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TRADE, PROTECTION, AND OPTIMAL TRADE POLICY IN A VERTICALLY RELATED MARKET*

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When the domestic production of a final product requires an intermediate good imported from a vertically integrated foreign firm, the foreign firm will not export the intermediate good but monopolize the domestic final product market unless the domestic country has a cost advantage in the primary input sector. Although the domestic country can always induce the foreign firm to export the intermediate good through either a tariff on imports of the final product or a subsidy on imports of the intermediate good, it is optimal to use a tariff on the final product, not a subsidy on the intermediate good. Whether or not the final product should be produced at home depends both on a degree of cost advantage in the primary input sector and on the foreign trade policy.

I. INTRODUCTION

In these days, one of the most prevalent reasons for the need to import by less-developed countries would be that they cannot produce a certain good domestically simply due to a lack of technology. A difference in the level of technology is frequently observed even among developed countries when one country successfully develops a new technology preceding the others. What cannot be overlooked at this point is that a gap in technology between countries frequently exists in an intermediate good sector rather than in a final product sector. Some countries are incapable of producing a good from scratch just because of a lack of technology in manufacturing the key inputs. It is also true that innovation is no less likely to happen in an intermediate good sector than in a final product sector. Therefore, it is often in the intermediate good market, not in the final product market, that a technological leader has a transitory advantage over the others. It is not hard to find such an example as semiconductors and computers. As a result, it is difficult to characterize international

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trade arising from a difference in technology without a closer look into the intermediate good market.

Consider an industry where a country is falling behind a foreign country in technology in a key intermediate good sector so that it cannot produce the intermediate good at home. To produce a final product at home, then, the country has to adopt the technology from the foreign country. There are various forms of foreign technology adoptions in practice such as joint venture or the technology transfer contract on the royalty basis. In this paper, however, we will study the case where the domestic country imports the technology-embodying intermediate good from the foreign country, which is also known as a technology transfer contract with tied purchase of inputs in some literature.

In many cases, a supplier of the intermediate good is vertically integrated so that it also produces the final product. If a vertically integrated foreign firm exports the intermediate good as well as the final product, it could make profits from both markets, but it will face competition by a potential entrant in the final product market at home. Since the price of the intermediate good influences the competitiveness of the potential entrant in the domestic final product market, however, the foreign firm charges for the input with a full consideration of the effect of its price on the profit from the export of the final product. In particular, it is possible for the foreign firm to charge such a high price for the input that the domestic firm cannot enter the downstream industry without a loss. If there is such a vertical market foreclosure at home, the foreign firm would enjoy a monopoly position in the domestic final product market at the cost of a potential profit from the intermediate good market. In order to identify the trade pattern of the intermediate good and the final product in this industry, therefore, it is necessary to understand the foreign firm's strategy for exports of the intermediate good in detail.

From the importing country's point of view, the strategic decision on the price of the intermediate good by the foreign firm provides an incentive for the government in the importing country to protect its final product industry through trade policies. In particular, it is in the interest of the domestic government to see what kinds of trade policies can help its domestic producer in the face of the possibility of vertical market foreclosure by the foreign firm. It is also important for the policy makers to recognize the welfare implication of such policies so that they can make the optimal decision as to whether or not the final product should be produced at home.

The purpose of this paper is to study the problems discussed in the preceding paragraphs. Spencer and Jones (1989), and Rodrik and Yoon (1989) study the same issue by considering the case where one unit of the final product is produced from one unit of the intermediate good. Both papers assume that the domestic firm also can produce an input that is perfectly substitutable for the foreign intermediate good, and that the domestic production cost of the input is

at least as high as that of the foreign firm. The two papers differ only in their assumptions about the production cost in the intermediate good sector at home. Spencer and Jones (1989) assume that the domestic marginal cost is strictly increasing, while Rodrik and Yoon (1989) assume that the domestic production requires a sunk cost with a constant marginal cost. The main differences in the models between this paper and two papers above are:

1) We assume that there is no domestic input that is perfectly substitutable for the foreign intermediate good. Instead, the production of the final product needs two inputs, the foreign intermediate good and a locally supplied primary input that are used in variable proportions.

2) In addition to the discussion about the effect of an arbitrary trade policy on trade of the intermediate good and on the domestic welfare, which are the main subjects in their papers, we include the analysis related to the optimal trade policy and determine how much of the final product should be imported and how much should be domestically produced at optimum.

3) We also discuss trade of the intermediate good and the domestic trade policy in the presence of foreign trade policy, which is not discussed in their papers.

Jones and Spencer (1989a) use the same model as that in Spencer and Jones (1989) to discuss the exporting country's trade policy. Theories of vertical integration can be found in many sources including Greenhut and Ohta (1976, 1979), Waterson (1982), and Abiru (1988). More recently, Quirmbach (1986) and Salinger (1988) investigate the possibilities of partial forward integration where vertically integrated and unintegrated producers coexist. As for international trade of intermediate goods, Dixit and Grossman (1982), Sanyal and Jones (1982), and Jones and Spencer (1989b) construct purely competitive models while Krishna and Itoh (1988) consider an imperfectly competitive model. Among the literature concerning trade policy under imperfect competition, Brander and Spencer (1984, 1985), Dixit (1988), and Eaton and Grossman (1986) are specially relevant to this paper.

The structure of the model is described in Section II. The market equilibrium, the role of trade policy, and the optimal trade policy by the domestic country are characterized with and without foreign trade policy in Section III and Section IV, respectively. Section V contains concluding remarks.

II. MODEL

A foreign firm, which has monopoly power in an upstream industry in the world, exports an intermediate good to a domestic country. The foreign monopolist is vertically integrated so that it can export a final product as well. A domestic firm, which cannot produce the intermediate good because of the lack of the technology, can produce the homogeneous final product only by using

the intermediate good imported from the foreign monopolist. It is assumed that there is only one potential entrant at home.

To maximize its total profit from both markets, the foreign monopolist has to make a decision as to how much of each good, the intermediate good and the final product, should be exported. As a sole supplier of the key input, however, the foreign firm can choose the price of the intermediate good strategically by taking full account of its effect on the final product market.

