{\partial W}{\partial \tau} = \frac{xp' - (e+v)p^{*\prime}}{p' + p^{*\prime}} - e = \frac{xp' - e(p' + 2p^{*\prime}) - vp^{*\prime}}{p' + p^{*\prime}} \tag{29a}$$

$$\frac{\partial W}{\partial \theta} = -c^*(v) \leq 0. \tag{29b}$$

Note that $\partial W/\partial \theta = 0$ if $v = 0$, or it is negative if $v > 0$. This implies that in Figure 3 with $v > 0$ iso-welfare contours closer to the horizontal axis represent higher welfare levels. The sign of $\partial W/\partial \tau$ as given by (29a), however, is ambiguous. This ambiguity arises because a higher τ discourages not just the home firm's export but also the foreign firm's export. While the former effect is detrimental, the latter is favorable because it makes the home firm more competitive in the local market. However, if τ and θ are close to prohibitive levels so that e and v are sufficiently small, an increase in τ will have an insignificant effect on the home firm's export and will help the home firm by discouraging the foreign firm's export. This implies that $\partial W/\partial \tau > 0$ in the area where e and v are sufficiently small.

Let us refer back to Figure 3. Schedules labeled $e = 0$ and $v = 0$ show the loci of τ and θ which give no export and no investment, respectively. The schedules divide the space into four regions: I, II, III and IV, and the intersecting point of the schedules can be interpreted as the autarkic point. In the same diagram, different levels of home welfare can be illustrated by iso-welfare contours. The iso-welfare contour through point A in Figure 3 is labeled W_A. The slope of any iso-welfare contour is given by

$$\left.\frac{\mathrm{d}\theta}{\mathrm{d}\tau}\right|_{\mathrm{d}W=0} = -\frac{\partial W/\partial \tau}{\partial W/\partial \theta} = \frac{xp' - e(p' + 2p^{*\prime}) - vp^{*\prime}}{c^*(v)(p' + p^{*\prime})}.$$

Since the sign of $\partial W/\partial \tau$ is ambiguous, an iso-welfare contour may be positively or negatively sloped. Even if it is positively sloped, it may be steeper or less steep than schedules $e = 0$ and $v = 0$. However, as we have explained, if (τ, θ) is in region III but close to point A, $\partial W/\partial \tau$ is positive. Therefore, any iso-welfare contour passing through the neighborhood of point A in this region is positively sloped and the level of welfare increases toward southeast. Given that $c^*(0) = 0$, an iso-welfare contour is vertical when $v = 0$, and in a region close to point A and with $v > 0$ it is positively sloped and very steep.

Proposition 5. *If the values of τ and θ are slightly less than their prohibitive levels, then the gains from export and/or investment for the home country are negative.*

Proof. Consider a point in Figure 3 such as point B in region III and close to point A, the autarkic point. Suppose that point B represents the existing levels of τ and θ. Since the iso-welfare contour through point A is very steep, the iso-welfare contour that passes through point B (not shown) must represent a lower welfare. This means that with near prohibitive levels of τ and θ, export and investment are immiserizing for the home country. ■

Collorary 1. *In the symmetry case with $\theta = \Theta$ and when the values of τ and θ are slightly less than prohibitive, the gains from trade and investment are negative for both countries.*

Collorary 1, which follows immediately from proposition 5, is similar to a result in Brander and Krugman (1983) who show that when the countries are identical and when the transport cost is slightly less than prohibitive, the gain from intraindustry trade is negative for both countries. Our model is more general than theirs because both intraindustry trade and intraindustry investment are allowed. Furthermore, we show that when the transport cost and the marketing disadvantages are slightly less than prohibitive, the home country is also hurt by goods trade only, or by investment only.

The above result cannot be generalized to other values of τ and θ. For a counter example, consider point C in Figure 3. With the corresponding values of τ and θ, the home country can improve its welfare by liberalizing trade and investment.

Proposition 6. *(a) An increase in θ is welfare deteriorating. (b) In the presence of free export, free investment is always gainful.*

Proof. Part (a) comes directly from condition (29b). To see part (b), consider any point, such as point C, in region III of Figure 3, and also point D, which is on schedule $v = 0$ and vertically above point C. By part (a), point D represents a lower welfare for the home country than point C does. Suppose that the existing values of θ and τ are represented by point C, but that the home government allows free export of the home firm but prohibits foreign investment. This policy is similar to a rise in the market disadvantage up to at least the level represented by point D. So point D gives the welfare with free export but no investment, while point C represents the welfare with free export and free investment. Part (a) then implies part (b). ■

The present framework has a strong implication for foreign investment. Although marketing disadvantage of investment may exist, investing and producing in another country represents an important option for a firm to lower the costs of supplying to an overseas market. Taking away this option from the firm by prohibiting investment or increasing θ hurts the firm's profit. Moreover, in the present framework, the total supply to the home market and thus the consumer surplus are independent of θ.

