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Trade and protection in vertically related markets

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We consider home country tariff and subsidy policies in a setting where a home firm is partially dependent on a foreign vertically integrated firm for supplies of a key input. The firms are Cournot competitors in the home market for the final product. We show that a tariff on final product imports may cause the foreign vertically integrated firm to reduce the price charged for the input under circumstances where a simple monopoly supplier of the input would increase its price. Supply conditions for the input significantly affect whether imports of the input should be taxed or subsidized.

1. Introduction

Countries that are rich in some raw material often restrict exports with the expressed aim of encouraging local processing activities. Resource industries such as oil, bauxite and lumber provide common examples. The hope is that local processing firms will expand production, increasing their exports of the final product. Such an outcome is possible if restricting exports of a raw material increases the cost at which a final product can be produced in the rest of the world. There is a vertical connection between the markets for the intermediate and final products: an export restriction at the intermediate stage can increase a country's exports of the final product.

This phenomenon is not restricted to resource industries and firms as well as governments can play a role in restricting the exports of a key input so as

*This paper is a revised version of an earlier 1988 manuscript entitled 'Protectionist Policies in Vertically Related International Markets'. In this revision we have taken the opportunity, in section 7, to comment on the recent paper by Rodrik and Yoon (1989), which addresses some of the same issues. Barbara Spencer gratefully acknowledges financial support from SSHRC grant no. 410-88-0074 and from the Centre for International Business Studies at U.B.C.

to improve their competitive position in the export market for the final product. For example, the Japanese computer industry, with the help of the Japanese government, recently restricted exports of DRAM semiconductors.[1] Since Japanese firms control about 80 percent of the world market for semiconductors, the export restriction served to increase the world price of semiconductors. Japanese exports of final computers rose as a consequence of the increase in costs faced by rival U.S. computer makers. Vertically integrated Japanese firms such as Toshiba and NEC were able to increase their profits in both the semiconductor and final computer markets.

In a companion paper, Spencer and Jones (1991), we analyze private and public policies towards trade in the country that has an advantage in the production of a raw material or other input and also competes in an imperfectly competitive export market for the final product. In the present paper we shift attention to trade policy in the country, referred to as the home country, that is at least partially dependent on imported supplies for its own final goods production. Supplies of the input can be produced in the home country but only at a higher cost. We assume that the home market for the homogeneous final product is characterized by Cournot competition between a home and foreign based firm. The generality of the results is indicated by allowing the final outputs to be either strategic substitutes or complements. Some brief attention is also given to the implications of Bertrand competition with differentiated products.

The signficance of the vertical connection in the foreign country between their exports of the intermediate and final products is highlighted by contrasting two alternative scenarios. On the one hand, a vertically integrated foreign firm makes joint profit-maximizing decisions as to export levels in the two markets. Alternatively, a monopoly firm exports only the input and a separate foreign firm (with its own input supplies) produces and exports the final product.[2] As we show, the vertically integrated foreign firm would charge the home firm a higher price for its exports of the input than would an independent monopoly supplier. Since foreign welfare is maximized by maximizing total profits from export sales, the vertically integrated firm's level of exports of the input can be viewed as a proxy for an optimal export restriction by the foreign government.[3]

Our objective is to explore the consequences for home country policies of the vertical relationship between productive activities abroad. A main issue

[1]This Japanese action was facilitated by a U.S. anti-dumping case against imports of semiconductors. Our model suggests that the U.S. action was not in the U.S. national interest.

[2]If a competitive industry produces the input, the monopoly supplier might be interpreted as a marketing board concerned only with exports of the input. Also, the Cournot final product market could arise from the actions of marketing boards in both countries [see Krishna and Thursby (1991)].

[3]This statement presumes that the government is prevented from taxing (or subsidizing) exports of the final product.

concerns the reaction of the foreign supplier in each scenario to a home country tariff applied to final product imports. Whereas a simple foreign monopoly supplier of the input might be expected to raise price in response to the extra home demand stimulated by the tariff, the vertical connection between export markets could cause a vertically integrated supplier to respond in opposite fashion, by lowering price.

In a free-trade setting, a vertically integrated supplier abroad might find its own interests best served by shutting off all exports of the input. This possibility of vertical foreclosure is examined in Spencer and Jones (1991).[4] In the present paper we briefly consider the roles of a subsidy to home production of the input and a subsidy paid on intermediate imports in ensuring supplies from abroad. The optimal use of this latter policy proves to be highly sensitive to the nature of the initial equilibrium. Subsidizing imported supplies usually improves welfare if there is initial vertical foreclosure, but when these supplies are guaranteed because of an infinitely elastic home supply of the input, a small tax on these imports becomes fully effective as a device to extract foreign rent.

The tendency of the vertically integrated firm to restrict exports of the input is an example of the general idea, due to Salop and Scheffman (1983, 1987), that a firm may gain from raising its rivals' costs even at some expense to itself. Here, the self-imposed cost is in the form of forgone profits from sales of the input, with the pay-off represented by a higher share in the market for the final product. Another relevant paper is Chang and Kim (1989), who use a substantially different model to consider trade policy towards imports of an intermediate product; home country incentives also differ since all of the final product is exported. More recently, Rodrik and Yoon (1989) have adopted our model framework with different assumptions about home country costs. We briefly discuss some of their results in section 7. The implications of vertically related markets for domestic tariff policy are examined in a general equilibrium purely competitive model by Jones and Spencer (1989) and some connections between that paper and the present one are discussed in section 6.

The structure of the model is described in section 2 of the paper. Section 3 deals with the Cournot equilibrium for the final good and the home firm's derived demand for imported supplies. Section 4 then examines the effect of vertical integration in the foreign supplier on the price charged for the input. The use of home country policies to move the equilibrium from vertical foreclosure to vertical supply is considered in section 5, and section 6 concerns the implications of these policies once vertical supply has been achieved. The special case in which the home marginal cost of production of

[4]Some recent papers concerned with the vertical foreclosure decision in a domestic context are Quirmbach (1986), Ordover, Saloner and Salop (1988) and Salinger (1988).

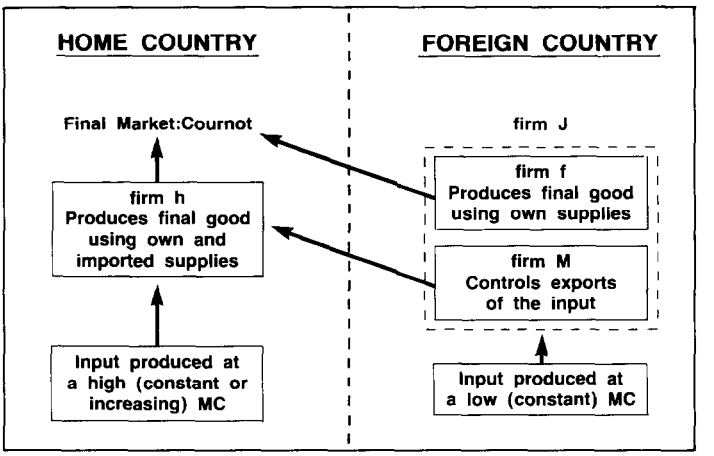

Fig. 1

the input is constant is discussed in section 7. Concluding remarks are presented in section 8.