If the domestic firm successfully enters the final product market, it can share a common technology in producing the final product with the foreign monopolist. The production of the final product y needs two inputs, the technology-embodying intermediate good x_1 and the second input x_2 that is available at home, and it will be expressed as $y=f(x_1, x_2)$. The production function $y=f(x_1, x_2)$ is assumed to be linearly homogeneous. Then, the unit cost function is independent of the output level, and it can be expressed as $c(w_1, w_2)$, where w_1 and w_2 are the prices of input 1 and input 2, respectively. Since both firms share the common technology in the final product sector, the unit cost function $c(w_1, w_2)$ is also common to both firms. The unit cost function $c(w_1, w_2)$ is assumed to be twice continuously differentiable. There is no fixed cost involving production of the final product.

The intermediate good x_1 is produced at a constant marginal cost k_1^* by the foreign monopolist, where superscript "*" denotes the foreign firm. Inputs x_2 and x_2^*, which will be called the "local input" hereinafter, are supplied locally at a constant price of k_2 and k_2^*, respectively. The domestic price of the local input is allowed to be different from that in the foreign country. However, the case where the price of the local input is identical in both countries is of special interest, since it enables us to observe the trade pattern caused only by a technological gap between countries.

Turning to trade policy, the domestic government intervenes in each market through a specific tariff t (a subsidy if it is negative) on imports of the final product and a specific subsidy s (a tariff if it is negative) on imports of the intermediate good. For the foreign country, we will consider two cases, with and without foreign trade policy, separately.

It is well known that an equilibrium in an imperfectly competitive market crucially depends on the assumptions about the type of competition in the market. Following Spencer and Jones (1989), and Rodrik and Yoon (1989), we assume that the equilibrium in the final product market is determined by the Cournot competition between two firms. But, as discussed in Section IV in this paper, the presence of foreign trade policy would change the nature of competition, say, from the Cournot model to the Stackelberg leader-follower model, although both firms play the Cournot game in the final product market. Section

III is concerned with the Cournot equilibrium while Section IV is concerned with the Stackelberg equilibrium.

III. DOMESTIC TRADE POLICY IN THE ABSENCE OF FOREIGN TRADE POLICY

Suppose the foreign country is not active in trade policy and that sales of the final product by the foreign firm and the domestic firm are determined by the Cournot competition. As discussed in Spencer and Jones (1989), we can consider three stages of decision to find the subgame perfect equilibrium in the model. At the first stage, the domestic government commits itself to its policies, a specific tariff (or subsidy) on imports of the final product and a specific subsidy (or tariff) on imports of the intermediate good. At the second stage, the foreign monopolist commits itself to the import price of the intermediate good. At the last stage, each firm makes a decision as to the quantity of the final product exported or produced.

3.1. Trade Policy against Vertical Market Foreclosure

Let $p=p(Y)$ be the inverse demand function for the final product, where p is the price of the final product, and $Y=y+y^*$ is the aggregate amount of the final product. It is assumed that the demand function has a negative slope, $p'(Y)<0$, and that it is twice continuously differentiable. Also, let $m_i(w_1, w_2)$ be the cost-minimizing unit input coefficient for input i when the prices of input 1 and 2 are w_1 and w_2, respectively, and q be the import price of the intermediate good. Then, the unit cost functions for each firm can be expressed as:

$$c(q-s, k_2)=(q-s)m_1(q-s, k_2)+k_2m_2(q-s, k_2) \text{ and}$$

$$c(k_1^*, k_2^*)=k_1^*m_1(k_1^*, k_2^*)+k_2^*m_2(k_1^*, k_2^*).$$

First, consider the equilibrium in the final product market. The domestic firm maximizes its profit by choosing y, given y^*, s and q:

$$\pi=\max_y[p(Y)-c(q-s, k_2)]y.$$

The first order condition for the problem is written as:

$$\frac{d\pi}{dy}=p(Y)+yp'(Y)-c(q-s, k_2)\leq 0. \qquad (1)$$
$$=0 \quad \text{if } y>0.$$

The foreign firm's total profit is the sum of the profit from exports of the final product and the profit from exports of the intermediate good. At this stage of decisions, the foreign firm maximizes its profit from exports of the final product by choosing y^*, taking y, t, s, and q as given:

$$\pi^* = \max_{y^*}[p(Y) - c(k_1^*, k_2^*) - t]y^* + (q - k_1^*)x_1(q - s, k_2, y),$$

where $x_1(q-s, k_2, y) = m_1(q-s, k_2)y$ is the domestic firm's derived demand for the intermediate good. The first order condition is:

$$\frac{d\pi^*}{dy^*} = p(Y) + y^*p'(Y) - c(k_1^*, k_2^*) - t \leq 0, \quad (2)$$
$$= 0 \qquad \text{if } y^* > 0.$$

To perform the comparative statics analysis, assume $y > 0$ and $y^* > 0$ for the moment. Total differentiation of (1) and (2) yields:

$$[2p'(Y) + yp''(Y)]dy + [p'(Y) + yp''(Y)]dy^* = m_1(q-s, k_2)(dq - ds), \quad (3)$$

$$[p'(Y) + y^*p''(Y)]dy + [2p'(Y) + y^*p''(Y)]dy^* = dt. \quad (4)$$

We make the assumption that each firm's marginal revenue decreases with an increase in the output of the other firm:

$$p'(Y) + yp''(Y) < 0, \text{ and } p'(Y) + y^*p''(Y) < 0$$

so that each firm's reaction function has a negative slope in the output space. Under the conditions above, the second order conditions for each firm's profit maximization problem are satisfied and the equation system given by (3) and (4) is stable. Now, it is convenient to define:

$$d_{11} = 2p'(Y) + yp''(Y), \; d_{12} = p'(Y) + yp''(Y)$$
$$d_{21} = p'(Y) + y^*p''(Y), \; d_{22} = 2p'(Y) + y^*p''(Y), \text{ and}$$
$$D = d_{11}d_{22} - d_{12}d_{21}.$$

Since $d_{ij} < 0$ for all $i, j = 1, 2$, and $D > 0$ by the assumption above, it is obvious to confirm that:

$$\partial y/\partial q = (1/D)d_{22}m_1(q-s, k_2) < 0, \; \partial y/\partial s = -(1/D)d_{22}m_1(q-s, k_2) > 0,$$

$$\partial y/\partial t = -(1/D)d_{12} > 0,\ \partial y^*/\partial q = -(1/D)d_{21}m_1(q-s, k_2) > 0, \quad (5)$$
$$\partial y^*/\partial s = (1/D)d_{21}m_1(q-s, k_2) < 0, \text{ and } \partial y^*/\partial t = (1/D)d_{11} < 0.$$

Either a tariff on imports of the final product or a subsidy on imports of the intermediate good increases domestic production and reduces imports of the final product.

