Endogenous Trade Patterns in Vertical Production*

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Abstract

This paper investigates trade patterns that occur between developed and developing countries in industries with vertical production structures. The price of intermediate good is affected not only by market conditions for the intermediate good but by market conditions for final good, as a result of backward linkages. We show that trade patterns depend on the relative size of the final good market, trade costs, prices of the intermediate good, wage differentials, and the degree of competition. The flow of components and the trade patterns for final goods may change drastically with economic development.

Keywords: Trade Patterns; Vertical Production; Backward Linkages; Economic Development

JEL classifications: F12; F21; F23

1 Introduction

In recent years, ASEAN countries and China have experienced high rates of economic growth, with the exception of the Asian financial crisis in the late 1990's (Barro, 2001). One of the outstanding factors that has contributed to this successful economic development is active foreign direct investment (FDI) from developed countries.

In the 1980's, low wage rates in developing countries created incentive for firms based in developed countries to build plants in the developing countries, with the purpose of producing manufacturing components for export to home countries. As East Asian countries grow and their standards of living increase, manufacturing components are used directly in the production of final goods for domestic supply and export to developed countries (Hobday, 1995). That is, economic development changes the trade patterns of components and final goods dramatically.

The purpose of this paper is to derive endogenous trade patterns between developed and

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developing countries in an industry that has a vertical production structure. Most studies analyzing trade patterns have been concerned with final goods markets. Both Rowthorn (1992) and Horstmann and Markusen (1992) derive endogenous trade patterns for final goods between two identical countries. Markusen and Venables (1998) introduce differences in factor endowments and analyze endogenous trade patterns with asymmetry. In this sense, our paper is an extension of these articles, but introducing an intermediate good sector is not trivial. While Gao (1999) introduces an intermediate good sector, he only considers a special case where multinational firms in a developed country produce components in a developing country and import these components to produce final goods. This aspect of multinational firms, however, cannot explain the importance of rapid market expansion in developing countries, which creates strong demand for final goods. For example, this can be seen with the recent outstanding expansion of the automobile and parts industry in China.

When we consider a vertical production structure, we must take into account linkages.[1)] According to Hirschman (1958), the effectiveness of economic development depends crucially on *forward* and *backward linkages*. We concur with Rodriguez-Clare (1996) and Markusen and Venables (1999) that the size of the market for final good restricts the size of the intermediate good market. Since the price of intermediate good is determined in the market, it is influenced by the size of the final good market. In this sense, the price of intermediate good depends not only on market conditions for the intermediate good but also on the market conditions for the final good.

As is widely observed, trade in parts and components, as well as final goods, is very active between developed and developing countries. We include trade in both final and intermediate good sectors into our model. Firms producing final good determine the number of plants, while firms in the intermediate good industry employ local labor and produce intermediate good for supply to both domestic and foreign markets. We show that the equilibrium price for the intermediate good depends on market conditions for the final good, trade costs on the intermediate good, wages, and the degree of competition (*i. e.*, the number of firms in each country). The equilibrium price of the intermediate good is closely related to the effectiveness of tariff policy. It is well known that higher trade costs induce FDI (*tariff-jumping argument*; see Rowthorn, 1992; Horstmann and Markusen, 1992). In our model, this *tariff-jumping effect* depends on the price of the intermediate good.

While we provide a complete framework for determining trade patterns endogenously, they strongly rely on parameter values. Therefore, we use numerical simulations to clarify the effect of asymmetries in countries on trade patterns. In particular, we focus on economic catching-up of the developing country and changes in trade cost. We show that the market structure depends on (1) the relative sizes of the final good markets in the developed and developing countries, (2) trade costs, (3) prices for the intermediate good, (4) wage differentials, and (5) the degree of competition, both in the final and intermediate good markets.

This paper is organized as follows. Section 2 provides the basic framework for our analysis. Section 3 examines output levels and possible trade patterns (*i. e.*, trade can be two-way or one-way, or no trade occurs), and derives the price of the intermediate good. Section 4 illustrates endogenous trade patterns and clarifies how market expansion in the developing country, wage differentials between two countries, changes in trade costs, and the degree of competition affect these trade patterns. Section 5 concludes.

2 The Model

In this section, we describe the basic framework. Consider two countries labeled country 1 and country 2, respectively. We focus on a particular industry where production has a vertical structure; one unit of the intermediate input is necessary to produce one unit of the final good. There are n_i firms in the final good industry and m_i firms in the intermediate good industry in country i ($i=1, 2$). Assume that firms in each industry are symmetric across countries. Each country has an intermediate good market and a final good market. Each firm in country i can supply products to the market in country j ($i, j=1, 2; i \neq j$), and then *iceberg* trade costs are charged; t for the final good and τ for the intermediate good, respectively ($t, \tau \geqslant 1$). In each market, firms compete in Cournot fashion.[2)]

We consider a two-stage game. In the first stage, final good firms decide whether to enter the market or not. When a firm enters the market, it chooses a number of plants; either one or two. We assume that firms set-up a plant in their home country if they choose one plant and that no firm can have more than one plant in a country. We thus call the former choice *national* and the latter *multinational*.[3)] Since not entering the market corresponds to choosing zero plants, we restate that final goods producers choose a number of plants from zero, one or two, in the first stage. Then in the second stage, firms compete in each market given the number of plants.

In the following, we provide detailed settings for both final and intermediate good producers.