2. Model structure

The model setting is illustrated in fig. 1. The outer dotted line on the foreign country side of the diagram indicates that the foreign vertically integrated firm, denoted by firm J (J for joint control), controls the exports of both products; otherwise an independent monopoly firm, denoted by firm M (M for monopoly), is responsible for exports of the input and another foreign firm, shown as firm 'f' in the figure, exports the final product. Home and foreign firms are all assumed to have access to supplies of the homogeneous input produced in their respective countries at marginal cost. Thus, whether firm M or firm J controls exports of the input, the final product is produced in the foreign country at the same marginal cost. This comparison serves to highlight the effect of joint control of both exports.

The technology of production of the final product is simplified by the assumption that one unit of the input together with a fixed proportion of labor is required to produce one unit of the final product.[5] The higher cost of production of the input in the home country is reflected by the assumption that the marginal cost, c^h, of the first unit produced in the home

[5]The assumption of fixed proportions technology fits with both the natural resource and the semiconductor chip examples. Allowing the home firm to substitute away from the imported input would tend to reduce the monopoly power of the foreign supplier, but it does not fundamentally affect the response to trade policy.

country exceeds c^f, the constant marginal cost of production in the foreign country. If the input is derived from a natural resource, combining variable factors with a fixed supply of the resource would often give rise to diminishing returns or increasing marginal costs. This effect becomes less important as the resource becomes more abundant. We model the asymmetry between the home and foreign countries by assuming that the natural resource or other critical fixed factor is sufficiently abundant in the foreign country to make foreign marginal cost constant,[6] but that generally home marginal cost is strictly increasing. The effects of a constant home marginal cost of production of the input are considered in section 7. When home marginal costs are increasing, the key intermediate input may be both imported and produced domestically. This fits with our computer industry example (semiconductor chips are both imported into the United States from Japan and produced within the United States) and is commonly the case in natural resource industries.

The subgame perfect equilibrium between firms incorporates two stages of decision. In stage 1, firm J (or firm M) commits to its export strategy for the input. Since the quantity of exports, x, and the price, r, charged for these exports are related by the requirement that the home firm's demand for x is equal to the supply, it is immaterial whether the foreign firm commits to a price or quantity at this stage. However, commitment to a price allows our analysis to be presented somewhat more simply and we take this approach.[7] In stage 2 the outputs of the final product are determined by Cournot (quantity Nash) competition. The home firm chooses the cost minimizing combination of imports, x, and its own production, x^h, of the input. Although we present the analysis as if the home firm is vertically integrated, the analysis applies equally to the case where the input is produced by a perfectly competitive industry in the home country.

In setting the price of the input in stage 1, firm J (or firm M) takes full account of the effect of the price on the subsequent Cournot (quantity Nash) equilibrium in the export market for the final product, including the response of firm 'h' in the production of its own supplies. Hence firm J will supply its rival only to the extent that the export of the input increases its overall profits. At the extreme, it may vertically foreclose by cutting off supplies

[6]When foreign marginal costs of production of the input are increasing, firm J would recognize that it can reduce its marginal cost of production of the final product by reducing its exports of the input. Thus, vertical foreclosure is more likely, but there is no basic change in the response to trade policy.

[7]If the foreign firm commits to exports x rather than price r at stage 1, our existing analysis with respect to r applies, but we would also require r to be determined by equating the home firm's demand for x with the supply. However, this alternative formulation does have the advantage that it supports the credibility of the stage 1 commitment: it more closely models the idea that it takes time to export the input and that the home firm must receive its supplies prior to its production of the final good.

altogether. Naturally firm J could further increase its profits if it could commit to the quantity of its exports of the final product in stage 1, putting it in a full Stackelberg leadership position. We assume that such a commitment is not possible.[8]

The home country is assumed to commit to its policies, a specific import tariff, t, on the final good, a specific subsidy, s, on intermediate imports, and a specific subsidy, σ, to local production, x^h, prior to stage 1. As is usual in these models, we consider the outcome of the second stage final goods market first (in section 3) and then turn to the stage 1 determination of the input price in section 4.

3. The final goods market

We consider only the market for the final product located in the home country. This involves no loss of generality if the home and foreign markets are segmented. Home and foreign production of the final product is denoted by y^h and y^f, respectively. The price p of the final product (in the home country) is given by the inverse demand curve $p=p(Y)$, where $p'(Y)<0$ and $Y=y^h+y^f$.

Letting w^h represent the (constant) cost of the home country labor required to produce one unit of the final product, the home firm's profit is

$$\pi^h=(p-r-w^h)y^h+rx^h-(C(x^h)-\sigma x^h), \tag{1}$$

where $C(x^h)$ is the total cost of home production of the input. The first term of (1) represents the home firm's profit when all supplies of the key input are imported; the remaining terms represent the adjustment to this profit when the firm produces some of its own supplies. The foreign profit from the export of the final product alone is given by

$$\pi^f=(p-t-c^f-w^f)y^f, \tag{2}$$

where c^f and w^f are the (constant) marginal costs of the key input and foreign country labor, respectively.

Turning to the input choice by the home firm, if the net marginal cost, $c^h-\sigma$, of the first unit of home production of the input (after payment of the subsidy) exceeds the price of r of imported supplies, then $x^h=0$ and the home firm produces using imported supplies only. Otherwise, the firm produces the intermediate good so as to equate the net marginal cost of production to the price of imported supplies: $C'(x^h)-\sigma=r$. This relationship defines home

[8]In Spencer and Jones (1991) we show that optimal policy by the government in the exporting country gives rise to an equilibrium that is equivalent to a Stackelberg outcome of this type.

production of the input as an increasing function of the import price r and the subsidy σ (subscripts denote partial derivatives):

$$x^h = x^h(r+\sigma), \quad \text{where } x_r^h = x_\sigma^h = 1/C''(x^h) > 0. \tag{3}$$

At a sufficiently high price, denoted by r^p, imports become prohibitively expensive and the home firm produces using only local supplies.

To examine the second stage Cournot equilibrium, let $V^h(y^h, y^f) \equiv \pi^h$ and $V^f(y^h, y^f) \equiv \pi^f$ represent home and foreign profit, respectively, as functions of the outputs y^h and y^f. Each firm sets its output to maximize its profit given the other firm's output level, the price r charged for the input and home country policies t, σ and s. The first-order conditions are

$$V_h^h = p + y^h p' - (r + w^h) = 0 \quad \text{and} \quad V_f^f = p + y^f p' - (t + c^f + w^f) = 0, \tag{4}$$

where the subscripts h and f represent partial derivatives with respect to y^h and y^f, respectively. We assume that the standard second-order and uniqueness conditions are satisfied:

$$V_{hh}^h = 2p' + y^h p'' < 0, \qquad V_{ff}^f = 2p' + y^f p'' < 0 \quad \text{and} \quad H = p'(3p' + Yp'') > 0, \tag{5}$$

where $H \equiv V_{hh}^h V_{ff}^f - V_{hf}^h V_{fh}^f$.