Next, consider the intermediate good market in which the foreign firm chooses the price charged for the intermediate good exported. The foreign firm chooses q, given t and s:

$$\pi^* = \max_q [p(Y) - c(k_1^*, k_2^*) - t]y^* + (q - k_1^*)x_1(q-s, k_2, y),$$

where $y = y(q, t, s)$ and $y^* = y^*(q, t, s)$ satisfy (1) and (2). The first order condition is:

$$\frac{d\pi^*}{dq} = y^* p'(Y)\left[\frac{dy^*}{dq} + \frac{dy}{dq}\right] + [p(Y) - c(k_1^*, k_2^*) - t]\frac{dy^*}{dq} \quad (6)$$
$$+ x_1(q-s, k_2, y) + (q - k_1^*)\left[\frac{dx_1(q-s, k_2, y)}{dq}\right] = 0,$$

since the foreign firm will never choose a zero price for the intermediate good. Since the case where $y^* = 0$ is of no interest, assume $y^* > 0$, that is, a positive amount of the final product is imported at equilibrium. Then, using (2) with an equality, (6) can be rewritten as:

$$\frac{d\pi^*}{dq} = [-p(Y) + c(k_1^*, k_2^*) + t]\frac{dy}{dq} + m_1(q-s, k_2)y \quad (6')$$
$$+ (q - k_1^*)\left[m_1(q-s, k_2)\frac{dy}{dq} + y\frac{\partial m_1(q-s, k_2)}{\partial q}\right] = 0,$$

where all derivatives are taken from the left-hand and dy/dq is given by (5). Given s and t, (6′) can be used to solve for q, and then (1) and (2) determine all the values of y, y^*, and x_1 at equilibrium.

In order to investigate the possibility of vertical market foreclosure, let $\bar{q}$ be the import prohibiting level of price at which the domestic demand for the intermediate good reduces to zero. When the foreign firm charges $\bar{q}$ for the intermediate good, therefore, it becomes a monopolist in the domestic final product market by achieving vertical market foreclosure. Define $d\bar{\pi}^*/dq = d\pi^*/dq|_{q=\bar{q}}$. Then, since $y = 0$ if $q = \bar{q}$, (6′) implies:

$$\frac{d\bar{\pi}^*}{dq}=[-\{p(y^*)-c(k_1^*, k_2^*)-t\}+(\bar{q}-k_1^*)m_1(\bar{q}-s, k_2)]\frac{dy}{dq}, \tag{7}$$

where $dy/dq < 0$ from (5). The expression above shows that $d\bar{\pi}^*/dq<0$, or, the foreign firm would be willing to export the intermediate good, if the foreign firm earns a higher profit margin from the export of the intermediate good (used in producing one unit of the final product) than from the export of one unit of the final product.

PROPOSITION 1

In the absence of domestic trade policy,

1) there will be a vertical market foreclosure at home if the domestic price of the local input is equal to or higher than that in the foreign country,

2) if the intermediate good and the local input are used in fixed proportions, the foreign firm supplies its rival with the intermediate good as long as the price of the local input is lower at home than in the foreign country, and

3) if the two inputs are used in variable proportions, it exports the intermediate good if the price of the local input is sufficiently lower at home than in the foreign.

PROOF

When $q=\bar{q}$, $p(Y)=p(y^*)=c(\bar{q}-s, k_2)$ from (1), and (7) can be written as:

$$\frac{d\bar{\pi}^*}{dq}=[-c(\bar{q}-s, k_2)+c(k_1^*, k_2^*)+t+(\bar{q}-k_1^*)m_1(\bar{q}-s, k_2)]\frac{dy}{dq}. \tag{7'}$$

Let $\overline{m_1}=m_1(\bar{q}-s, k_2)$and $m_i^*=m_i(k_1^*, k_2^*)$, $i=1$ and 2. Then, We can rewrite (7′) as:

$$\frac{d\bar{\pi}^*}{dq}=[s\overline{m_1}+t+(m_1^*-\overline{m_1})k_1^*+(m_2^*-\overline{m_2})k_2^*-(k_2-k_2^*)\overline{m_2}]\frac{dy}{dq}. \tag{7''}$$

1) Suppose $k_2\geq k_2^*$. Since $m_i=m_i(k_1^*, k_2^*)$ is the cost-minimizing input coefficient for input i when the prices of input 1 and 2 are $k_1^*$and k_2^*, respectively:

$$(m_1^*-\overline{m_1})k_1^*+(k_2^*-\overline{m_2})k_2^*\leq 0.$$

Then, since $dy/dq<0$ from (5), (7″) implies $d\bar{\pi}^*/dq\geq 0$ when $s=t=0$.

2) If two inputs are used in fixed proportions, $m_1^* = \overline{m_1}$ and $\overline{m_2} = m_2^*$. Thus, when $s=t=0$, $d\bar{\pi}^*/dq<0$ for all $k_2^*>k_2$.

3) Suppose $k_2<k_2^*$ and that two inputs are used in variable proportions. Then, since $\bar{q} \geq k_1^*$ and $k_2 < k_2^*$, it is the case that $m_1^* > \overline{m_1}$ and $\overline{m_2} > m_2^*$ when $s=t=0$. As a result, $d\bar{\pi}^*/dq<0$ if $(k_2^*-k_2)$ is a large positive number.