2.1 Final good producers

The inverse demand function in the final good market of country i is given by $P_i = A_i - X_i$,[4)] where P_i is price, X_i is total quantity, and A_i is a positive constant ($i=1, 2$). A_1 and A_2 are not necessarily equal.

In the first stage, final good firms must decide whether or not to enter the market. For a given intermediate good price, q_i, final good firms in country i (hereafter we call them *firm i*) calculate their profits, and only enter if the profits are positive ($i=1, 2$). If firm i enters the market, it can choose either national or multinational. The cost for a national firm is

$$C_i^n = q_i X_{ii} + t q_i X_{ij} + w_i f, \tag{1}$$

where X_{ij} expresses the output produced by firm i and consumed in country j ($i, j=1, 2$), w_i stands for the wage rate in country i, and the constant f shows the cost of headquarter services or plant-specific fixed costs in terms of labor. When firm i chooses multinational, it must build a plant in country j as well as a headquarters and a plant in country i ($i, j=1, 2,$

$i \neq j$). In doing so, firm i incurs an additional cost $w_j g$ in addition to $w_i f$. Furthermore, assume that firm i acquires intermediate goods from the intermediate good market where it locates.[5)] Then, the cost for a multinational firm is

$$C_i^m = q_i X_{ii} + q_j X_{ij} + w_i f + w_j g. \tag{2}$$

Let $\prod_i^n$ and $\prod_i^m$ be the profits of a national and multinational firm i, respectively. From equations (1) and (2), these profits are expressed as

$$\prod_i^n = (P_i - q_i) X_{ii} + (P_j - tq_i) X_{ij} - w_i f, \tag{3}$$
$$\prod_i^m = (P_i - q_i) X_{ii} + (P_j - q_j) X_{ij} - w_i f - w_j g \tag{4}$$

2.2 Intermediate good producers

By summing demand for intermediate good over the final good firms, we derive the total demand for the intermediate good for a given q_i and q_j. Since one unit of the final good is produced using one unit of the intermediate good, the total demand for the intermediate good is expressed as $D_i(q_i, q_j)$. Then, the equilibrium condition for the intermediate good market is given by

$$D_i(q_i, q_j) = M_i, \tag{5}$$

where M_i is the total supply of the intermediate good in country i. That is, $M_i = m_i y_{ii} + m_j y_{ji}$, where y_{ij} is the amount of the intermediate good produced in country i and purchased in country j ($i, j=1, 2$). Solving equation (5), we derive the inverse demand in the intermediate good market. Equation (5) implies a backward linkage; *i. e.*, the state of the intermediate good market depends on whether the final good producers choose zero plants (no entry), one plant (national), or two plants (multinational). That is, the size of the intermediate good market is restricted by the size of the final good market.

Assume that one unit of the intermediate good is produced using one unit of labor with no fixed costs. Then, the profit of an intermediate good firm i ($i=1, 2$) is written as

$$\pi_i = (q_i - w_i) y_{ii} + (q_j - \tau w_i) y_{ij}. \tag{6}$$

3 Outputs, Prices, and Possible Trade Patterns

In this section, we focus on the second stage and compute Cournot equilibrium solutions. As equation (5) implies, the demand for the intermediate good is determined by the final good industry. Thus, we examine the final good industry first, and then consider the intermediate good industry.

Trade patterns are determined by the number of plants chosen by firms 1 and 2 in the first stage. In our model, there are nine trade patterns, which may be characterized by a pair (h, k) where h and k respectively stand for the number of plants chosen by firm 1 and 2 ($h, k = 0, 1, 2$). Denoting the profit of firm i ($i=1, 2$) in trade pattern of (h, k) as $\prod_i(h, k)$,

Table 1: Nash equilibrium outputs and profits

	X_{ii}	X_{ij}	X_{ji}	X_{jj}
(0, 0)	0	0	0	0
(1, 1)(a)	$\frac{A_i-(n_j+1)q_i+tn_jq_j}{n_i+n_j+1}$	$\frac{A_j-(n_j+1)tq_i+n_jq_j}{n_i+n_j+1}$	$\frac{A_i-(n_i+1)tq_j+n_iq_i}{n_i+n_j+1}$	$\frac{A_j-(n_i+1)q_j+tn_iq_i}{n_i+n_j+1}$
(1, 1)(b)	$\frac{A_i-(n_j+1)q_i+tn_jq_j}{n_i+n_j+1}$	0	$\frac{A_i-(n_i+1)tq_j+n_iq_i}{n_i+n_j+1}$	$\frac{A_j+q_j}{n_j+1}$
(1, 1)(c)	$\frac{A_i-q_i}{n_i+1}$	0	0	$\frac{A_j-q_j}{n_j+1}$
(1, 0)	$\frac{A_i-q_i}{n_i+1}$	$\frac{A_j+tq_i}{n_i+1}$	0	0
(2, 0)	$\frac{A_i-q_i}{n_i+1}$	$\frac{A_j+q_j}{n_i+1}$	0	0
(1, 2)(a)	$\frac{A_i-q_i}{n_i+n_j+1}$	$\frac{A_j-t(n_j+1)q_i+n_jq_j}{n_i+n_j+1}$	$\frac{A_i-q_i}{n_i+n_j+1}$	$\frac{A_j-(n_i+1)q_j+n_itq_i}{n_i+n_j+1}$
(1, 2)(b)	$\frac{A_i-q_i}{n_i+n_j+1}$	0	$\frac{A_i-q_i}{n_i+n_j+1}$	$\frac{A_j-q_j}{n_j+1}$
(1, 2)(c)	$\frac{A_i-q_i}{n_i+1}$	0	0	$\frac{A_j-q_j}{n_j+1}$
(2, 2)	$\frac{A_i-q_i}{n_i+n_j+1}$	$\frac{A_j-q_j}{n_i+n_j+1}$	$\frac{A_i-q_i}{n_i+n_j+1}$	$\frac{A_j-q_j}{n_i+n_j+1}$