Solving the conditions (4) simultaneously, we obtain the Cournot equilibrium outputs:

$$y^f = y^f(r, t) \quad \text{and} \quad y^h = y^h(r, t). \tag{6}$$

[For convenience, we omit the constants w^h, w^f and c^f in (6).] Since r is defined as the price the home firm actually pays for imports of the intermediate product, the subsidy s on these imports affects final outputs only through its effect on r and does not directly appear in (6). Similarly, the subsidy σ to home production of the input affects r but does not otherwise change final outputs.

In the absence of offsetting home country advantages in final goods production, the high cost at which the input can be produced in the home country would make y^h small in relation to y^f. At the extreme, it is possible that $y^h = 0$ so that the foreign firm gains a monopoly of the market for the final product. Since $V_{hf}^h = p' + y^h p''$ is negative when y^h is small, a small home firm reacts to an increase in final product imports by reducing its own output; that is, when the home firm is small, it must view the outputs as strategic substitutes. This does not rule out the possibility that the larger

foreign firm views the outputs as strategic complements ($V^f_{fh}=p'+y^f p''>0$), giving it an incentive to expand its output in response to an increase in production by the home firm. As Bulow, Geanakoplos and Klemperer (1985) point out, a large firm may regard the outputs as strategic complements, even though they are strategic substitutes from the viewpoint of its small rival. A feature of this paper is the attention given to the trade policy effects of asymmetries in the size of firms.

The comparative static effects of an increase in the import price r and the tariff t are important for the subsequent results. Totally differentiating (4) using (5) to sign the expressions, we obtain:

$$y^h_r=(2p'+y^f p'')/H<0, \qquad y^f_t=(2p'+y^h p'')/H<0 \quad \text{and} \quad Y_r=Y_t=p'/H<0. \tag{7}$$

Each firm's output of the final product is decreasing in own marginal cost (as represented by an increase in r for the home firm and an increase in t for the foreign firm). An increase in r or in t always reduces home consumption of the final product.

The signs of the cross effects,

$$y^h_t=-(p'+y^h p'')/H \quad \text{and} \quad y^f_r=-(p'+y^f p'')/H, \tag{8}$$

depend on whether the final outputs are strategic substitutes or strategic complements. If the outputs are strategic substitutes for both firms, then $y^h_t>0$ and $y^f_r>0$; each firm reacts to an increase in its rival's cost by expanding own output. Since the outputs must be strategic substitutes for a small firm, it follows that $y^h_t>0$ when the home firm is small. A large foreign firm may view the outputs as either strategic substitutes or strategic complements, making $y^f_r<0$ in the latter case. If the home firm views the outputs as strategic complements, then $y^h_t<0$.

The home firm's derived demand for intermediate imports is its output at the Cournot equilibrium less its own production of the input:

$$x(r,t,\sigma)=y^h(r,t)-x^h(r+\sigma). \tag{9}$$

An increase in the price charged for imported supplies reduces the home firm's demand, both because it decreases the home firm's output and because it encourages home production of the input: from (3) and (7), $x_r=y^h_r-x^h_r<0$. If the foreign vertically integrated firm forecloses, it sets the (prohibitive) price, r^p, reducing the home firm's demand for imported supplies to zero: $x(r^p,t,\sigma)=0$.

4. Strategic choice of the input price

We turn now to the stage 1 determination of the price that the foreign supplier will charge the home firm for the input. The strategic interaction between the home country markets for the intermediate and final products is captured by the assumption that firm J exports both products. Firm J's profit (and the foreign country's welfare from firm J's exports) is

$$\pi^{J}(r,t,s,\sigma)=(r+s-c^{f})x(r,t,\sigma)+\pi^{f}(r,t), \tag{10}$$

where $\pi^{f}(r,t)$, the profit from final product exports, is given by (2) evaluated at the second stage Cournot equilibrium. As a benchmark for comparison, we consider an alternative market structure in which the foreign monopoly supplier, firm M, is concerned only with maximizing profit from the export of the input, given by the first term of (10).

Firm M sets its price for the input (denoted by r^{M}), taking full account of the effect of the second stage relationships on the home firm's derived demand. This gives rise to the standard first-order condition for a monopoly:

$$\pi_{r}^{M}(r^{M},t,s,\sigma)=x+(r^{M}+s-c^{f})x_{r}=0. \tag{11}$$

Joint control of the two exports gives firm J the additional consideration of the 'strategic effect', $\pi_{r}^{f}(r,t)$, of the price charged for the input on its own second stage profits from final product exports. If firm J decides to supply some of the input, then, from (10), its price for the input (denoted by r^{J}) satisfies[9]

$$\pi_{r}^{J}(r^{J},t,s,\sigma)=x+(r^{J}+s-c^{f})x_{r}+\pi_{r}^{f}(r^{J},t)=0. \tag{12}$$

The strategic effect is positive: an increase in the price charged the home firm for the input reduces home production of the final product, increasing the price that firm J receives for its final product exports. From (2), (4) and $\mathrm{d}p/\mathrm{d}r=p'Y_{r}$:

$$\pi_{r}^{f}=y^{f}\,\mathrm{d}p/\mathrm{d}r+(p-t-c^{f}-w^{f})y_{r}^{f}=y^{f}p'y_{r}^{h}>0. \tag{13}$$

As shown by (13), the strategic effect can be separated into two parts, a terms of trade effect and a volume of trade effect of the input price on the market for the final product. Since $\mathrm{d}p/\mathrm{d}r>0$, raising r always raises both terms of trade (r and p). If the foreign firm views the outputs as strategic

[9]Firm J sets $r\leqq r^{P}$ to maximize (10). The first-order condition (12) is satisfied when $r<r^{P}$. We assume that π^{J} is strictly concave for all $r\leqq r^{P}$. Although π_{r}^{J} is not differentiable at $r=c^{h}-\sigma$, it remains strictly concave since $x_{r}^{h}=0$ for $r\leqq c^{h}-\sigma$ and $x_{r}^{h}<0$ for $r\geqq c^{h}-\sigma$.

substitutes, then raising r also increases the volume of its exports of the final product. Foreign exports of the final product fall in the strategic complements case [see (8)]. It also proves to be useful to relate the strategic term to the profit margin that firm J earns from its final product exports: using (4) to substitute for $y^f p'$ in (13), we obtain:

$$\pi_r^f = -(p - t - c^f - w^f) y_r^h > 0. \tag{14}$$

As might be expected, the strategic interaction between the markets gives firm J an incentive to increase the price charged for the input above the independent monopoly level. The only requirement is that exports of the final product remain positive. If exports of the final product are forced to zero, as they would be by a prohibitively high home country tariff, then firm J becomes identical to firm M. We assume for the remainder of the paper that $t < t^*$, where t^* denotes the prohibitive tariff.

Proposition 1. The foreign vertically integrated firm charges its domestic rival a price for the input that exceeds the independent monopoly level:

$$r^J > r^M, \quad \textit{for } t < t^*.$$

Proof. Using (11) to evaluate (12) at r^M, we have $\pi_r^J(r^M, t, s, \sigma) = \pi_r^f > 0$ for $t < t^*$. Since $\pi_{rr}^J < 0$, firm J's profits are increased by setting r^J above r^M. □

The effect of an increase in the price of imported supplies on the Cournot output equilibrium is illustrated in fig. 2 for the case of linear demand (the reaction functions have negative slopes so the outputs are strategic substitutes). If r is increased from r^M to r^J, the Cournot equilibrium moves from point M to point J. The increase in the home firm's marginal cost reduces home output for any given level of foreign output, shifting the home firm's reaction function in towards the origin. As fig. 2 also illustrates, an import tariff t on the final product serves as an instrument by which the home country can affect the Cournot equilibrium. An increase in the tariff increases the marginal cost faced by the foreign exporter of the final product, shifting the foreign reaction function in towards the origin, as shown by the dotted line in fig. 2.