Unless the domestic country has a cost advantage in the primary input sector, the foreign firm chooses not to export the intermediate good to its potential rival but to monopolize the final product market at home. If such vertical market foreclosure occurs at equilibrium under free trade, is it possible for the domestic country to protect its final product industry through some trade policies? The following proposition answers the question.

PROPOSITION 2

If there occurs vertical market foreclosure at free-trade equilibrium, the domestic country can induce the foreign firm to export the intermediate good by either a tariff on imports of the final product, a subsidy on imports of the intermediate good, or a combination of the two.

PROOF

First, consider a subsidy on imports of the intermediate good. Since $\bar{q}$ must satisfy the relation $p(y^*) = c(\bar{q}-s,\ k_2)$, $\overline{m_1}(d\bar{p}/ds-1) = p'(y^*)(dy^*/ds)$. But, since y^* is not affected by s when $q=\bar{q}$, $dy^*/ds=0$ and $d\bar{q}/ds=1$, that is, $\bar{q}$ increases by the same amount as s increases. Thus, $\overline{m_1}$ and $\overline{m_2}$ would not change as s changes. It follows from (7″) that there is some $s>0$ such that $d\pi^*/dq<0$ for any $t>0$. Next, to consider a tariff on imports of the final product, note that an increase in t raises $\bar{q}$, resulting in a fall in $\overline{m_1}$ and a rise in $\overline{m_2}$. Then, (7″) implies that there exists some $t>0$ such that $d\bar{\pi}^*/dq<0$ for any $s\geq 0$ unless the substitution effect between two inputs is substantial. If the substitution effect is large, we can always find some $s>0$ such that $d\bar{\pi}^*/dq<0$ for a given $t>0$.

Both a tariff on imports of the final product and a subsidy on imports of the intermediate good are effective measures to promote the domestic final product industry, and the protectionism is well justified in the industry under consideration.

3.2. Optimal Trade Policy by the Importing Country

It was shown that the domestic country could always induce the foreign firm to export the intermediate good by implementing appropriate trade poli-

cies, but this does not necessarily mean that producing the final product at home be optimal. This section studies the condition under which domestic production is optimal and the domestic trade policy that should be implemented at optimum.

The welfare level of the domestic country is measured by the sum of consumer's surplus, the profit of the domestic firm, and the net government revenues, tariff revenues minus subsidy expenditures:

$$w=\int_0^Y p(x)dx-p(Y)Y+[p(Y)-c(q-s, k_2)]y+ty^*-sm_1(q-s, k_2)y,$$

where $q=q(t, s)$, $y=y(t, s, q(t, s))$, and $y^*=y^*(t, s, q(t, s))$ are the equilibrium values determined by (1), (2), and (6′). The domestic government chooses t and s to maximize the level of welfare defined above. For a comprehensible result, we will consider the linear demand, $p(Y)=a-bY$, where $a>0$ and $b>0$, and the Leontief technology, $y=\min(x_1/m_1, x_2/m_2)$, where $m_1=m_1^*$ and $m_2=m_2^*$. Total differentiation of the welfare function above yields:

$$dw=[p(Y)-qm_1-k_2m_2]dy-m_1ydq-y^*[p(Y)-t]+tdy^* \tag{8}$$

With a demand and a production functions given above, (1) and (2) are simplified as:

$$p(Y)+yp'(Y)-[(q-s)m_1+k_2m_2]\leq 0, \quad =0 \text{ if } y>0, \tag{9}$$

$$p(Y)+y^*p'(Y)-t-[k_1^*m_1+k_2^*m_2]\leq 0, \quad =0 \text{ if } y^*>0. \tag{10}$$

Because of the possibility that either domestic production or imports of the final product are eliminated, it is necessary to take a corner solution into consideration. Nevertheless, we will proceed assuming an interior solution for the moment, and obtain corner solutions as extreme cases. Then, $\partial y/\partial q=(2/3p'(Y))m_1$ from (5), and so, (6′) reduces to:

$$qm_1=k_1^*m_1-p'(Y)y^*-(3/2)p'(Y)y. \tag{11}$$

Two methods are known to be used in doing this exercise. We can express equation (8) in terms of dt and ds, and evaluate $\partial w/\partial t=0$ and $\partial w/\partial s=0$ to find the optimal rates of t and s. Alternatively, we can express the equation in dy and dy^* terms to see the effect of y and y^* on the domestic welfare. [See

Dixit(1988) for more details.] In this chapter, we will use the second method, which is more useful in dealing with a corner solution.

Since $d(p(Y)-t)=-p'(Y)dy^*$ from (10) and $m_1dq=-p'(Y)dy^*-(3/2)p'(Y)dy$ from (11), we can now rewrite (8), using (10) and (11), as:

$$dw=[p(Y)+p'(Y)y^*+3p'(Y)y-k_1^*m_1-k_2m_2]dy$$
$$+[p(Y)+p'(Y)y+2p'(Y)y^*-k_1^*m_1-k_2^*m_2]dy^*.$$

For the following analysis, it is useful to note that the welfare function w defined here has a unique global maximum since it is strictly concave for all y and y^*.

Now, we will characterize the equilibrium that would exist in the presence of the optimal trade policy by the domestic country.

A. Suppose that:

$$p(Y)+p'(Y)y^*+3p'(Y)y-k_1^*m_1-k_2m_2\leq 0 \text{ for all } y>0. \tag{12}$$

Then, it is optimal to set $\tilde{y}=0$ and $\tilde{y}^*=\tilde{Y}$, where "$\sim$" denotes the equilibrium values at optimum. It follows that at optimum:

$$\frac{\partial w}{\partial y^*}=p(\tilde{y}^*)+2p'(\tilde{y}^*)\tilde{y}^*-k_1^*m_1-k_2^*m_2=0, \tag{13}$$

and $\tilde{y}^*=(1/3b)(a-k_1^*m_1-k_2^*m_2)$. Then, we can rewrite (12), the condition under which none of the final product is produced by the domestic firm at optimum, as:

$$(k_2-k_2^*)m_2\geq(1/3)(a-k_1^*m_1-k_2^*m_2) \tag{12'}$$

Note that this happens only if $k_2^*<k_2$, because the right-hand side of (12') is positive. Therefore, it is optimal for the domestic country not to produce the final product at home but to import all the final product consumed at home, if the foreign firm has an enough cost advantage (as given by (12')) in the local input sector.