For firm j's strategy k ($k=0, 1, 2$), firm i's equilibrium profits are
$\prod_i^o=0$,
$\prod_j^n=(X_{ii})^2+(X_{ij})^2-w_if$,
$\prod_i^m=(X_{ii})^2+(X_{ij})^2-w_jf-w_jg$,
where $\prod_i^o$ is the profit of firm i choosing *not entering* ($i, j=1, 2, i\neq j$).

we drop the superscripts n and m.

Here, we focus on the trade pattern (1, 1), where there are national firms in each country, to examine outputs, profits, intermediate prices and possible trade patterns. Equilibrium outputs and profits for all regions are summarized in Table 1.

3.1 Final good market equilibrium

From equation (3), the first order conditions are

$$\frac{\partial \prod_i}{\partial X_{ii}}=P_i-q_i-X_{ii}=0 \tag{7}$$

$$\frac{\partial \prod_j}{\partial X_{ji}}=P_i-tq_j-X_{ji}=0. \tag{8}$$

Note that $P_i=A_i-X_i$ and $X_i=n_iX_{ii}+n_jX_{ji}$ ($i, j=1, 2; i\neq j$). Summing equations (7) and (8) over the number of firms in country i and j and solving them, we obtain

$$X_{ii}=\frac{A_i-(n_j+1)q_i+tn_jq_j}{n_i+n_j+1} \tag{9}$$

$$X_{ji}=\frac{A_i-(n_i+1)tq_j+n_iq_i}{n_i+n_j+1}. \tag{10}$$

Equilibrium profits are calculated using equations (9) and (10) (see Table 1).

Let us focus on *possible trade patterns*; *i. e.*, examine whether trade can be *two-way* or *one-way*, or *no trade* can occur. Note that, from equation (10), exports are decreasing in the level of trade costs. Setting X_{ji} equal to zero, we obtain the threshold trade cost level t_i as

$$t_i=\left(\frac{A_i-q_i}{(n_i+1)q_i}+1\right)\frac{q_i}{q_j}\ ;\ i,\ j=1,\ 2,\ i\neq j. \tag{11}$$

That is, if the trade costs are higher than t_i, X_{ji} is equal to zero. The threshold trade cost level can be interpreted as a prohibitive trade barrier. The value of t_i depends on three factors: (1) the relative cost for the intermediate good (q_i/q_j); (2) the size of the final good market $((A_i-q_i)/q_i)$; and (3) the competitiveness in the final good market (n_i+1). Exports from country j to country i will occur if the relative cost for the intermediate good in country i is expensive (*i. e.*, firm j prefers to purchase the intermediate good in country j rather than in country i), if the market in country i is large, and/or if the market is less competitive, so that a high price will be realized in country i. We find a similar threshold value, t_j, for country j that is a necessary condition for exports from country i to country j to be positive $(i,\ j=1,\ 2;\ i\neq j)$. t_i and t_j are not necessarily equal. Depending on the level of t_i and t_j, we obtain the following possible trade patterns.

Lemma 1

Suppose that $t_i>t_j$ $(i,\ j=1,\ 2;\ i\neq j)$. *Then,*

(1) *If* $t_i>t_j>t$, *two-way trade is possible between the two countries* (*i. e.*, $X_{ij}>0$ *and* $X_{ji}>0$).

(2) *If* $t_i>t>t_j$, *one-way trade is possible with country j exporting and country i importing* (*i. e.*, $X_{ij}=0$ and $X_{ji}>0$).

(3) *If* $t>t_i>t_j$, *no trade is possible between the two countries* (*i. e.*, $X_{ij}=0$ and $X_{ji}=0$).

Because products are homogeneous, two-way trade corresponds to (*intra-industry trade*). Equation (11) and Lemma 1 state that if one-way trade occurs, the exporting (*resp.* importing) country is likely to have relatively low production costs, and a small and competitive market (*resp.* high production costs, and a large and less comptitive market). Before closing this subsection, we touch upon the concept of t_i $(i=1,\ 2)$.

Corollary 1 (Rowthorn (1992))

Suppose $A_i=A$, $n_i=1$, and $q_i=1$ $(\forall_i=1,\ 2)$. *Define* $\mu\equiv(A-1)/2$ and $\lambda\equiv(t-1)/\mu$. Then, from equation (10), $X_{ji}>0$ for $\lambda<1$ and $X_{ji}=0$ for $\lambda\geqslant 1$ $(i,\ j=1,\ 2;\ i\neq j)$.

Corollary 1 states that our definition of t_i is a direct extension of Rowthorn (1992).

3.2 Intermediate good market equilibrium

Next, we derive inverse demand functions for the intermediate good through the final good market equilibrium and find the intermediate good market equilibrium. According to Lemma 1, we have three possible trade patterns in the final good industry. The inverse demands for intermediate good depend on these possible trade patterns.