The welfare effect of a change in τ is not so clear. Thus prohibiting export may improve or hurt welfare. The reason is that limiting domestic export discourages the domestic firm's profit, but reducing the import from the foreign firm has a positive effect on the domestic firm's profit. The sign of the net effect is ambiguous except in some special cases such as the one described in Proposition 5 or in the one described in the following proposition:

Proposition 7. *In the symmetry case with identical technologies and market demands, zero transport cost, and no market disadvantage, free trade in goods and investment benefits both economies.*

Proof. Let us use superscript "a" to denote the values of variables under autarky, and superscript "o" to denote those under free trade and investment. In the symmetry case, as analyzed above, schedule $e = 0$ passes through origin O with free trade and investment. Since the countries are symmetric, we consider the change in welfare of the home country only. Using the welfare function defined in (23), the home welfare levels under situations A and O can be expressed as $W^a = CS^a + \pi^a$ and $W^o = CS^o + \pi^o$. Note that by Propositions 1 and 2 the total supply to each market is independent of τ and θ. Consumer surplus thus remains the same under situations A and O, i.e., $CS^a = CS^o$. With zero transport cost and no market disadvantage, the home firm has an incentive to serve the foreign market, not only because of the competition between the firms, but also of the increasing marginal cost in each market. In other words, each firm will invest in another market to take advantage of a smaller marginal cost in the overseas market. The home firm thus gets a profit higher than the autarkic profit, i.e., $\pi^a < \pi^o$. Combining the above results, we have $W^a < W^o$. ■

In general, without symmetry, the level of home welfare under autarky (represented by point A) and that under free trade and investment (represented by point O) cannot be ranked.

7 Competing in Terms of Input Advantages

So far we have been assuming that the input advantage of each firm possesses is fixed. We now relax this assumption. Let us consider the following three-stage game. In stage one, the government chooses a tariff $t \geq 0$. In stage two, the two firms choose simultaneously and in a non-cooperative way the quantities of input M. Then in stage three, the two firms compete in a Cournot way in terms of the levels of production and investment as described in previous sections.

We first consider stage 3 of the game. In this stage, the quantity of input M of each firm has already been chosen. As a result, this stage is just what we have described in earlier sections, and there is no need to repeat here. We assume that initially intraindustry trade and intraindustry investment exist. To help us analyze the second stage, we have to determine the impacts of a change in the quantities of input M on the firms' production and investment.

Differentiating the MRE condition for the two firms as described by (6), keeping t and τ constant, we have

$$\begin{bmatrix} \phi+\gamma & -\phi \\ -\Phi & \Phi+\gamma \end{bmatrix} \begin{bmatrix} \mathrm{d}x \\ \mathrm{d}X \end{bmatrix} = \begin{bmatrix} 2p^{*\prime} + (m-x)p^{*\prime\prime} \\ -(p^{*\prime} + Xp^{*\prime\prime}) \end{bmatrix} \mathrm{d}m + \begin{bmatrix} -(p' + xp'') \\ 2p' + (M-X)p'' \end{bmatrix} \mathrm{d}M. \quad (30)$$

We focus on the impacts of the input advantages on the outputs of the home firm, since similar expressions for the foreign firm can be derived. Solving the system of equations in (30), we have

$$\frac{\partial x}{\partial m} = \frac{[2p^{*\prime} + (m-x)p^{*\prime\prime}](\Phi+\gamma) - \phi(p^{*\prime} + Xp^{*\prime\prime})}{\Delta} \quad (31a)$$

$$\frac{\partial x}{\partial M} = \frac{\phi[2p' + (M-X)p''] - (p' + xp'')(\Phi+\gamma)}{\Delta}. \quad (31b)$$

The expressions in (31) have ambiguous signs. In this section, we consider the special case of linear demands in both countries, implying that both ϕ and Φ reduce to $\gamma = p' + p^{*\prime}$, and that $\Delta = 3\gamma^2$. The expressions in (31) reduce to

$$\frac{\partial x}{\partial m} = \frac{p^{*\prime}}{p' + p^{*\prime}} > 0 \quad (32a)$$

$$\frac{\partial x}{\partial M} = 0. \quad (32b)$$

Thus, with a linear domestic demand, the home firm's supplies to the local market increases, to a less extent, with its input advantage, but it is not affected by the foreign firm's input advantage.

We now derive the effects on the home firm's export and investment. Focusing again on the home firm and differentiating the MCE condition of the home firm, we have

$$\begin{bmatrix} c'' & -\theta c^{*\prime\prime} \\ 1 & 1 \end{bmatrix} \begin{bmatrix} \mathrm{d}e \\ \mathrm{d}v \end{bmatrix} = -\begin{bmatrix} c'' \\ 1 \end{bmatrix} \mathrm{d}x + \begin{bmatrix} 0 \\ 1 \end{bmatrix} \mathrm{d}m. \quad (33)$$

Note that the foreign firm's input advantage does not appear in (33). Since M does not affect x and the home firm's MCE condition, it does not affect

e and v, either. Making use of (32a) and solving equation (33), we have:

$$\frac{\partial e}{\partial m} = -\frac{p^{*\prime}}{p' + p^{*\prime}} + \frac{\theta c^{*\prime\prime}}{c'' + \theta c^{*\prime\prime}} \tag{34a}$$

$$\frac{\partial v}{\partial m} = \frac{c''}{c'' + \theta c^{*\prime\prime}} > 0. \tag{34b}$$