In this case, the optimum rate of tariff (or subsidy) on imports of the final product can be found from (10), which holds now with an equality, using (13):

$\tilde{t}=-p'(\tilde{y}^*)\tilde{y}^*>0.$

It is optimal to levy a tariff on imports of the final product. To find a subsidy (or a tariff) on imports of the intermediate good that yields such an outcome, (11) (with $y=0$) implies that $\tilde{q}m_1 = -p'(\tilde{y}^*)\tilde{y}^*+k_1^*m_1$. Then, since (9) holds with an inequality in this case, we can get:

$$sm_1\leq[(k_2-k_2^*)m_2-(1/3)(a-k_1^*m_1-k_2^*m_2)].$$

Since the right-hand side of the expression above is not negative by (12′), any small tariff on imports of the intermediate good can persuade the domestic firm not to produce the final product in this case.

B. At the other extreme, if:

$$p(Y)+p'(Y)y+2p'(Y)y^*-k_1^*m_1-k_2^*m_2 \leq 0 \text{ for all } y^*> 0, \qquad (14)$$

then it is optimal to set $\tilde{y}^*=0$ and $\tilde{y}=\tilde{Y}$. It follows that at optimum:

$$\frac{\partial w}{\partial y}=p(\tilde{y})+3p'(\tilde{y})\tilde{y}-k_1^*m_1-k_2m_2=0, \qquad (15)$$

and $\tilde{y}=1/4b(a-k_1^*m_1-k_2m_2)$. Then the condition (14) can be rewritten as:

$$a-k_1^*m_1-k_2^*m_2\leq(k_2^*-k_2)m_2. \qquad (14')$$

Since the left-hand side of (14′) is positive, this condition cannot be true if $k_2^*\leq k_2$. Thus, if the price of the local input is lower at home than in the foreign country by some degree (as given by (14′)), it is optimal to meet all the domestic demand for the final product only from its own production.

As for trade policies, we can find the optimal rate of subsidy (or tariff) on imports of the intermediate good explicitly in this case. From (11), $\tilde{q}m_1=-(3/2)p'(\tilde{y})\tilde{y}+k_1^*m_1$. Then, from (9) which holds now with an equality, we can get:

$$\tilde{s}m_1=(7/2)b\tilde{y}-(a-k_1^*m_1-k_2m_2)<0,$$

where the negativity follows from (15). A tariff on imports of the intermediate

good is optimal. To reach this equilibrium, the domestic country should intervene in the market through a tariff on imports of the final product, since:

$$t \geq (3/4)(a - k_1^* m_1 - k_2^* m_2) - (1/4)(k_2^* - k_2)m_2$$

from (10). t is negative if $3(a - k_1^* m_1 - k_2^* m_2) < (k_2^* - k_2)m_2$ but this is immaterial since $y^* = 0$ even under free trade in this case.

C. Now, consider an interior solution in which domestic production and imports of the final product coexist. From (12′) and (14′), we can see that this happens if:

$$-(1/3)(a - k_1^* m_1 - k_2^* m_2) < (k_2^* - k_2)m_2 < a - k_1^* m_1 - k_2^* m_2. \tag{16}$$

When both $\tilde{y}$ are $\tilde{y}^*$ positive, we have:

$$\frac{\partial w}{\partial y} = p(\tilde{Y}) + p'(\tilde{Y})\tilde{y}^* + 3p'(\tilde{Y})\tilde{y} - k_1^* m_1 - k_2 m_2 = 0, \text{ and} \tag{17}$$

$$\frac{\partial w}{\partial y^*} = p(\tilde{Y}) + p'(\tilde{Y})\tilde{y} + 2p'(\tilde{Y})\tilde{y}^* - k_1^* m_1 - k_2^* m_2 = 0 \tag{18}$$

From (17) and (18), we can show:

$$\tilde{y}^* = 2\tilde{y} - (1/b)(k_2^* - k_2)m_2, \tag{19}$$

where $\tilde{y}$ and $\tilde{y}^*$ can be found by solving (19) and either (17) or (18). In particular, if $k_2 = k_2^*$, $\tilde{y}^* = 2\tilde{y}$ at optimum, and the domestic firm should produce half of what the foreign firm exports.

Turning to the policy issue, the optimal level of subsidy (or tariff) on imports of the intermediate good can be found from (9) which holds with an equality in this case. Using (11) and (17), then, we can show:

$$\tilde{s}m_1 = (1/2)p'(\tilde{Y})\tilde{y} < 0.$$

A tariff on imports of the intermediate good is optimal. In addition, we can use (10) (with an equality) and (18) to find the optimal tariff for the final product:

$$\tilde{t} = -p'(\tilde{Y})\tilde{Y} > 0.$$

The domestic industry must be promoted only by a tariff on imports of the final product.

The main results in this section are summarized in the following proposition.

PROPOSITION 3

With a linear demand and a Leontief technology for the final product,
1) the domestic production should be promoted (if it is desirable) by a tariff on imports of the final product and not by a subsidy on imports of the intermediate good,
2) it is optimal for the domestic country to produce some or all of the final product consumed at home unless the price of the local input is substantially higher at home than in the foreign country (as given by (14′) and (16)),
3) it is optimal for the domestic country to allow the domestic firm [the foreign firm] to monopolize the final product market if the price of the local input is sufficiently lower [higher] at home than in the foreign country (as given by (14′) [(12′)]), and
4) it is optimal for the domestic country to impose a tariff on imports of the intermediate good, whenever it is imported for domestic production of the final product.