Let us consider the two-way trade case, *i. e.*, $t_i>t_j>t$. From cost function (1), Shepard's lemma yields firm i's demand for the intermediate good as follows.

$$\frac{\partial C_i}{\partial q_i}=X_{ii}+tX_{ij} \tag{12}$$

Therefore, the equilibrium condition in the intermediate good market, equation (5), is rewritten as $M_i=n_i(X_{ii}+tX_{ij})$ (i, $j=1$, 2; $i\neq j$). Using the same method, we derive the equilibrium conditions for one-way trade ($X_{ij}=0$ and $X_{ji}>0$) as $M_i=n_iX_{ii}$ and $M_j=n_j(X_{jj}+tX_{ji})$, and for no-trade ($X_{ij}=X_{ji}=0$) as $M_i=n_iX_{ii}$ and $M_j=n_jX_{jj}$ (i, $j=1$, 2; $i\neq j$).

We find that the inverse demand functions can be expressed in the following linear form, irrespective of trade patterns (the derivation is contained in Appendix);

$$q_i=a_i-b_{ii}M_i-b_{ji}M_j \tag{13}$$

for i, $j=1$, 2, $i\neq j$, where a_i, b_{ii} and b_{ij} are constants, which are determined by which trade patterns occur. Note that $b_{ij}=b_{ji}$ holds for any trade patterns. Using this condition, we find the price of the intermediate good, q_i.

Proposition 1

For any trade patterns, the price of the intermediate good in country i is described as

$$q_i=\frac{a_i+m_iw_i+\tau m_jw_j}{m_i+m_j+1}. \tag{14}$$

Proof. *See Appendix.*

Proposition 1 states that the price of the intermediate good depends only on the constant intercept a_i, and neither b_{ii} nor b_{ij}. As shown in Appendix, the value of a_i ($i=1$, 2) is related to the constant intercept of the final good demand A_i. Finally, using equations (6) and (14), we find the Cournot equilibrium outputs in the intermediate good market (see Appendix A).

4 Endogenous Trade Patterns

In this section, we focus on the first stage, where the final good producers choose the number of plants and trade pattern regimes (we simply call them *Regimes* below) are determined. Among the nine regimes, we find a Nash equilibrium, which determines a subgame perfect equilibrium. Using the payoffs given in Table 1, we can detect and illustrate Nash equilibrium regimes. But the complexity of the solutions in the second stage makes it difficult to compare the profits. Thus, we use numerical analysis to focus on how equilibrium trade patterns are affected by the relative market sizes and the trade cost level for the final goods. For now, we consider an international duopoly in the final good market; *i. e.*, $n_1=n_2=1$. Later, we will consider a case where the number of firms is different in each country. In both cases, the number of the intermediate producers in each country is fixed to one.

We incorporate asymmetries between the two countries into our analysis. Assume that country 1 is highly developed. This means that the final good market in country 1 is greater than that in country 2 ($A_1>A_2$) and that the wage level in country 1 is higher than that in

Table 2: Payoff matrices

Table 2.a: Payoff Matrix (t=1.1, α=0.5)

		Firm 2		
		0	1	2
Firm 1	0	(0, 0)	(0, 12.31)	(0, 10.41)
	1	(13.4, 0)	(6.34, 5.21)	(5.52, 5.47)*
	2	(10.65, 0)	(4.15, 6.20)	(4.42, 4.18)

*… Nash equilibrium

Table 2.b: Payoff Matrix (t=1.6, α=0.95)

		Firm 2	
		1	2
Firm 1	1	(10.25, 9.59)*	(7.18, 8.77)
	2	(8.71, 6.94)	(7.26, 7.02)*

*… Nash equilibrium

Table 2.c: Payoff Matrix (t=1.6, α=0.45)

		Firm 2	
		1	2
Firm 1	1	(4.61, 4.77)	(4.13, 4.81)
	2	(4.51, 4.33)	(4.23, 3.99)

country 2 ($w_1 > w_2$). We express these relations as $A_2=\alpha A_1$ and $w_2=\beta w_1$ (α, $\beta \in (0, 1]$), respectively. We use common parameter values in the following analysis: $A_1=10$, $w_1=1$, $\tau=1$, $f=0$ and $g=0.8$.[6)]