Equations (34) suggest that an increase in m encourages the output of the home firm's subsidiary, but its impact on the firm's export level is ambiguous. Rearrenging the terms in (34a) gives a sufficient (and necessary) condition for $\partial e/\partial m > 0$:

$$\frac{p'}{p^{*\prime}} > \frac{c''}{\theta c^{*\prime\prime}}. \tag{35}$$

Condition (35) is easy to interpret: If the local marginal cost is rising relatively slowly than the rise in the marginal cost faced the home firm's subsidiary, with more input advantage the home firm will tend to relie more on export than on investment as a way to supply to the foreign market.

We now turn to the second stage of the game: Each firm chooses the optimal input advantage to maximize its profit, taking the input advantage of the other firm and the tariff rate as given. To examine how firms choose the input advantage, let us assume that in the long run there is a cost for acquiring the input advantage given by $g(m)$, which is initially assumed to be fixed and included in the fixed cost f in the short run. The marginal cost of the input advantage is assumed to positive and rising: $g'(m) > 0$, $g''(m) > 0$. Similarly, the input-advantage cost function of the foreign firm can be written as $G(M)$, where $G'(M) > 0$, $G''(M) > 0$.

The profit function of the firms can now be written as

$$\begin{aligned} \pi &= xp(q) + (e+v)p^*(q^*) - c(x+e) - \tau e - \theta c^*(v) \\ &\quad -g(m) - f - f^* \end{aligned} \tag{36a}$$

$$\begin{aligned} \Pi &= (E+V)p(q) + Xp^*(q^*) - C^*(X+E) - (t+\tau)E \\ &\quad -\Theta C(V) - G(M) - F - F^*. \end{aligned} \tag{36b}$$

The firms' Lagrangian functions can be defined in the same way as before. The home (foreign) firm chooses m (M) to maximize its profit, taking the input advantage of the other firm and the tariff rate as given. By the Envelope

Theorem and using (5a), the first-order condition of the home firm is

$$\begin{aligned}\mathcal{L}_m &\equiv \frac{\partial \mathcal{L}}{\partial m} = \lambda - g'(m)\\ &= p(x+M-X) + xp'(x+M-X) - c'(x+e) - g'(m)\\ &= 0. \end{aligned} \tag{37}$$

Using the comparative-static results derived earlier, the derivatives of π_m are

$$\mathcal{L}_{mm} = \frac{2p'p^{*\prime}}{p'+p^{*\prime}} - \frac{\theta c'' c^{*\prime\prime}}{c''+\theta c^{*\prime\prime}} - g'' < 0 \tag{38a}$$

$$\mathcal{L}_{mM} = \frac{p'p^{*\prime}}{p'+p^{*\prime}} < 0 \tag{38b}$$

$$\mathcal{L}_{mt} = 0. \tag{38c}$$

The first-order condition $\mathcal{L}_m = 0$ is illustrated by schedule HH in Figure 5. Its slope can be obtained from condition (38a) and (38b) and is equal to

$$\left.\frac{\mathrm{d}M}{\mathrm{d}m}\right|_{\mathrm{HH}} = -\frac{\mathcal{L}_{mm}}{\mathcal{L}_{mM}} < 0. \tag{39}$$

The profit-maximization condition of the foreign firm can be derived in a similar way. Its first-order condition is

$$\begin{aligned}\mathcal{L}^*_M &\equiv \frac{\partial \mathcal{L}^*}{\partial M} = \lambda^* - G'(M)\\ &= p^*(X+m-x) + Xp^{*\prime}(X+m-x) - C^{*\prime}(X+E) - G'(M)\\ &= 0. \end{aligned} \tag{40}$$

The second-order derivatives of the foreign firm's profit function are

$$\mathcal{L}^*_{Mm} = \frac{p'p^{*\prime}}{p'+p^{*\prime}} < 0 \tag{41a}$$

$$\mathcal{L}^*_{MM} = \frac{2p'p^{*\prime}}{p'+p^{*\prime}} - \frac{\Theta C'' C^{*\prime\prime}}{C^{*\prime\prime}+\Theta C''} - G'' < 0 \tag{41b}$$

$$\mathcal{L}^*_{Mt} = -\frac{p^{*\prime}}{p'+p^{*\prime}} + \frac{C^{*\prime\prime}}{C^{*\prime\prime}+\Theta C''}. \tag{41c}$$

Note that if the two countries are identical and if the market disadvantages are zero and there is no trade restriction, then $\mathcal{L}^*_{Mt} = 0$. Taking t as given, the first-order condition $\mathcal{L}^*_M = 0$ is illustrated by schedule FF in Figure 5. Its sloped is obtained from conditions (41a) and (41b), and is equal to

$$\left.\frac{\mathrm{d}M}{\mathrm{d}m}\right|_{\mathrm{FF}} = -\frac{\mathcal{L}^*_{Mm}}{\mathcal{L}^*_{MM}} < 0. \tag{42}$$

By comparing equations (39) and (42), we can see that as long as both firms are not very different from each other in the sense that they have similar cost structures, then schedule HH is steeper than schedule FF, as shown in the diagram. This is the case assumed here.