Jones and Spencer (1989) show that a subsidy on imports of the intermediate good improves the domestic welfare if there is no tariff on imports of the final product. But, if we consider two instruments at the same time, a tariff on imports of the intermediate good, not a subsidy, is optimal, and the domestic production should be promoted only by a tariff on imports of the final product. A tariff on imports of the intermediate good contributes to the domestic welfare not only by extracting some foreign firm's profit but by discouraging the domestic producer that employs the intermediate good at a higher cost than the foreign producer does ($q > k_1^*$).

Ⅳ. DOMESTIC TRADE POLICY IN THE PRESENCE OF FOREIGN TRADE POLICY

In the previous section, it is assumed that the foreign country is not active in trade policy. But, what happens if the foreign country is also implementing some trade policies for its exporting industry? As shown in Brander and Spencer (1985), and Jones and Spencer (1989a), the role of trade policy by the exporting country is to change the initial condition of the game that firms play in the market in favor of the exporter. In the context of our model, suppose that the exporting country uses a subsidy and/or a tariff on exports of the final product and the intermediate good as policy instruments. Then, the optimal

policy by the exporting country adjusts the export of both goods to the level that would have occurred (in the absence of the subsidy or the tariff) if the exporting firm could commit to its quantity of the final product exported at the same stage where it commits to the export price of the input. [See Jones and Spencer (1989a) for more details.] Thus, trade policy by the foreign country enables the foreign firm to take a position as a Stackelberg leader even in the final product market.

In this section, we assume that the foreign country is also active in trade policy and that the domestic government chooses s and t before the foreign government commits itself to its policies. This assumption is not hard to believe if we recall that many developing countries, which are technological laggards, often offer long-term trade policies that are generally applicable to any industry which meets some minimum requirements such as import substitution, for instance, while most developed countries often set up their policies strategically responding to the actions taken by their trade partners. Under this framework, then, the effect of the foreign trade policy can be fully taken into account without specifying any foreign policy instrument, if we treat the foreign firm as a Stackelberg leader in the both markets. Accordingly, we assume that the foreign firm commits itself to its quantity of the final product exported as well as to the price of the intermediate good at the same stage. The domestic firm, a follower, chooses its quantity of the final product to be produced at the final stage.

4.1. Trade Policy against Vertical Market Foreclosure

In formalizing the model described above, there is no change in the profit maximization problem faced by the domestic firm from the case in the previous section. As a result, the final product y chosen by the domestic firm satisfies the following first order condition found in the previous section:

$$p(Y)+yp'(Y)-c(q-s, k_2)\leq 0, \ =0 \ \text{if} \ y>0. \tag{1}$$

The foreign firm, on the other hand, is now able to utilize its knowledge of the rival's reaction function in choosing not only the price of the intermediate good but its exports of the final product. Thus, the foreign firm maximizes its profit by choosing y^* and q at the same stage, given s and t:

$$\pi^* = \max_{y^*, q} [p(Y)-c(k_1^*, k_2^*)-t]y^*+(q-k_1^*)m_1(q-s, k_2)y,$$

where $y=y(y^*, q, s, t)$ satisfies (1). The first order conditions are:

$$\frac{\partial \pi^*}{\partial y^*}=p(Y)-c(k_1^*, k_2^*)-t+y^*p'(Y)\left[1+\frac{\partial y}{\partial y^*}\right] \tag{20}$$
$$+[q-k_1^*]m_1(q-s, k_2)\frac{\partial y}{\partial y^*}\leq 0, \ =0 \text{ if } y^*>0.$$

$$\frac{\partial \pi^*}{\partial q}=y^*p'(Y)\frac{\partial y}{\partial q}+m_1(q-s, k_2)y \tag{21}$$
$$+(q-k_1^*)\left[m_1(q-s, k_2)\frac{\partial y}{\partial q}+y\frac{\partial m_1(q-s, k_2)}{\partial q}\right]=0.$$

The first order condition (21) holds with an equality, since the foreign firm would never chooses a zero price for the input. Now, from (1), it can be shown that, for $y>0$:

$$\frac{\partial y}{\partial y^*}=-\frac{p'(Y)+yp''(Y)}{2p'(Y)+yp''(Y)}<0, \text{ and} \tag{22}$$
$$\frac{\partial y}{\partial q}=\frac{m_1(q-s, k_2)}{2p'(Y)+yp''(Y)}<0.$$

Then, y, y^*, and q at equilibrium can be determined by solving (1), (20), and (21).

To answer the question on vertical market foreclosure, we can apply the same argument as that in the previous section. As in the previous section, let the import prohibiting level of the price of the intermediate good be $\bar{q}$, which may differ in magnitude from the one defined in the previous section. Then, (21) with $q=\bar{q}$ implies:

$$\frac{\partial \bar{\pi}^*}{\partial q}=[y^*p'(y^*)+(\bar{q}-k_1^*)m_1(\bar{q}-s, k_2)]\frac{\partial y}{\partial q}. \tag{23}$$

Now, let $\sigma=\partial y/\partial y^*$, which shows the slope of the reaction curve for the domestic firm at a given q. Then, when $q=\bar{q}$, (20) reduces to:

$$p(y^*)-c(k_1^*, k_2^*)-t+y^*p'(y^*)(1+\sigma)+(\bar{q}-k_1^*)\overline{m}_1\sigma=0.$$

But, since $1+\sigma=p'(Y)/(2p'(Y)+yp''(Y))>0$ by (22), the equation above can be arranged as:

$$y^*p(y^*)=\frac{1}{1+\sigma}[-p(y^*)+c(k_1^*, k_2^*)+t-(\bar{q}-k_1^*)\overline{m}_1\sigma]. \tag{24}$$

In addition, substituting $\bar{q}$ for q in (1), we get:

$$p(y^*)=c(\bar{q}-s, k_2). \tag{25}$$

Then, from (24) and (25), (23) can be rewritten as:

$$\frac{\partial \bar{\pi}^*}{\partial q}=\frac{1}{1+\sigma}[-c(\bar{q}-s, k_2)+c(k_1^*, k_2^*)+t+(\bar{q}-k_1^*)\overline{m_1}]\frac{\partial y}{\partial q}.$$

As noted earlier, $\bar{q}$ (and so, $\overline{m_1}$ and $\overline{m_2}$) defined in this section may be different in magnitude from those defined in the previous section where there is no foreign trade policy. Making the comparison between the expression above and (7′) in the previous section, however, we can see that both expressions are qualitatively identical except the term $1/(1+\sigma)$ that is positive. In particular, all the parts 1), 2), and 3) in Proposition 1 remain in effect, provided that the magnitude of cost advantage required for vertical supply in part 3) is adjusted accordingly. As for trade policy, all the policy tools to induce vertical supply described in Proposition 2 are also effective in this case, although the rate of the tariff and/or the subsidy need to be adjusted.