4.1 A benchmark

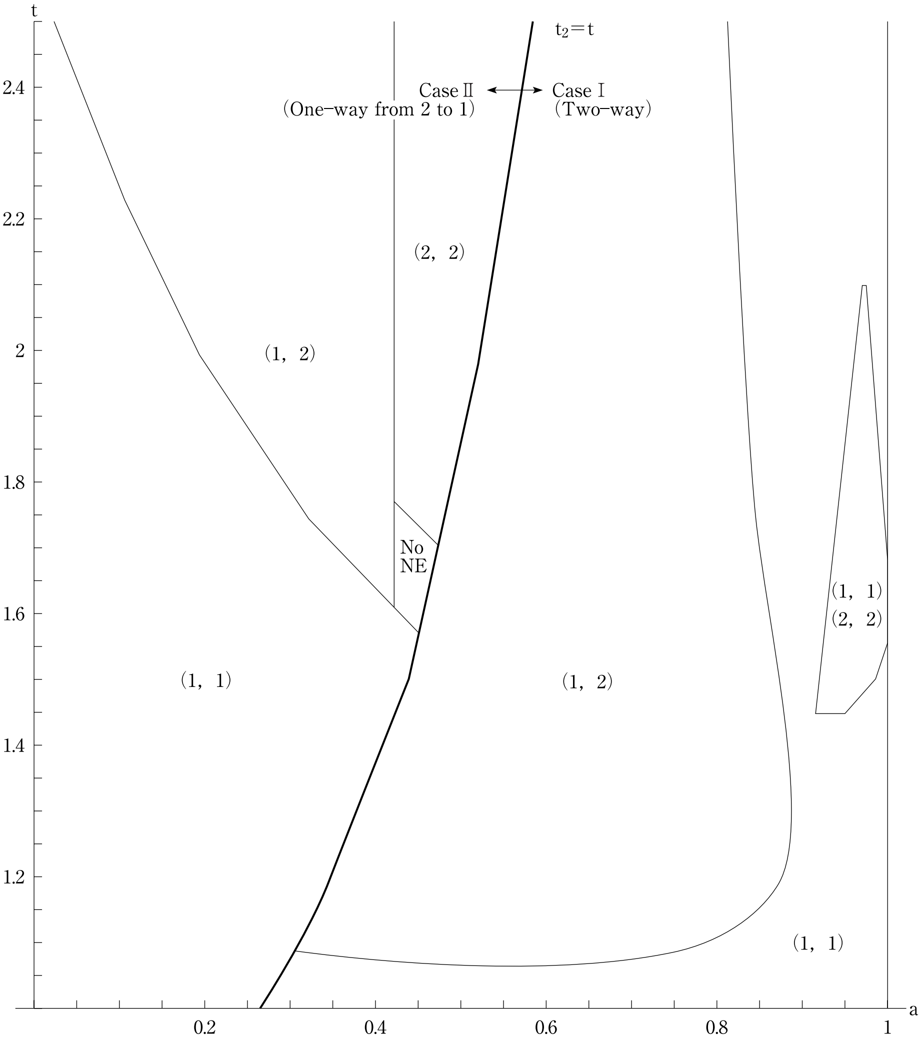
We allow α to change between (0, 1], for a given β. First, suppose that $\beta=0.7$, which illustrates the case where the wage differential between the two countries is relatively small.

Before proceeding, we describe how the equilibrium trade pattern is determined. Once we know the values of t and α, we can compare the profits of each regime. For example, consider a case where $t=1.1$ and $\alpha=0.5$ (see Table 2.a). In this case, a Nash equilibrium trade pattern is (1, 2). From Table 2.a, we find that a regime that includes any firm taking a zero plant strategy cannot be a Nash equilibrium. We thus exclude the choice 0 from firms' choices below. Considering different values of t and α, we can describe equilibrium trade patterns. Figure 1 illustrates trade patterns on (α, t) space. Since we focus on the case where country 1's market is bigger than country 2's, the domain of α is between zero and one. We eliminate extremely high trade costs, because the results are not significant, and confine our attention to $t \leqslant 2.5$.

In figure 1, it is worthwhile to note that there are two possible trade patterns: two-way trade (Case I) and one-way trade from country 2 to country 1 (Case II). The right (*resp.* left) side of the $t_2=t$ line is Case I (*resp.* Case II). This result illustrates that it is reasonable to anticipate two-way trade between countries with similar market sizes.

In Case I, Regimes (1, 1), (1, 2), and (2, 2) are possible Nash equilibrium regimes. Regime (1, 1) (intra-industry trade) tends to appear as a Nash equilibrium if (a) A_2 is sufficiently large and/or (b) t is extremely low. In contrast, Regime (1, 2) is likely to be an equilibrium when t is sufficiently high. Although trade costs are small and input costs in country 2 are lower

Figure 1: Trade Patterns ($n_1=n_2=1$, $\beta=0.7$)



than in country 1, a large market size in country 1 causes plants to cluster. Regime (2, 2) (foreign direct investment) may appear when country 2's market size is close to country 1's and trade costs are sufficiently high. Note that Regime (2, 2) is observed as a multiple-equilibria (1, 1)/(2, 2) (see Table 2.b).

In case II, Regimes (1, 1), (1, 2) and (2, 2) are also possible trade patterns. Regime (1, 1) appears when there is an extremely large market size differential (*i. e.*, α is sufficiently small) and/or low trade costs (*i. e.*, t is low). Note that trade occurs only from country 2 to country 1. Regime (1, 2) is an equilibrium if t is sufficiently high ($t>1.5$) and α is small. When the market size in country 2 grows to around half of country 1's ($\alpha \geqslant 0.43$), Regime (2, 2) is chosen as an equilibrium. The results imply that small trade costs make exporting advantageous and a large market size enhances the incentive for firms to conduct foreign direct investment. Note that there is an additional regime where there is no Nash equilibria in case

II. Table 2.c is the example where $t=1.6$ and $\alpha=0.45$. In this case, trade pattern cannot be determined from the strategic behavior of firms.[7)]

Figure 1 may illustrate economic catching-up stages of developing countries under a given tariff policy. Suppose that $t=1.8$. Then, as the market size in country 2 develops (*i. e.*, α increases), the equilibrium trade pattern changes as follows (attached parentheses are realized trade patterns): (1, 1) (one-way trade) → (1, 2) (no trade) → (2, 2) (no trade) → (1, 2) (one-way trade) → (1, 1) (two-way trade) → (1, 1)/(2, 2) (two-way or no trade). In addition, Figure 1 describes how a change in trade costs may bring about drastic changes in the pattern of trade. We predict that intra-industry trade is likely to appear rather than foreign direct investment with reductions in trade costs, such as the realization of a free trade agreement.