Under the general demand conditions that we consider, it is possible that a higher price paid for the input might actually increase the home firm's profits. When the foreign exporter of the final product regards the outputs as strategic complements, it reacts to an increase in the price charged its rival for the input by reducing its final product exports [see (8)]. This reaction strengthens the tendency for the price of the final product to rise and it is possible that home profits might rise, particularly if the home firm produces

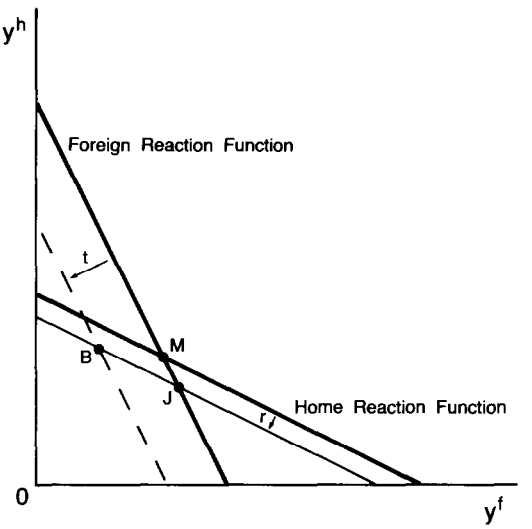

Fig. 2

some of its own supplies of the input.[10] This raises the question as to whether the home country might gain from an increase in the price of imported supplies. Proposition 2 shows that this is not the case: the consumer loss from the higher price for the final product is sufficiently large to offset any feasible profit gain. Further details and the proof are provided in the appendix.

Proposition 2. If $t=s=\sigma=0$, *an increase in the price of imported supplies reduces home country welfare.* □

Combining Proposition 2 with Proposition 1 it follows that the home country is worse off when faced with a vertically integrated foreign supplier than with a simple foreign monopoly exporter of the input.

The next two sections are concerned with the implications of vertical integration in the foreign supplier for home country policies. The central question is: Does the price paid for imported supplies respond differently to the home country policy instruments s, t, and σ when the output is supplied by firm J than when it is supplied by firm M? Vertical integration in the foreign supplier introduces the possibility of vertical foreclosure. In section 5 we briefly examine the usefulness of home country policies as a means of

[10]From (1) and (4), $d\pi^h/dr = y^h(p'y_r^f - 1) + x^h$ is larger if $y_r^f < 0$ and $x^h > 0$.

inducing firm J to supply at least some of the input. In section 6 we compare firm J's and firm M's reaction to these policies in a setting of vertical supply.

5. Home country policy and the vertical supply decision

As Spencer and Jones (1991) show, the decision by firm J as to whether to supply some of the input to its rival depends critically on the difference in profit margins that firm J earns from the export of the input and the final product. Let $m(r,t,s)=(r+s-c^{f})-(p-t-c^{f}-w^{f})$ represent this difference in profit margins evaluated at the Cournot equilibrium. Substituting (14) into (12) [using (9)], we can write

$$\pi_r^J(r,t,s,\sigma)=x+m(r,t,s)\,y_r^h-(r+s-c^f)x_r^h. \tag{15}$$

Firm J engages in vertical supply if and only if a reduction in r below the foreclosure price, r^p, increases its overall profits making $\pi_r^J<0$ when evaluated at r^p. As can be seen by setting $x=0$ in (15), vertical supply is always profitable if the difference in profit margins evaluated at the foreclosure price is strictly positive. Firm J then earns a higher profit margin from the export of the first unit of the input than it earns on its final exports. If home country production of the input is sufficiently responsive to price (x_r^h large and positive), firm J will supply the input even if $m(r^p,s,t)<0$.

The role of the quantity of home production of the input in the foreclosure decision as well as the effect of the tariff in inducing vertical supply is investigated in Spencer and Jones (1991). We now extend this analysis to consider the implications of the subsidies s and σ and country specific differences in labor costs. Using $r^p-p=x^hp'-w^h$ [from (4)], the difference in profit margins can be expressed as

$$m(r^p,t,s)=x^h(r^p+\sigma)p'+s+t+w^f-w^h. \tag{16}$$

It follows from (16) that a sufficiently large subsidy s to imported supplies will make the difference in profit margins positive, inducing vertical supply. Also, vertical supply could be a consequence of low home labor costs in final goods production. A low cost of home production of the final product is associated with a low price for the final product and a high home demand for the input, both of which tend to increase the difference in profit margins.[11] Conversely, a subsidy σ to home country production of the input

[11]This suggests that a resource-rich developing country may gain from exporting some of the raw resource even though it wishes to encourage its own high-cost processing industry.

tends to make vertical supply less profitable by reducing the price that the home firm is willing to pay for the first unit of imported supplies.[12]

Although subsidy (and tariff) policies can be used to induce vertical supply, this does not mean that such policies are in the domestic interest. First, consider the effects of policies that apply at the final output stage. These policies (such as the tariff t or a subsidy to home labor costs in final goods production) make vertical supply more profitable only to the extent that they expand the home firm's final output, increasing own marginal costs of production of the input and the price that the home firm is willing to pay for the first unit of imported supplies. However, as we know from Proposition 2, an increase in the cost of the input tends to reduce domestic welfare. Thus, even if these policies are beneficial as a means of shifting foreign profits earned on final exports to the home country, the optimal level of the policy may fall short of the level needed to induce vertical supply. Also, in a real-world setting, these types of policies may well lead to an increase in rent-seeking activities by affected interest groups, imposing substantial additional costs on the economy.

The more direct policy of a subsidy to imported supplies suffers from other serious drawbacks. Such a policy could be viewed as a direct reward to the foreign firm for refusing to supply the input. The very fact that the subsidy is paid to foreigners could also make it politically unacceptable. It is nevertheless interesting that in the limited context of our model, a subsidy to imported supplies is generally beneficial to the home country. The country gains from the lower price for the input, yet the cost of the policy is small because the subsidy payment is small; the subsidy rate is applied to a negligible quantity of imports in the neighborhood of vertical foreclosure. This result holds independently of whether the outputs of the final product are strategic substitutes or complements. The only qualification is that high labor costs do not make the home country too inefficient as a producer of the final product. The proof of Proposition 3 is provided in the appendix.

Proposition 3. If there is vertical foreclosure in the absence of home country policy and if $w^f - w^h \gtreqless 0$, *then home country welfare is increased by a sufficiently large subsidy rate applied to intermediate imports to induce vertical supply.* □

Proposition 3 is interesting both because of the generality of the result[13]

[12]This follows since $x(r^p, t, \sigma) = 0$ defines $r^p = r^p(t, \sigma)$, where $r^p_\sigma = x^h_\sigma / x_r < 0$. An increase in σ tends to increase π^I_r at r^p, reducing the profitability of vertical supply: from (15) at $r = r^p$ (with $x = 0$), $d\pi^I_r/d\sigma = \pi^I_{rr} r^p_\sigma - (r + s - c^f) x^h_{r\sigma} > 0$ when $x^h_{r\sigma}$ is small or negative [or $C'''(x^h) \gtreqless 0$ from (3)].