PROPOSITION 4

Whether or not the exporting country carries out the optimal trade policy makes no difference both in determining the pattern of trade (as shown in Proposition 1) and in implementing the domestic trade policy against vertical market foreclosure (as shown in Proposition 2).

4.2 Optimal Trade Policy by the Importing Country

Turning to the issue on the optimal trade policy by the domestic country, we assume that the demand function and the production technology for the final product is linear and of Leontief, respectively, as in the previous section. Then, since $\partial q/\partial y^*=-(1/2)$, and $\partial y/\partial q=(1/2p'(Y))m_1$ by (22), the equations (1), (20), and (21) can be written as:

$$p(Y)+yp'(Y)-(q-s)m_1-k_2m_2\leq 0, \ = 0 \text{ if } y>0. \tag{26}$$

$$p(Y)+(1/2)y^*p'(Y)-k_1^*m_1-k_2^*m_2-t \tag{27}$$
$$-(1/2)[q-k_1^*]m_1\leq 0, \ = 0 \text{ if } y^* > 0.$$

$$y^*p'(Y)+2p'(Y)y+(q-k_1^*)m_1=0. \tag{28}$$

As before, we proceed assuming an interior solution for the moment. Then, from (28):

$$m_1 dq = -p'(Y)dy^* - 2p'(Y)dy.$$

Also, from (27) using the equation above:

$$\begin{aligned} d(p(Y)-t) &= -(1/2)p'(Y)dy^* + (1/2)m_1 dq \\ &= -p'(Y)dy - p'(Y)dy^*. \end{aligned}$$

Then, using (27) and (28) together with two equations above, (8) in the previous section can be rewritten as:

$$\begin{aligned} dw = &[p(Y)+2p'(Y)y^*+4p'(Y)y-k_1^*m_1-k_2m_2]dy \\ &+[p(Y)+2p'(Y)y+2p'(Y)y^*-k_1^*m_1-k_2^*m_2]dy^*. \end{aligned}$$

The welfare function w in this case is also strictly concave in all y and y^* so that there exists a unique global maximum in the maximization problem.

As in the previous section, there are three possibilities for the optimal solution in the model.

A. First, consider the case in which $\tilde{y}=0$ and $\tilde{y}^*=\tilde{Y}$ at optimum. This case arises if:

$$p(Y)+2p'(Y)y^*+4p'(Y)y-k_1^*m_1-k_2m_2 \leq 0 \text{ for all } y > 0. \qquad (29)$$

Then, since w is strictly concave for all y, we have at optimum:

$$\frac{\partial w}{\partial y^*}=p(\tilde{y}^*)+2p'(\tilde{y}^*)\tilde{y}^*-k_1^*m_1-k_2^*m_2=0, \qquad (30)$$

and $\tilde{y}^*=(1/3b)(a-k_1^*m_1-k_2^*m_2)$. Hence, the condition (29) above becomes:

$$(k_2^*-k_2)m_2 \leq 0, \text{ or } k_2^* \leq k_2. \qquad (29')$$

If the domestic price of the local input is equal to or greater than that in the foreign country, it is optimal not to produce the final product at home and to import all the final product from the foreign firm. This is a quite different

result from that found in the previous section. Without foreign trade policy, it is optimal to produce some of the final product at home even if the price of the local input is somewhat higher at home than in the foreign country as shown in (12′). But, if the exporting country helps the foreign firm to be a Stackelberg leader in both markets through an appropriate trade policy, it is not optimal to produce the final product at home even if the price of the local input is identical in the two countries.

Now, from (28) with $\tilde{y}=0$:

$$\tilde{q}m_1=k_1^*m_1-p'(\tilde{y}^*)\tilde{y}^*. \tag{31}$$

Then, the optimal level of tariff on imports of the final product can be found from (27) using (30) and (31):

$$\tilde{t}=-p'(\tilde{y}^*)\tilde{y}^*>0.$$

To find the level of subsidy (or tariff) on imports of the intermediate good for persuading the domestic firm not to produce the final product, (26) which now holds with an inequality can be arranged as:

$$sm_1\leq p'(\tilde{y}^*)\tilde{y}^*-(k_2^*-k_2)m_2$$

by using (30) and (31). A tariff on imports of the intermediate good is required to prevent the domestic firm from entering the final product market, unless the domestic price of the local input is substantially higher than that of the foreign country.

B. To consider the other extreme, suppose that:

$$p(Y)+2p'(Y)y+2p'(Y)y^*-k_1^*m_1-k_2^*m_2\leq 0 \text{ for all } y^*>0. \tag{32}$$

Then, it pays to set $\tilde{y}=\tilde{Y}$ and $\tilde{y}^*=0$ at which w attains its global maximum. It follows that at optimum:

$$\frac{\partial w}{\partial y}=p\,\tilde{y}\,+4p'(\tilde{y})\tilde{y}-k_1^*m_1-k_2m_2=0, \tag{33}$$

and $\tilde{y}=(1/5b)(a-k_1^*m_1-k_2m_2)$. As a result, the condition (32) can be rewritten as:

$$(2/3)(a-k_1^*m_1-k_2^*m_2)\leq(k_2^*-k_2)m_2. \tag{32'}$$

Since the left-hand side of (32′) is positive, the condition requires $k_1^*>k_2$. The domestic country must have enough cost advantages over the foreign country in the local input sector to achieve this outcome.