4.2 Effects of wage differentials

Based on the above results, let us consider the effects of a change in wage differentials. Suppose that the wage differential expands, *i. e.*, β becomes smaller than 0.7. The observed properties are summarized as follows:

Case I:

(i) Regime (1, 2) expands and Regime (1, 1) contracts (the border between (1, 1) and (1, 2) shifts southwest); since q_2 decreases significantly, production in country 2 becomes more advantageous.

(ii) Regime (1, 1)/(2, 2) contracts, and may disappear for a small β; by expansion of the wage differential, the multiple equilibria are eliminated.

(iii) A no-Nash-equilibria regime may appear and expand as the wage differential becomes wider; large gaps in the production environment between firms 1 and 2 prevents their best responses from matching.

Case II:

(i) Regime (2, 2) expands and Regime (1, 2) contracts (the border between (1, 2) and (2, 2) shifts west).

(ii) Regime (1, 1) expands as β decreases, but if the wage differential is extremely large, Regime (1, 1) contracts.

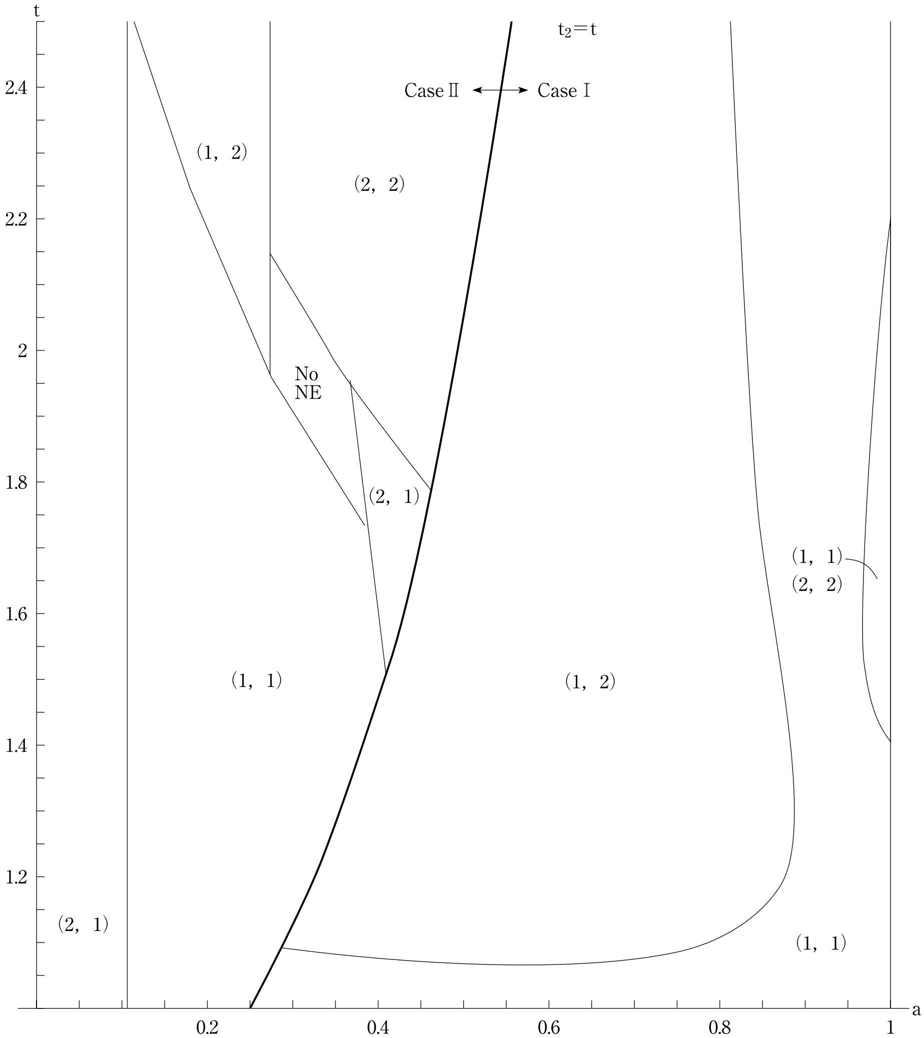
(iii) Regime (2, 1) appears with high trade costs and/or an extremely large market size differential; the trends described above occur because production in country 2 becomes more advantageous.

(iv) Regime with no-Nash-equilibria expands as the wage differential increases.

The expanding the wage differential makes it advantageous for firms to produce in country 2. Therefore, Regime (2, 1) appears for a sufficiently small β.

So far, the value of β has been exogenously provided. In reality, however, economic development tends to create wage increases as well as market expansion. Suppose that the wage level in country 2 rises at the same rate as market expansion; *i. e.*, $\beta=\alpha$. Figure 2 illustrates this proportional growth case. Since β increases at the same rate as α, Figure 2 is a composition of figures for $\beta \in (0, 1]$ on α-axis. Note that Case I has similar properties to the benchmark case ($\beta=0.7$) while case II has the properties shown in this subsection,

Figure 2: Trade Patterns ($n_1=n_2=1$, $\alpha=\beta$)



because one-way (*resp.* two-way) trade occurs for low (*resp.* high) levels of $\alpha=\beta$.