[13]When there is vertical supply, the optimality of a tax or a subsidy on intermediate imports depends on specific demand and cost conditions. The optimal policy towards imports of a final product is sensitive to home demand conditions even in the simple case in which the product is supplied by a foreign monopolist [see Katrak (1977) and Brander and Spencer (1984a, b)].

and because it holds at one extreme of the supply spectrum. As such, it provides a useful base from which to show the significance of supply conditions for home country policy. In section 7 we consider the other extreme in which vertical supply is always a profitable strategy because of infinitely elastic home supplies of the input.

6. Response to home country policies under vertical supply

We now consider home country policies in the region of vertical supply where the input price set by firm J satisfies the first-order condition (12). In subsection 6.1 we compare the responses of the input prices r^J and r^M to a home country tariff on final product imports. In subsection 6.2 we turn to a brief consideration of the effects of the subsidy policies σ and s.

6.1. A home country tariff on final product imports

Consider first the case of supply by a foreign monopolist. The tariff affects the monopoly supplier by shifting the home firm's derived demand for the input. Generally, a monopoly firm, such as firm M, responds to a shift in demand (whether outward or inward) by increasing its price, if and only if the new demand curve is less elastic at the original price.[14] In our present case, let $\eta^x = -rx_r/x$ represent the (positive) elasticity of home demand for imported supplies. Then, differentiating (11) and using $r^M + s - c^f = -x/x_r$ [from (11)], the effect of the tariff on the price r^M charged by firm M is

$$r_t^M(t, s, \sigma) = -[y_t^h + (r^M + s - c^f) y_{rt}^h]/\pi_{rr}^M = x(\partial\eta^x/\partial t)/\eta^x \pi_{rr}^M, \tag{17}$$

where $\partial\eta^x/\partial t = r(x_r y_t^h - x y_{rt}^h)/x^2$. Thus the tariff increases the input price if and only if $\partial\eta^x/\partial t < 0$.

In considering the sign of the pricing response given by (17), it is important to specify whether the home firm views the outputs as strategic substitutes or complements. As shown in section 3, the home firm expands in response to the tariff in the former case and contracts in the latter case. Considering the former case first (our main case of interest), a home country tariff on final product imports will shift out the home firm's demand for imported supplies. As one might expect, the monopolist would normally respond by increasing the price charged for the input. This tendency is reflected by $y_t^h > 0$ in (17), but the new demand curve does not always become less elastic at the original price. To ensure this, it is necessary to restrict y_{rt}^h to be small or positive. (The sign of y_{rt}^h depends on both p'' and

[14]See Jones (1987) for the significance of this feature for the Brander and Spencer (1984b) argument that an import subsidy may be optimal in the face of foreign monopoly power.

p''' and is in general ambiguous. If demand for the final product is linear, then $y^h_{rt}=0$ and it follows immediately that $\partial n^x/\partial t<0$ and $r^M_t>0$.) In the alternative case in which a large home firm views the outputs as strategic complements, the tariff tends to have the opposite effect: firm M tends to reduce the price charged for the input, in response to the cut back in demand.

Now consider the effect of the tariff when firm J exports both products. Differentiating (12), then using $r^J+s-c^f=-(x+\pi^f_r)/x_r$ from (12) and $\partial\eta^x/\partial t$ as in (17), we obtain:

$$r^J_t(r,s,\sigma)=-[y^h_t+(r^J+s-c^f)y^h_{rt}+\pi^f_{rt}]/\pi^J_{rr}=[x(\partial\eta^x/\partial t)/\eta^x-S_t]/\pi^J_{rr}, \quad (18)$$

where $S_t=\pi^f_{rt}-\pi^f_r y^h_{rt}/x_r$ is the effect of the tariff on the strategic component of the pricing decision. Considering the first term of the second expression in (18), firm J responds to a shift in demand for the input due to the tariff just as would a simple monopoly supplier, i.e. firm J increases the price charged for the input whenever $\partial\eta^x/\partial t$ is negative. It is the second term, S_t, of (18) that captures the effect of the vertical connection between firm J's export markets.

The sign of S_t depends fundamentally on whether the tariff has its expected effect in reducing the profit margin that firm J earns on its final product exports. A lower profit margin tends to reduce the magnitude of the strategic component of the pricing rule and make $S_t<0$ (see Proposition 4 below). Considering only the export market for the final product, this gives firm J an incentive to reduce the price charged its rival for the input. In effect, by reducing the importance of the export market for the final product, the tariff tends to bring firm J's behavior closer to that of a simple monopoly exporter of the final product. Conversely, a higher profit margin tends to make $S_t>0$. This latter case can only apply for a limited range of tariff values. As the tariff is increased close to the prohibitively high level t^* at which firm J ceases to export the final product, the profit margin on final product exports must fall. At t^*, this profit margin and the strategic component of the pricing rule are both reduced to zero.

A tariff reduces the profit margin on final product exports if it does not cause price overshifting, that is, if a one dollar increase in the tariff increases the price of the final product, but by less than one dollar. From (7), this can be expressed as

$$1-p'Y_t=p'(2p'+Yp'')/H>0. \quad (19)$$

Condition (19) is satisfied whenever industry marginal revenue for the final product is decreasing in industry output, i.e. whenever $\mathrm{d}(p+Yp')/\mathrm{d}Y=2p'+Yp''<0$. This is always the case if final demand is linear or concave to

the origin. If the home firm is small, then y^f is approximately equal to Y and (19) is implied by the second-order condition for the choice of y^f by the foreign firm.

Some sufficient conditions for S_t to be negative are set out in Proposition 4. As Proposition 4 shows, S_t is negative under a broad class of conditions.

Proposition 4. *S_t is negative under the following sets of conditions:*

(i) *the tariff does not cause price overshifting and*
(ii) (a) *the input is not produced in the home country* ($x^h = 0$), or
(b) *home produced supplies of the input are not very responsive to price* (x_r^h/x_r *is small*), or
(c) *the demand curve for the final product is not too non-linear* (y_{rt}^h/x_r *is small*).

Proof. Differentiating π_r^f [as given by (14)], we obtain:

$$\pi_{rt}^f = y_r^h(1 - p'Y_t) + y^f p' y_{rt}^h \quad \text{and} \quad S_t = y_r^h(1 - p'Y_t) - y^f p' y_{rt}^h x_r^h / x_r. \tag{20}$$

Since $y_r^h < 0$ from (7), the first term of S_t is negative if and only if (19) is satisfied. The second term is small under the stated conditions. □

Supposing that S_t is negative, the importance of vertical integration in the foreign supplier for the response to a tariff can be seen most clearly when the home firm views the outputs as strategic substitutes. In this case the monopoly pricing and strategic responses to a tariff tend to go in opposite directions. Considering the market for the input alone, both firm J and firm M would tend to charge a higher price in response to the higher demand brought about by the tariff; but the reduction in the profit margin earned on final product exports gives firm J an incentive to reduce its price. We show in Proposition 5 that in a significant group of cases this latter effect is sufficiently large actually to reverse the direction in which the input price moves in response to a tariff. The home firm then enjoys both lower costs and reduced competition from final product imports.[15]

Proposition 5. *When an increase in the tariff on final product imports causes firm M to increase the price charged for the input, firm J would reduce the price charged for the input under the following sets of conditions:* (i) $p'' = 0$, or (ii) $p'' < 0$, $y^h < y^f$ *and* $m(r, t, \sigma)$ *or* y_{rt}^h *is small.*

[15]The optimal tariff, as in Brander and Spencer (1984a), is not necessarily increased by the fall in r. Imports y^f then fall more sharply, making the tariff less effective as a device to collect revenue.