Turning to the issue of trade policy at home, from (28):

$$\tilde{q}m_1=k_1^*m_1-2p'(\tilde{y})\tilde{y}. \tag{34}$$

Then, since (26) holds with an equality in this equilibrium, using (33) and (34), we get:

$$\tilde{s}m_1=p'(\tilde{y})\tilde{y}<0.$$

A tariff on imports of the intermediate good is optimal. To find a rate of tariff (or subsidy) for the final product to have this outcome at equilibrium, we can use (27), (33), and (34) to show:

$$t\geq-3p'(\tilde{y})\tilde{y}-(k_2^*-k_2)m_2.$$

The domestic country must impose a tariff on imports of the final product to dissuade the foreign firm from exporting it, unless the domestic country has a substantial cost advantage in the local input sector.

C. Now, consider the case with an interior solution in which both $\tilde{y}$ and $\tilde{y}^*$are positive at optimum. From (29′) and (32′), we know that this case arises if:

$$0<(k_2^*-k_2)m_2<(2/3)(a-k_1^*m_1-k_2^*m_2). \tag{35}$$

Comparing the condition (35) above with (16) in the previous section, we can see that the range in which domestic production and imports coexist at optimum is much smaller with foreign trade policy than without it. In the presence of foreign trade policy, it is optimal that the domestic country allow the foreign firm to monopolize the domestic final product market even if the price of the local input is identical in two countries. However, the cost advantage required for the domestic firm to monopolize the final product market is also relatively small at optimum in the presence of foreign trade policy.

Now, let us characterize an equilibrium in this case. With an interior solu-

tion, we have:

$$\frac{\partial w}{\partial y}=p(Y)+2p'(Y)y^*+4p'(Y)y-k_1^*m_1-k_2m_2=0, \text{ and} \tag{36}$$

$$\frac{\partial w}{\partial y^*}=p(Y)+2p'(Y)y+2p'(Y)y^*-k_1^*m_1-k_2^*m_2=0. \tag{37}$$

Solving for (36) and (37) for y and y^*, we get:

$$\tilde{y}=(1/2b)(k_2^*-k_2)m_2, \text{ and}$$

$$\tilde{y}^*=(1/3b)(a-k_1^*m_1-k_2^*m_2)-(1/2b)(k_2^*-k_2)m_2.$$

The output produced by the domestic firm depends only on the differential of the price of the local input between two countries, while the final product produced by the foreign firm decreases as $(k_2{}^*-k_2)$ increases. The price of the intermediate good then can be found from (28):

$$\tilde{q}m_1=k_1^*m_1-2p'(\tilde{Y})\tilde{y}-p'(\tilde{Y})\tilde{y}^*. \tag{38}$$

As for trade policy, it is possible to find both $\tilde{t}$ and $\tilde{s}$ explicitly in this case, since both (26) and (27) hold with an equality. The optimal tariff on imports of the final product can be found from (27), using (37) and (38), while the optimal rate of subsidy (or tariff) on imports of the input is determined by (26) together with (37) and (38):

$$\tilde{t}=-p(\tilde{Y})\tilde{Y}>0, \text{ and } \tilde{s}m_1=p'(\tilde{Y})\tilde{Y}=-\tilde{t}<0.$$

It is optimal to impose a tariff on imports of the intermediate good for the same reason as that explained in the previous section, and to use a tariff on imports of the final product to promote the domestic industry. Interestingly, the optimal rate of tariff on imports of each good (measured in per unit of the final product) is identical in this case.

The main results of this section are summarized in the following proposition.

PROPOSITION 5

Suppose that the exporting country carries out the optimal trade policy. Then, with a linear demand and a Leontief technology for the final product,

1) the domestic production should be promoted (if it is desirable) by a tariff on imports of the final product and not by a subsidy on imports of the intermediate good,
2) it is optimal for the domestic country not to produce the final product if the domestic price of the local input is equal to or higher than that in the foreign country,
3) the cost advantage in the local input sector required for the domestic firm to monopolize the final product market at optimum is smaller than that in the absence of the foreign trade policy (as given by (32′)), and
4) it is optimal for the domestic country to impose a tariff on imports of the intermediate good, whenever it is imported for domestic production of the final product.

Comparing Proposition 5 with Proposition 3 in the previous section, we can see that the domestic production (if necessary) must be promoted by a tariff on imports of the final product not by a subsidy on imports of the intermediate good in both cases. Whether or not the foreign country pursues the optimal trade policy, however, is an important factor to be considered by the domestic country in making its optimal decision as to how much of the final product should be produced at home and how much should be imported.

V. CONCLUSION

In this paper, we have examined trade and trade policies in a vertically related market when a country lags behind the foreign country in the technology in the key input sector. Without trade policy in the importing country, it is very likely that there will be no trade in the technology-embodying intermediate good and that a vertically integrated foreign firm monopolizes the final product market in the importing country. But, the domestic country can induce the foreign firm to supply the input either by a tariff on imports of the final product or by a subsidy on imports of the intermediate good.

For the optimal trade policy, the domestic production (if necessary) must be promoted by a tariff on imports of the final product not by a subsidy on imports of the intermediate good within our framework. Whether or not the foreign country implements its trade policy, however, is an important factor to be considered by the domestic country in making its optimal decision as to whether or not the final product should be produced at home. For example, it is not optimal to produce the final product at home when the price of the local input is identical in two countries in the presence of foreign trade policy, while it is optimal to produce some of the final product at home even if the price of the local input is somewhat higher at home than in the foreign country in the absence of foreign trade policy. Overall, the protectionism in an industry that is

dependent upon the foreign technology in the intermediate good sector is well justified.

This paper considers a linear pricing system in transactions of the intermediate good. In the intermediate good market in the world, however, various nonlinear pricing schemes such as two part tariffs are often used. The research along this line is necessary to complete the model in this paper. In addition, it is well known that the effects and the prescriptions of the optimal trade policy under imperfect competition are very sensitive to the model, particularly to the demand structure. The further studies regarding the optimal trade policy are also required to obtain a more general result.

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