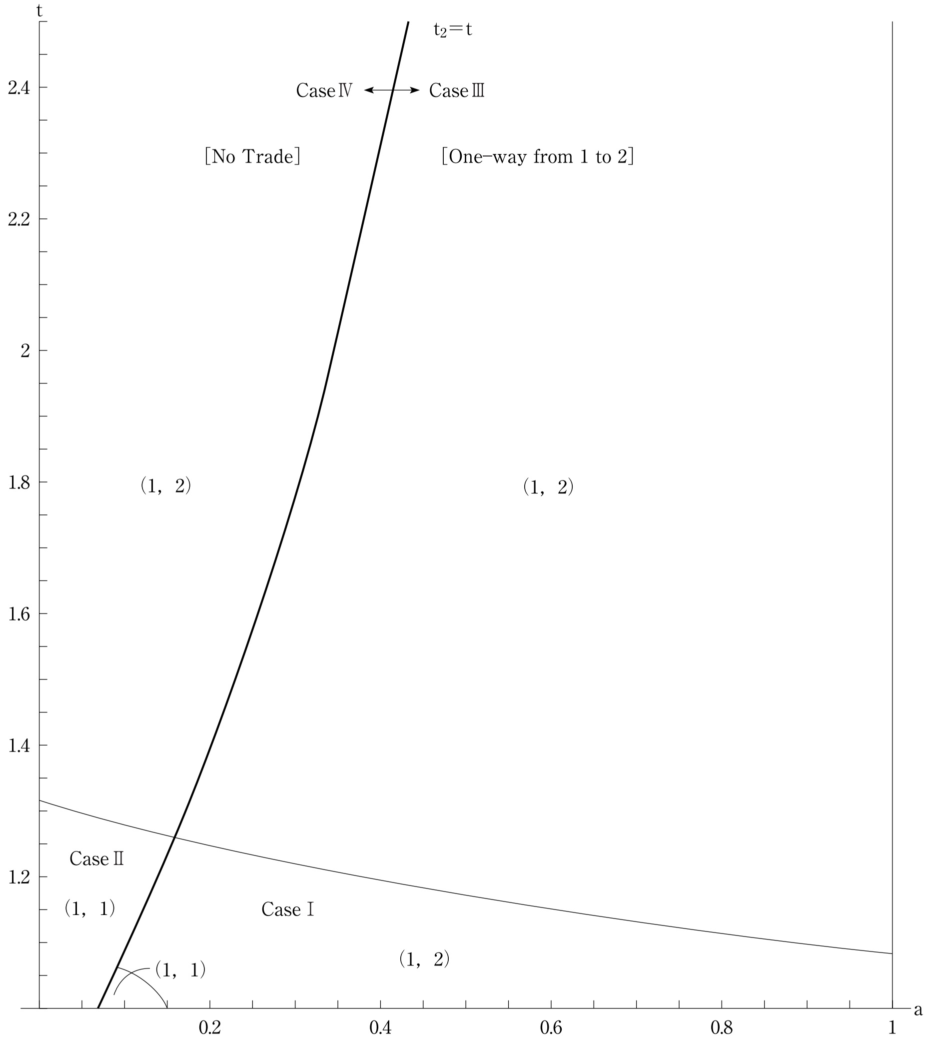
4.3 Effects of the degree of competition

Finally, we focus on the effect of the degree of competition (*i. e.*, the number of firms). Suppose that $n_i=2$ and $n_2=1$. Figure 3 shows the equilibrium regimes in this situation.

One novelty is that the $t_1=t$ line appears in the figure. Then, there are four possible trade patterns; not only Case I (two-way) and Case II (one-way from country 2 to 1) but also Case III (one-way from country 1 to 2) and Case IV (no-trade). For almost all cases with the exception of a situation where the market is extremely small and trade costs are low, the equilibrium regime is $(1, 2)$. The direction of one-way trade may or may not be opposite to that of the benchmark case.

If the number of firm 1s increases further (*i. e.*, $n_1\geqslant 3$; $n_1\in \mathrm{N}$), the $t_1=t$ line shifts to the left

Figure 3: Trade Patterns ($n_1=2$, $n_2=1$, $\beta=0.7$)



and disappears again, and the $t_2=t$ line shifts up. As a result, the possible trade pattern is Case-III: one-way trade from country 1 to country 2. Thus, an increase in the degree of competition promotes exports from the developed country to the developing country.

5 Concluding Remarks

We have investigated trade patterns in an industry with vertical production In particular, we consider trade patterns between developing and developed countries and focus on the effects of trade costs and economic catching-up of the developing country.

We show that the price of intermediate good depends not only on market conditions in the intermediate good industry but also on the market conditions in the final good industry. This result illustrates the backward linkages between the intermediate and final good industries.

We conduct a numerical analysis to analyze endogenous trade patterns and obtain the following results. First, given a Cournot duopoly in the final good market, an expansion in the market of the developing country is necessary for trade to be two-way. With a small market in the developing country, the incentive for firms in a developed country to export their products is reduced, and a possible trade pattern is one-way trade from the developing country to the developed country. Second, when trade costs are sufficiently small, each firm is likely to have a plant in its home country and exports. When trade costs are high, it is advantageous for firms in the developing country to possess a foreign plant, and as market size in the developing country grows, firms are likely to conduct foreign direct investment. Third, an increase in the wage differential raises incentive for firms in the developed country to have a foreign plant in order to exploit lower wages. Finally, an increase in the number of firms may change the possible trade patterns drastically.

Compared to other literature on trade patterns, we consider a more general situation. We include asymmetries of market size and wage level into our model, and, in addition, we focus on the situation where the numbers of firms are different between countries. Also, our results can explain and predict recent movements in the world economy.