Proof. From differentiation of (15) , firm J's response to the tariff can be written in the form

$$r_t^J = -(y_t^h + y_r^h m_t + m y_{rt}^h)/\pi_{rr}^J, \tag{21}$$

where $m_t = 1 - p'Y_t > 0$ from $p'' \leqq 0$ and (19). Expanding the first two terms of (21), using (7), (8) and (19), we obtain:

$$y_t^h + y_r^h(1 - p'Y_t) = (Y_t)^2[(p' + y^f p'') + (p''/p')(y^f - y^h)(2p' + Yp'')] < 0, \tag{22}$$

when $p'' = 0$ *or* $p'' < 0$ and $y^h < y^f$. The third term, $m(r, t, \sigma) y_{rt}^h$, of (21) is zero if $p'' = 0$ and is otherwise assumed to be small. That $r_t^M > 0$ follows from (17). □

Proposition 5 follows most directly in case (i) where demand for the final product is linear. In this case, using $\pi_{rt}^f = (p' y_r^h) y_t^f$ and (18), r_t^J is negative if and only if

$$y_t^h + (p' y_r^h) y_t^f < 0. \tag{23}$$

Thus, whether firm J raises or lowers the price charged for the input in response to the tariff depends on the magnitudes of two opposing effects: (i) the increase in the derived demand for the input by the home firm ($y_t^h > 0$) and (ii) the reduction in the size of the strategic term because of the fall in firm J's exports of the final good ($y_t^f < 0$). The expression $p' y_r^h$ in the strategic term links the prices in the two markets: an increase in r increases p through its effect in reducing home production of the final product. In this linear case the term $p' y_r^h = 2/3$ and, as fig. 2 illustrates, the tariff hike reduces imports of the final product by twice as much as it increases the derived demand for imported supplies (the move from J to B). Thus, the reduction in the strategic term dominates the increase in demand for the input causing r^J to fall. Since firm M is concerned only with the demand for the input, it responds by raising r^M. More generally, taking it as a reasonable assumption that y_{rt}^h is small or the difference in profit margins $m(r, t, s)$ is small,[16] condition (ii) of Proposition 5 shows that this result extends to the class of cases in which the home firm is smaller than the foreign firm and demand for the final product is concave to the origin ($p'' < 0$).

The lines JB and JM of fig. 3 illustrate the effect of the tariff on the input prices set by firm J and firm M, respectively, in the linear demand case. From Proposition 1, JB lies above MB (r^J exceeds r^M) at all points other than at B where the tariff t^* is prohibitive. When its exports of the final

[16] If $m > 0$, the result holds if $y_{rt}^h \leqq 0$ or small. From (7) and (8), $y_{rt}^h = p''Y_t[y_r^h y_r^f - y_t^h y_t^f] - p''(Y_r)^3[2(p' + (y^f - y^h)p'')/p' + (y^f - 2y^h)p'''/p'')]$ is negative when $p'' < 0$, $y^h < y^f$ and p'''/p'' is small.

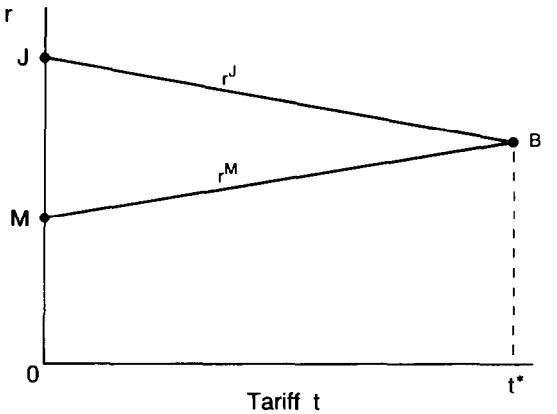

Fig. 3

product are reduced to zero, firm J charges the simple monopoly price. The line MB has a positive slope; in contrast, the tariff causes firm J to reduce its price, giving JB a negative slope.[17]

Since the results of this section can be affected by the nature of demand conditions, the question arises as to whether they are robust to other market structures. In considering Bertrand competition (with differentiated final products), it makes a difference whether the foreign firm is actually a vertically integrated supplier or whether the restrictions on exports of the input are simply a consequence of government policy in the exporting country. As Spencer and Jones (1991) show, a vertically integrated foreign firm would increase the price charged for its final product above the standard Bertrand level (for any given price charged by the home firm) so as to increase its profits from the export of the input. If the foreign government restricts exports of the input, Bertrand competition takes the standard form.

Although the requirement that final outputs be differentiated complicates the analysis, the main insights of this section are not affected by either of these forms of Bertrand competition. As we show in the appendix, the strategic term in the foreign firm's or foreign government's pricing decision is again dependent on the profit margin earned on final product exports. As before, home country policies that reduce this profit margin tend to reduce the strategic incentive to set the input price above the simple monopoly level and vice versa. With differentiated products there is more scope for price overshifting, but nevertheless the tariff reduces the strategic term in the linear demand case.

[17]Fig. 3 assumes that there is vertical supply at $t=0$. If a positive tariff is required to induce vertical supply, the line JB would start at this point.

Jones and Spencer (1989) also consider government policy towards vertically related markets, but in the context of a general equilibrium model in which both the intermediate and final products are produced by competitive industries. Despite the major differences between the two models, there are some similarities in the results. There is an incentive for a country exporting supplies that are used by foreign competitors in the final goods market to restrict these exports even more tightly than suggested by simple monopoly pricing. The export restriction allows the exporting country to enjoy an improvement in its terms of trade on final product exports as well as an increase in real income through the mechanism of general equilibrium changes in wages and prices. Also, despite inherent ambiguities in general equilibrium analysis, a tariff set by the importing country on final product imports can serve to reduce the price paid for imported supplies.[18]

6.2. *Home country subsidies at the input stage*

Both firm J and firm M respond to a subsidy to imported supplies by reducing the price paid by the home firm for the input: from (12) and (11),

$$r_s^J = -x_r/\pi_{rr}^J < 0 \quad \text{and} \quad r_s^M = -x_r/\pi_{rr}^M < 0. \tag{24}$$

By charging a lower price, the supplying firm can export more of the input, increasing the total subsidy payment. The prices charged by firm J and firm M also fall in response to a subsidy to home production of the input as long as the supply curve for the input in the home country is not too non-linear. As the subsidy increases, the home firm produces more of its own supplies, reducing its demand for imports. From (12) and (11), when $x_{r\sigma}^h$ is positive or small,[19]

$$r_\sigma^J = (x_\sigma^h + (r+s-c^f)x_{r\sigma}^h)/\pi_{rr}^J < 0 \quad \text{and} \quad r_\sigma^M = (x_\sigma^h + (r+s-c^f)x_{r\sigma}^h)/\pi_{rr}^M < 0. \tag{25}$$

Although both firm J and firm M respond to the subsidy policies by reducing the price charged for the input, vertical integration can nevertheless have a significant effect on the magnitude of the price reduction. Direct comparisons are difficult because the pricing responses are affected by the magnitudes of the initial prices, r^J and r^M, but a clear-cut result can be obtained for the case in which demand and supply are linear. As we show in

[18]In Jones and Spencer (1989), we discuss the tendency of the tariff to reduce the input price set by a vertically integrated firm (as in Proposition 5), referencing an earlier version of the current paper.