The intersecting point between schedule HH and schedule FF, depicted by point N, is the Nash equilibrium, showing the optimal input advantages of the firms, m^n and M^n, subject to the tariff rate imposed by the home government.

The expression in condition (41c), which determines how schedule FF is affected by a change in the tariff rate, has an ambiguous sign. Rearranging the terms, we can show that $\mathcal{L}^*_{Mt} > 0$ if and only if

$$\frac{\Theta C''}{C^{*\prime\prime}} < \frac{p'}{p^{*\prime}}. \tag{43}$$

One interesting, special case is that the countries are identical with zero market disadvantage, and that free trade initially is allowed. In this case, the two expressions on both sides of the inequality sign in (43) are equal, implying that $\mathcal{L}^*_{Mt} = 0$, i.e., a small tariff does not affect schedule FF.

We now turn to the first stage of the game. In this stage, the home government chooses the tariff rate, knowing well the best responses of the firms in later stages. Suppose that the home government has chosen an initial tariff rate, which may or may not be zero. We now examine how a change in the tariff rate may affect the decisions of the firms.[12] Using the second-order derivatives of the profit functions, we have

$$\begin{bmatrix} \mathcal{L}_{mm} & \mathcal{L}_{mM} \\ \mathcal{L}^*_{Mm} & \mathcal{L}^*_{MM} \end{bmatrix} \begin{bmatrix} \mathrm{d}m \\ \mathrm{d}M \end{bmatrix} = -\begin{bmatrix} 0 \\ \mathcal{L}^*_{Mt} \end{bmatrix} \mathrm{d}t,$$

[12]It will be interesting to derive the optimal tariff that maximizes, say, national welfare. However it is beyond the scope of this paper.

which can be solved to give

$$\frac{\mathrm{d}m}{\mathrm{d}t} = \frac{\mathcal{L}_{mM}\mathcal{L}^*_{Mt}}{D^m} \tag{44a}$$

$$\frac{\mathrm{d}M}{\mathrm{d}t} = -\frac{\mathcal{L}_{mm}\mathcal{L}^*_{Mt}}{D^m}, \tag{44b}$$

where $D^m \equiv \mathcal{L}_{mm}\mathcal{L}^*_{MM} - \mathcal{L}_{mM}\mathcal{L}^*_{Mm} > 0$. The sign of D^m implies that schedule HH is steeper than schedule FF. The results given by (44) can be illustrated in Figure 5. If condition (43) is satisfied so that $\mathcal{L}^*_{Mt} > 0$, an increase in t shifts schedule FF up but schedule HH remains unchanged. Given the initial value of m^n, there is an increase in M to $M^{n\prime\prime}$. The new Nash equilibrium, $(m^{n\prime}, M^{n\prime})$, is depicted by point N′, with a higher M but a lower m as compared with the initial equilibrium. The result is summarized by the following proposition:

Proposition 8. *In the long run, a small increase in trade protection will induce the home firm to choose a smaller input advantage and the foreign firm a bigger input advantage if and only if condition (43) is satisfied.*

The possibility that an increase in trade protection may affect the firms' input advantages raises some new issues. For example, we showed earlier that in the short run with a given input advantage, an increase in t will encourage the home firm to supply more to the local market. However, if sufficient time is given, and if condition (43) is satisfied, the home market will choose to have a smaller input advantage, and the protective effect of the tariff will be smaller.

Proposition 9. *The long-run protection effect on the domestic sale of the home firm of a small home tariff is smaller than its short-run protection effect if and only if condition (43) is satisifed.*

Another interesting issue is about the long-run tariff-jumping investment. In the short run, an increase in the home tariff will encourage more investment by the foreign firm. When the firms choose their input advantages in the long run, the total effect of an increase in trade protection on its investment is

$$\frac{\mathrm{d}V}{\mathrm{d}t} = \frac{\partial V}{\partial t} + \frac{\partial V}{\partial M}\frac{\mathrm{d}M}{\mathrm{d}t} \tag{45}$$

Proposition 10. *(a) Long-run tariff-jumping investment exists and is equal to the short-run tariff-jumping investment in the symmetric case with two identical countries, no market disadvantage, and free trade initially. (b) Long-run tariff-jumping investment by the foreign firm in the home market is larger than the short-run tariff-jumping investment if and only if condition (43) is satisfied.*

Proof. Part (a) is due to the fact that $\mathrm{d}M/\mathrm{d}t = 0$ if the two countries are identical, and if there are no market disadvantages and trade restrictions. Part (b) is obtained by using the signs of $\partial V/\partial M$ and $\mathrm{d}M/\mathrm{d}t$ and equation (45). ■

8 Concluding Remarks

In this paper, a model is developed to analyze the phenomenon of intraindustry trade and intraindustry investment. When two large firms, one in each country, are producing a homogeneous product and competing internationally in both markets, they are facing three options: domestic sale, export, and investment in the other market. This paper analyzes how the two firms choose the options optimally to improve their profits.