There are several possible extensions to our model. One is providing a more detailed setup for the intermediate good sector. In our analysis, we consider a fix and small trade cost for the intermediate good industry (for numerical simulation, the value of τ is equal to one), and assume that the intermediate good producers do not incur fixed costs. If we allow τ to change, or include fixed costs in the intermediate good sectors, we will obtain trade patterns for the intermediate good sector in addition to those of the final good sector. Another possibility is including a technology differential. For simplicity, we assume production technologies are common (in the sense of marginal costs) across industries. In reality, however, a technology differential exists between developing and developed countries (Ramstetter, 2001; Ito, 2002), furthermore, technology transfers are often observed (Ramachandran, 1993). The results of our analysis may change if these issues are incorporated.

Appendix: Intermediate Good Price and Outputs

(1) Region (1, 1) for $t_i > t_i > t$;

Since the demand for intermediate good in country i is the sum of the domestic demand, equation (5) is rewritten as

$$M_i = n_i (X_{ii} + tX_{ij}). \tag{A1}$$

Substituting equations (9) and (10) into (A1), we have

$$n_i (n_j + 1)(1 + t^2) q_i - 2n_i n_j t q_j = n_i (A_i + tA_j) - (n_i + n_j + 1) M_i. \tag{A2}$$

By solving equations (A2) with respect to q_i and q_j, we have inverse demand functions for

M_i and M_j as equation (13) in the text

$$q_i = a_i - b_{ii}M_i - b_{ij}M_j$$

where

$$a_i = \frac{n_j}{\Delta}[(n_i(n_i+1)(1+t^2)+2n_in_jt^2)A_i + (n_i(n_i+1)(1+t^2)-2n_in_j)tA_j)],$$

$$b_{ii} = \frac{n_j}{\Delta}(n_i+1)(n_i+n_j+1)(1+t^2),$$

$$b_{ii} = \frac{2n_in_jt}{\Delta}(n_i+n_j+1) = b_{ji},\ \ and$$

$$\Delta = n_in_j((n_i+1)(n_j+1)(1+t^2)^2 - 4n_in_jt^2).$$

Since there are m_i intermediate good firms in country i, supply in the intermediate good market i is

$$M_i = m_iy_{ii} + m_jy_{ji}. \tag{A3}$$

Let us consider the profit-maximizing behavior of intermediate good firms. The profit of an intermediate good firm in country i is given by

$$\pi_i = (q_i - w_i)y + (q_j - \tau w_i)y_{ij}$$

The first order conditions for profit maximization are derived as follows.

$$\frac{\partial \pi_i}{\partial y_{ii}} = q_i - w_i - b_{ii}y_{ii} - b_{ji}y_{ij} = 0 \tag{A4}$$

$$\frac{\partial \pi_j}{\partial y_{ji}} = q_i - \tau w_j - b_{ii}y_{ji} - b_{ji}y_{jj} = 0. \tag{A5}$$

Summing equations (A4) and (A5) over intermediate good firm and adding them together, we have the following.

$$(m_i+m_j)q_i - (m_iw_i + m_j\tau w_j) - b_{ii}M_i - b_{ij}M_j = 0. \tag{A6}$$

Note that in the above we use equation (A3) and $b_{ij} = b_{ji}$. From equation (13) and (A6), we obtain the price of the intermediate good (equation (14))

$$q_i = \frac{a_i + m_iw_i + m_j\tau w_j}{m_i + m_j + 1}.$$

Proposition 1 is thus proved. From equations (A4) and (A5), we have

$$\begin{pmatrix} b_{ii} & b_{ji} \\ b_{ij} & b_{jj} \end{pmatrix}\begin{pmatrix} y_{ii} \\ y_{ij} \end{pmatrix} = \begin{pmatrix} q_i - w_i \\ q_j - \tau w_i \end{pmatrix}. \tag{A7}$$

Solving (A7), we obtain the equilibrium outputs:

$$y_{ii} = \frac{\Omega_1}{\Omega}\ \ and\ \ y_{ij} = \frac{\Omega_2}{\Omega}$$

where $\Omega = b_{ii}b_{jj} - b_{ij}b_{ij}$, $\Omega_1 = b_{jj}q_i - b_{ji}q_j - (b_{jj} - \tau b_{ji})w_i$, and $\Omega_2 = b_{ii}q_i - b_{ij}q_j - (\tau b_{ii} - b_{ij})w_i$. (Derivations for the other regions are available upon request.)

Notes

1) In this paper, the price of intermediate good is determined in the intermediate good market. We may, alternatively, introduce bargaining schemes where demanders (final good sector) and suppliers (intermediate good sector) bargain over profit shares (*e. g.* Grossman and Helpman, 2002).

2) This setting is observed in the literature in vertical production (*e. g.*, Ishikawa and Lee, 1997).

3) We follow the definition of *multinational* provided by Markusen (2002).

4) Our results do not change qualitatively even if the slope of the function is not one.

5) In other words, we assume $\frac{1}{\tau} < \frac{q_i}{q_j} < \tau$. This assumption is familiar in the literature dealing with vertical production (e. g. Venables, 1995).

6) In the real world, tariffs on the intermediate goods seems to be lower than those on final goods. For instance, duties on imported parts are nearly zero among member countries of the WTO. In this simulation, we assume that each final good producer acquires intermediate good locally even under $\tau = 1$, in order for our analysis to be consistent with that in the previous section.

7) If we allow mixed strategy Nash equilibrium, we can eliminate the no-Nash-equilibrium region.

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