[19]Using (3), we obtain $x_{r\sigma}^h = x_{rr}^h = -C'''x_r^h/(C'')^2 \gtreqless 0$ if $C''' \gtreqless 0$.

Proposition 6, the vertical connection between markets then gives firm J an incentive to reduce the price charged for the input by more than would firm M.

Proposition 6. If $p''=0$ *and* $x^{h}_{rr}=0$, *an increase in* σ *or in* s *causes firm J to reduce the price charged the home firm for the input by a larger amount than would an independent monopoly supplier:*

$$r^{J}_{\sigma}<r^{M}_{\sigma}<0 \quad \textit{and} \quad r^{J}_{s}<r^{M}_{s}<0. \tag{26}$$

Proof. If $x^{h}_{rr}=0$, then $x^{h}_{r\sigma}=0$, ensuring that $r^{J}_{\sigma}<0$ and $r^{M}_{\sigma}<0$ from (25), The result then follows from (24), (25) and $\pi^{M}_{rr}=2x_{r}<\pi^{J}_{rr}=2x_{r}-p'Y_{r}y^{h}_{r}<0$. □

The simple relationships given by Proposition 6 do not hold under general demand conditions for every value of σ and s. Nevertheless, subsidies at the input stage tend to bring the price charged by firm J closer to the simple monopoly level for the same general reason as we discussed in connection with the tariff. As the price of imported supplies falls (in response to an increase in s or in σ), home final output increases, reducing the price of the final product. Thus, both these subsidy policies reduce firm J's profit margin on final product exports. As before, ignoring secondary effects of changes in r on the magnitude of the response y^{h}_{r}, the lower profit margin tends to reduce the magnitude of the strategic term in the pricing rule for the input.[20]

7. Constant marginal cost of home production

We now consider the special case in which the home marginal cost of production of the input is constant at c^{h}. If the home firm preferentially uses its own supplies when imported supplies cost the same, then imports of the input will be reduced to zero at the price $r^{p}=c^{h}-\sigma$. However, by setting a price even slightly below $c^{h}-\sigma$, say at $r^{d}=c^{h}-\sigma-\delta$, where δ is small, the foreign supplier (whether it is firm J or firm M) can deter the home firm from entering as a producer of the input. As Spencer and Jones (1991) point out, firm J always chooses vertical supply in this situation. By setting r at the entry-deterring value r^{d}, firm J earns profit from the export of the input, but this action does not affect the domestic firm's marginal cost or firm J's profit from the export of the final product. The foreign supplier may also choose an internal solution in which the input price is set strictly below r^{d}. This internal solution is just the vertical supply equilibrium studied previously, with the

[20]Since $\pi^{f}_{rs}=\pi^{f}_{r\sigma}=0$, the responses of firms J and M differ because the term π^{f}_{rr} makes π^{J}_{rr} differ from π^{M}_{rr}. From (13), (14) and $dp/dr=p'Y_{r}>0$, it follows that $\pi^{f}_{rr}=-(dp/dr)y^{h}_{r}+y^{f}p'y^{h}_{rr}>0$ if y^{h}_{rr} is small. By reducing r, the subsidy policies tend to reduce the magnitude of π^{f}_{r}.

added special condition that there is no home production of the input.[21] Our previous policy analysis applies in this case.

Turning to the case in which the foreign supplier sets the entry-deterring price, Proposition 7 shows that a small tax on intermediate imports (negative value of s) would be fully absorbed by either firm J or firm M. The supplier recognizes that if it increases its price, its sales will drop to zero as the home firm starts producing all its own supplies. In this situation, a small tax on intermediate imports is a perfect rent-extracting device.[22]

Proposition 7. If firm J or firm M supply the input at the entry-deterring price r^d, then a small tax on imported supplies has no effect on the price or quantity of these imports.

Proof. Both r^d and $x(r^d, t, \sigma)$ are unaffected by a tax on imported supplies (negative value of s). When the tax is small, it remains profitable for firm J or firm M to supply the input. □

Since firm J and firm M set the same price and respond in the same way, vertical integration in the foreign supplier plays no role.

Proposition 7 is then very closely related to a Brander and Spencer (1981) result that an import tariff is a perfect rent-extracting device when a foreign monopolist exporting a final product is trying to prevent domestic entry into the production of the final product. However, in this current application, the equilibrium is very fragile. If the marginal cost at which the input can be produced domestically is only slightly increasing, then an internal solution occurs in which the intermediate product is both imported and produced domestically. A tax on imported supplies is then no longer a perfect rent-extracting device, and indeed may reduce home country welfare because of its effect in increasing the price of these supplies. When home production conditions give rise to vertical foreclosure, a subsidy, not a tax, generally improves home country welfare (see Proposition 3).

Rodrik and Yoon (1989) assume a constant marginal cost of domestic production, as in this section, but with a fixed cost of domestic entry as well. The entry-deterring price then exceeds home marginal cost because the home firm must incur the fixed cost in order to enter as a producer of the input. Nevertheless, a small tax applied to imports of the input remains a perfect rent-extracting device, as in Proposition 7. When there is a fixed cost, a tariff

[21]The price r satisfies the first-order condition (12) for firm J and condition (11) for firm M with $x^h = 0$. The entry-deterring price r^d is then sufficiently high that it does not constrain either firm. This outcome is more likely if there is very little home demand for the input at r^d (because $c^h - \sigma$ is very high).

[22]This is also the case for a subsidy σ to home production of the input. However, such a policy may not be credible; if it works, it is never paid.

imposed on final product imports reduces the input price charged by the foreign supplier at the entry-deterring equilibrium, whereas in our case, with no fixed costs, the price $r^d = c^h - \delta$ is unaffected by the tariff.

8. Concluding remarks

A foreign vertically integrated firm has an incentive to restrict the extent to which it supplies a higher cost domestic firm with an input when both firms compete in a Cournot market for the final product. The vertically integrated structure of the foreign supplier leads it to price the intermediate input above the level that would be set by a foreign monopoly exporting only intermediates, and, at the extreme, to engage in vertical foreclosure. In a domestic context, anti-trust action would be the commonly suggested remedy, but this policy tool is not normally available to domestic firms facing injury from a foreign firm.

This paper has examined three policy instruments that are available to the home country in an international setting: an import tariff on the final product, a subsidy or tax paid on imports of the input and, finally, a subsidy to own production of the input. We consider the effect of these policies on the vertical supply decision, but the main focus of the paper has been to demonstrate that the reaction of the foreign vertically integrated supplier to these policy instruments can be significantly affected by its vertically integrated nature.