The present paper analyzes the roles of transport costs, tariff, and market disadvantages on trade and investment in a unified model. How domestic sales, exports, and investments are affected is examined. The paper also derives the conditions under which a firm would want to satisfy the demand in the market in another country by both export and investment, and also the conditions under which simultaneous intraindustry trade and intraindustry investment exists. This paper also examines whether intraindustry trade and intraindustry investment are substitutes.

The welfare effects of trade and investment are also investigated in the present paper. It is argued that trade and investment may not be gainful, and if both the transport cost and the market disadvantage are near their prohibitive levels, then trade and investment are detrimental to both countries. The present model has a strong argument for free investment, especially when free trade is initially allowed. The welfare impact of prohibiting trade, however, is ambiguous.

The present paper also analyzes how the firms compete in terms of input advantages in the long run. When the firms have enough of time to alter their input advantages in response to a change in the home government's trade protection, some of the short-term results may not hold. For example, the positive impact of a tariff on the home firm's supply to the local market may be smaller in the long run, and a short-run tariff-jumping investment may become a tariff-jumping deinvestment in the long run.

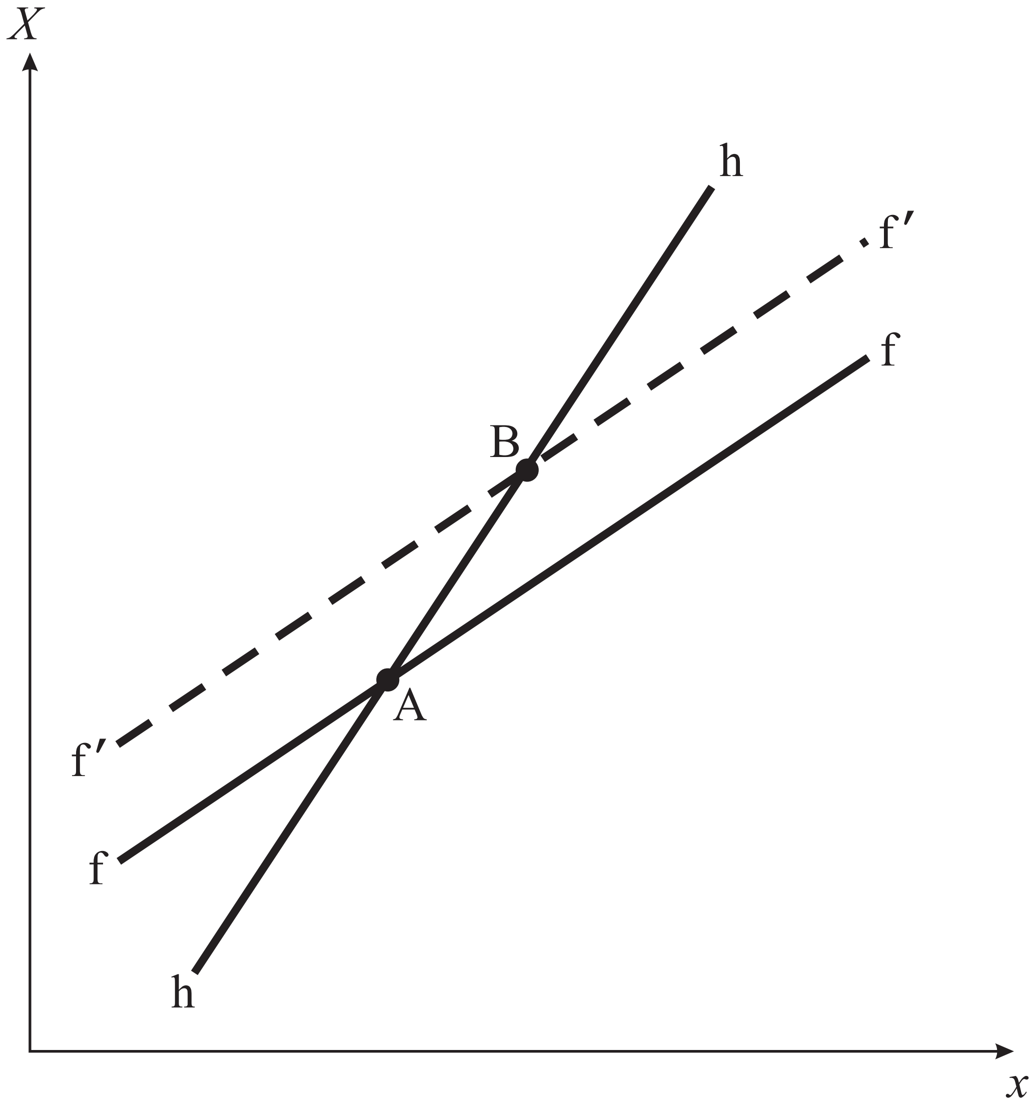

Figure 1

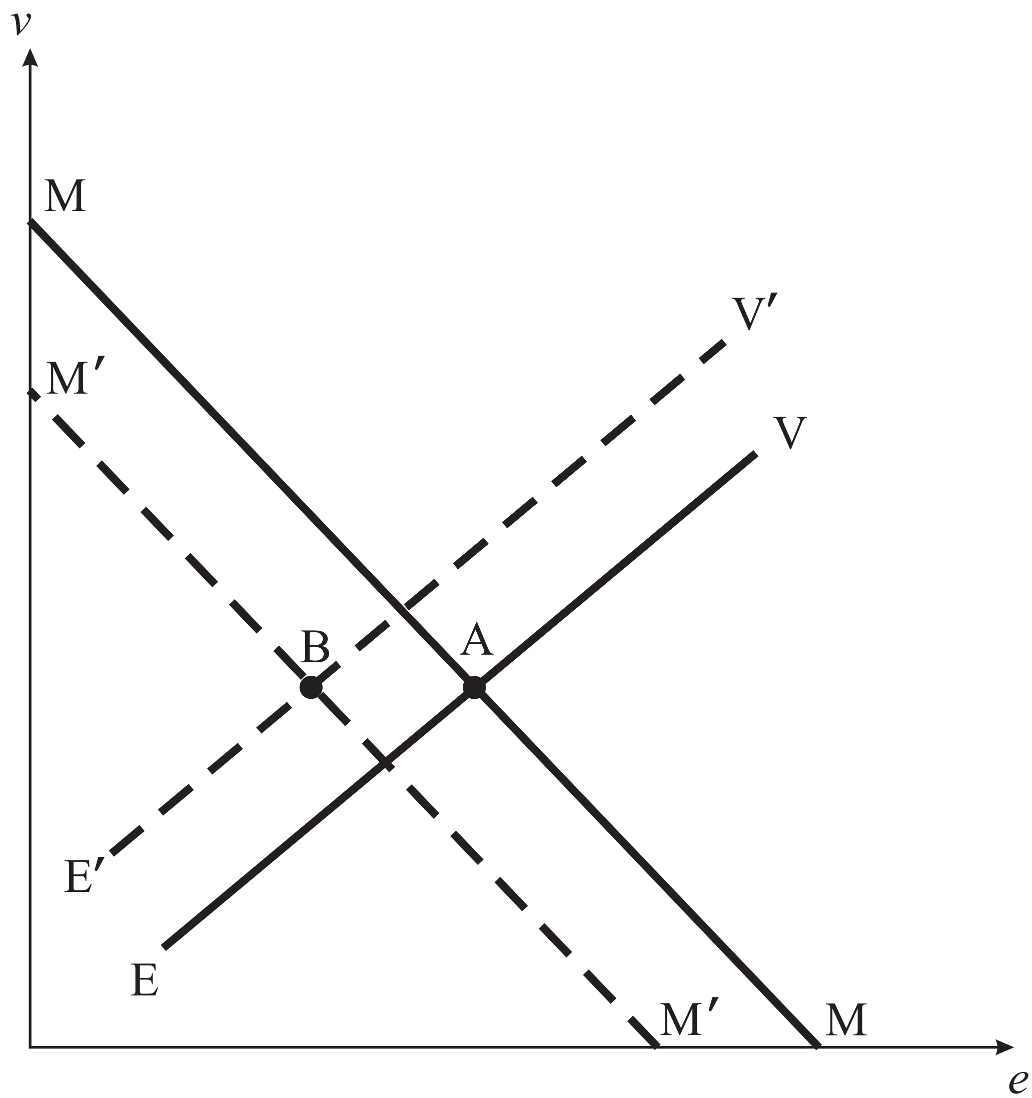

Figure 2

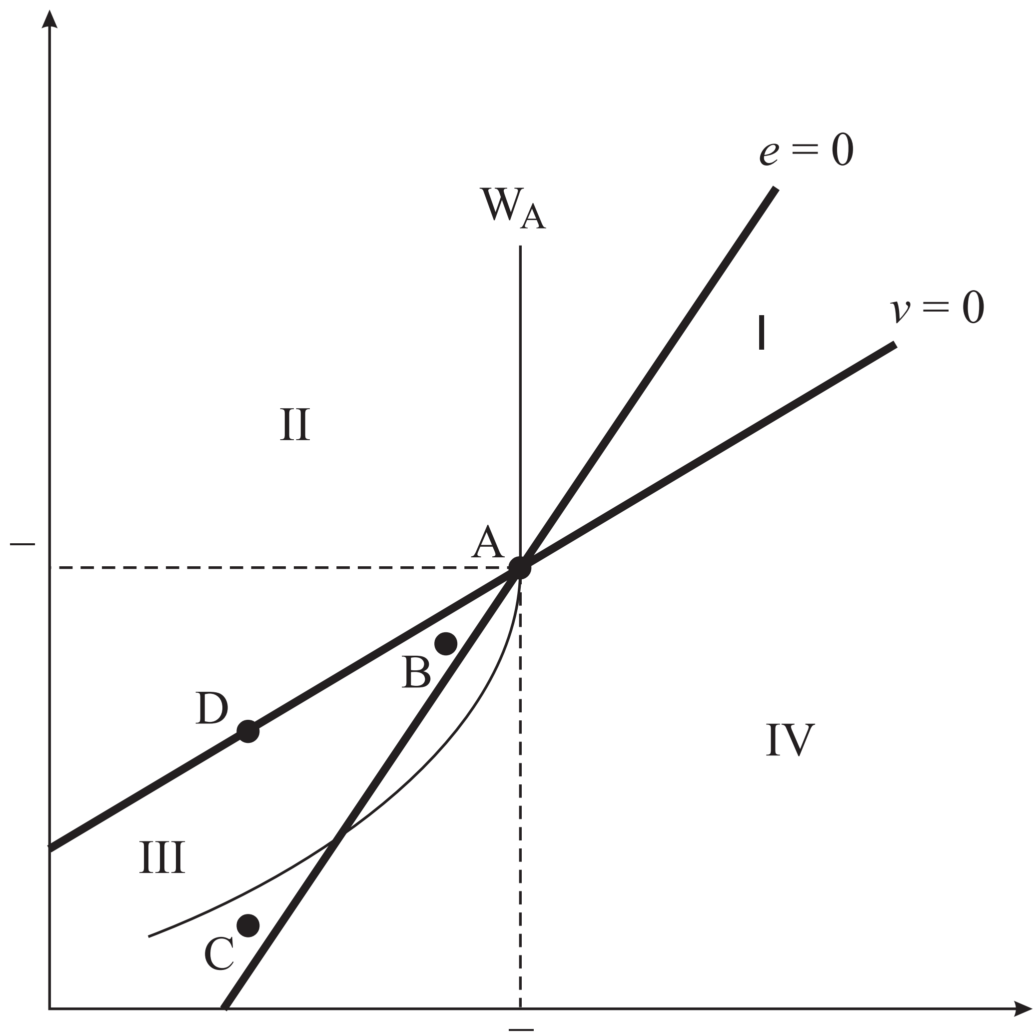

Figure 3

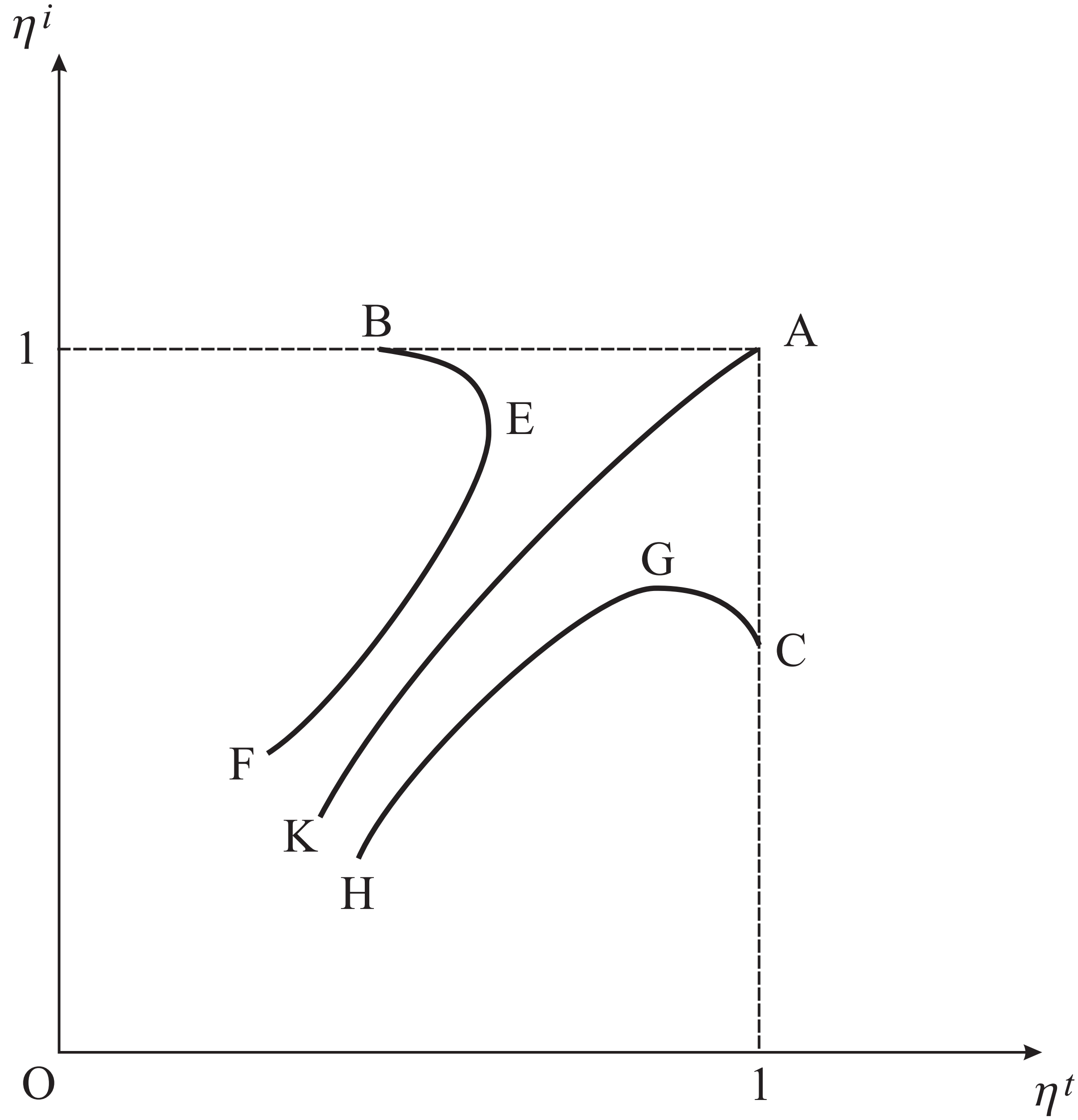

Figure 4

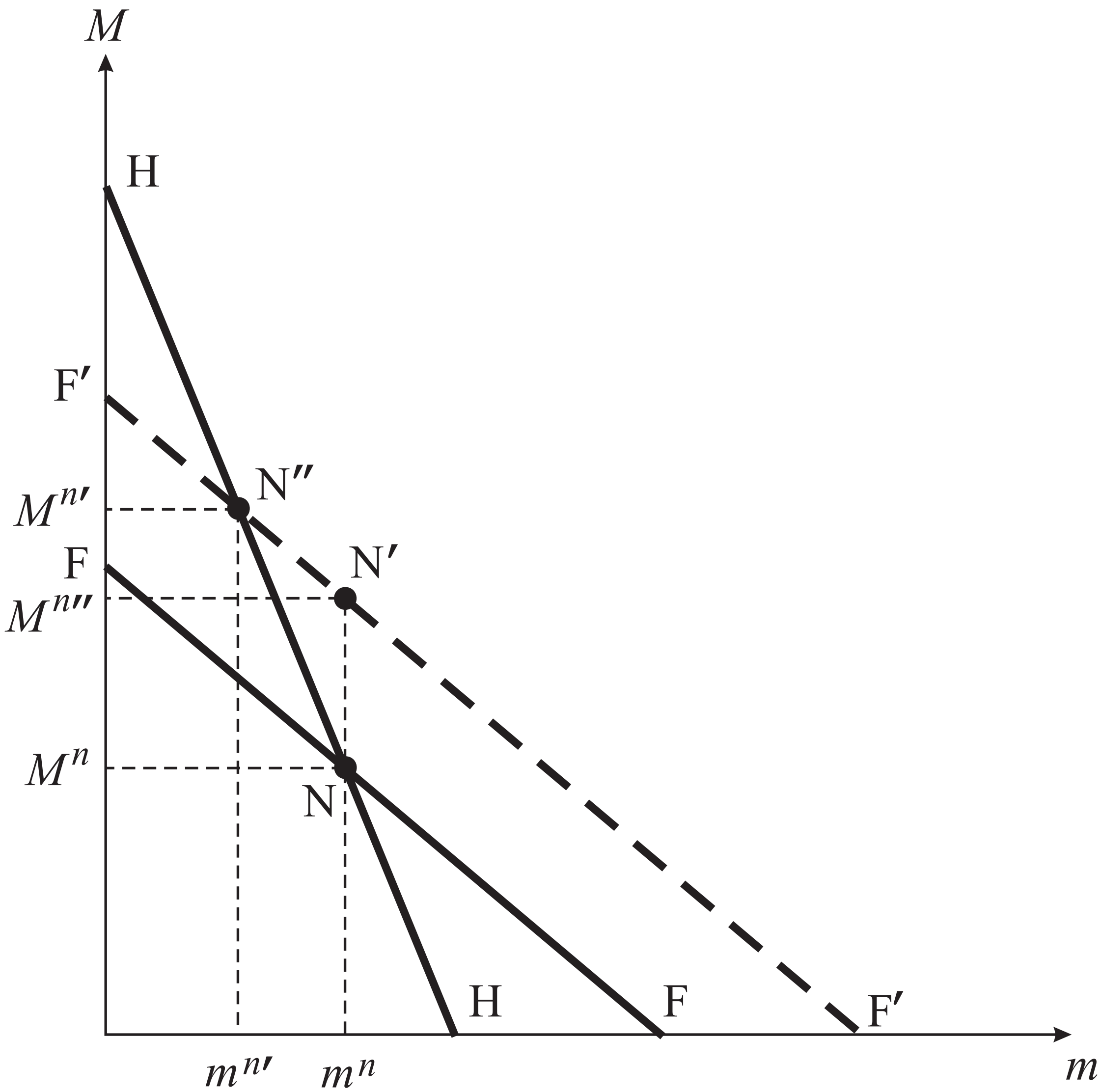

Figure 5

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