An alternative possibility is that the home firm may attempt to negotiate a long-term contract with the foreign supplier. This would be to the home firm's advantage only to the extent that it has bargaining power. The ability of the home firm to make such arrangements could be substantially increased by a credible threat of home government policy intervention supposing that the parties fail to reach a satisfactory agreement. For example, a credible threat to impose a tariff on imports of the final product might be just as effective as the tariff itself in reducing the price paid for imported supplies. If bargaining is successful, the home country gains from a lower price for imported supplies, but avoids the additional effects, whether positive or negative, of the tariff on the market for the final product.

In a more general context, the possibility that firms or the government in a resource-rich or technologically-advantaged country might restrict exports of a key input greatly increases the incentives for firms in less-endowed countries to secure their access to low-cost supplies. A common way of attempting to achieve this is through foreign direct investment. If the input is resource based, a firm in the high-cost (home) country may directly invest in production facilities in the low-cost country (foreign) so as to extract its own supplies of the resource. This would preclude vertical supply restrictions by foreign firms, but it does not rule out the possibility that the foreign

government might tax or otherwise restrict exports of the input with essentially the same outcome. In this situation our analysis suggests that a home country tariff set on imports of the final processed product might induce the foreign government to loosen its export restriction. A new consideration comes into play if the final processing activity is also footloose. An export restriction by the foreign country could serve the additional purpose of inducing the home firm to move its final production facilities to the foreign country, whereas a home country tariff on final product imports would have the opposite effect of encouraging both the home and foreign firms to locate their final production facilities in the home country.

Appendix

We first derive the home country welfare function and prove Propositions 2 and 3 of the text. We then briefly examine the implications of Bertrand competition with differentiated products.

Home country welfare is based on the additive utility function $W=u(Y)+z$, where $u(Y)$ is utility from the consumption of Y and z is utility from a numeraire good, produced by a competitive industry in which a constant marginal product of labor fixes the wage at \$1. We assume that the cost $C(x^h)$ (as well as $w^h y^h$) represents labor income. Profit π^h includes any above-normal returns, including the return to any specific factor, such as a resource, required for the production of x^h. Setting home country income (including the tariff revenue less subsidy payments) equal to expenditure and substituting for z in W, we obtain the usual welfare function used in partial equilibrium analysis:

$$W=u(Y)-pY+\pi^h+L+ty^f-\sigma x^h-sx, \tag{A.1}$$

where L is the total fixed supply of labor (and total wage bill).

Proof of Proposition 2. At the Cournot equilibrium, $W=W(r,t,s,\sigma)$ and, using $u'(Y)=p$ and $d\pi^h/dr=y^h p' y_r^f-x$, we obtain:

$$W_r=-(y^f p' Y_r+y^h p' y_r^h+x)+(ty_r^f-sx_r-\sigma x_r^h), \tag{A.2}$$

which is negative [from (7)] at $t=s=\sigma=0$. □

Proof of Proposition 3. Let s^F represent the critical value of s at which firm J just chooses foreclosure, then s^F satisfies (12) at $x=y^h-x^h=0$. If $t=\sigma=0$, then from (15) and (16), s^F satisfies

$$\pi^J_r(r^p, 0, 0, s^F) = y^h p' y^h_r - (r^p - c^f)x^h_r + (w^f - w^h)y^h_r + s^F x_r = 0. \tag{A.3}$$

If $s \leqq s^F$, then s is not paid. Since $\pi^J_{rs} = x_r < 0$, a small increase in s above s^F makes $\pi^J_r(r^p, 0, 0, s^F) < 0$, inducing vertical supply. Substituting s^F from (A.3) into (A.2) at $x = 0$, we obtain $W_r = -y^f p' Y_r - (r^p - c^f)x^h_r + (w^f - w^h)y^h_r < 0$ if $w^f - w^h \geqq 0$. Since $r^J_s < 0$ [from (24)], $dW/ds = W_r r^J_s - x > 0$ for a small increase in s above s^F. Given foreclosure at $s = 0$, the subsidy s^F is positive. □

Bertrand competition

The demand functions for home and foreign final products are $y^h = q^h(p^h, p^f)$ and $y^f = q^f(p^h, p^f)$, respectively. Own price effects, $q^h_h \equiv \partial y^h/\partial p^h$ and $q^f_f \equiv \partial y^f/\partial p^f$, are negative and cross price effects, q^h_f and q^f_h, are positive but smaller in magnitude. Home profit, $\Pi^h \equiv V^h(p^h, p^f)$, is given by (1) with p replaced by p^h. Foreign profit, $\Pi^f \equiv V^f(p^h, p^f)$, from final exports is given by (2) with p replaced by p^f. When Bertrand competition takes the standard form, the first-order conditions for the choice of p^h and p^f are

$$V^h_h(p^h, p^f) = y^h + (p^h - r - w^h)q^h_h = 0$$

and

$$V^f_f(p^h, p^f) = y^f + (p^f - t - c^f - w^f)q^f_f = 0. \tag{A.4}$$

Condition (A.4) *defines* $p^h = p^h(r, t)$ and $p^f = p^f(r, t)$ with partial derivatives $p^h_r = q^h_h V^f_{ff}/H^B > 0$, $p^f_t = q^f_f V^h_{hh}/H^B > 0$, $p^h_t = -q^f_f V^h_{hf}/H^B$ and $p^f_r = -q^h_h V^f_{fh}/H^B$, where $H^B = V^h_{hh} V^f_{ff} - V^h_{hf} V^f_{fh} > 0$.

Strategic effect of r. Analogously to (13) and (14) in the Cournot analysis,

$$\Pi^f_r(r, t) = y^f p^f_r + (p^f - t - c^f - w^f)\, dy^f/dr = (p^f - t - c^f - w^f)q^f_h p^h_r > 0. \tag{A.5}$$

From (A.4), a larger strategic effect is associated with a higher profit margin on final product exports and the strategic effect tends to be reduced by any policy that reduces this profit margin. If demand is linear, the strategic effect is reduced by the tariff, i.e. $S_t = \Pi^f_{rt} = -(1 - p^f_t)q^f_h p^h_r < 0$ since $1 - p^f_t = (2q^f_f q^h_h - q^f_h q^h_f)/H^B > 0$. When $q^h_f = q^f_h$, the reduction in the strategic term is not sufficient to outweigh the increase in home demand for the input and the input price rises: $r^J_t > 0$ since, analogously with (23), $\Pi^J_{rt} = dy^h/dt + \Pi^f_{rt} = q^h_h q^f_f (q^f_h)^3/H^B > 0$ using $dy^h/dt = q^h_h p^h_t + q^h_f p^f_t = q^h_h q^f_f q^h_f/H^B$ and (A.5).

In the modified Bertrand model presented by Spencer and Jones (1991), it can be shown that $\Pi^f_r = (p^f - t - c^f - w^f)q^f_h p^h_r - (r + s - c^f)q^h_f p^f_r$. Nevertheless, if demand is linear, $S_t = \Pi^f_{rt}$ reduces to the same expression as in the standard Bertrand model and is negative (as before).

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