NBER WORKING PAPER SERIES

VERTICAL FORECLOSURE AND INTERNATIONAL TRADE POLICY

Barbara J. Spencer

Ronald W. Jones

Working Paper No. 2920

NATIONAL BUREAU OF ECONOMIC RESEARCH
1050 Massachusetts Avenue
Cambridge, MA 02138
April 1989

This research is part of NBER's research program in International Studies. Any opinions expressed are those of the authors not those of the National Bureau of Economic Research.

NBER Working Paper #2920
April 1989

VERTICAL FORECLOSURE AND INTERNATIONAL TRADE POLICY

ABSTRACT

We examine conditions under which a low cost vertically integrated manufacturer has an incentive to export an intermediate product to its higher cost (vertically integrated) rival rather than to vertically foreclose, fully cutting off supplies. The nature of supply conditions in the importing country, the size of an import tariff on the final good and optimal policy by the exporting country are all shown to be important for this decision. The exporting country may gain by taxing exports of the final (Cournot) product even though, under Cournot competition, an export subsidy is optimal in the absence of a market for intermediates. In this case, optimal policy also requires an export tax on intermediates, but the higher tax on final goods serves to divert sales to the more profitable market for intermediates increasing the extent of vertical supply. It is optimal to tax the export of both goods or to subsidize the export of both goods. It is never optimal to tax one and subsidize the other.

Barbara J. Spencer
Faculty of Commerce
University of British Columbia
Vancouver, B.C. V6T 1Y8
CANADA

Ronald W. Jones
Department of Economics
University of Rochester
Rochester, NY 14627

VERTICAL FORECLOSURE AND INTERNATIONAL TRADE POLICY

BARBARA J. SPENCER AND RONALD W. JONES

In countries that are dependent on imports of a key intermediate product or raw material from a dominant world supplier there is often substantial concern about the price and the availability of imports. For example, Japanese suppliers (with the help of the Japanese government) recently restricted the exports of one megabite DRAM computer chips, substantially raising their price[1]. These suppliers control about 80% of the market for computer chips and the higher prices and shortage in supply have forced U.S. producers of computers to curtail production and increase prices. Vertically integrated Japanese firms such as Toshiba and N.E.C. have benefitted both from increased profits in the market for computer chips and from the improvement in their competitive position in the market for final computers.

This paper first examines the incentives for a vertically integrated firm to export an intermediate product to a higher cost foreign rival, lowering its rival's costs, rather than to engage in vertical foreclosure thus fully cutting off supplies[2]. The rival is also assumed to be vertically integrated, but it can produce the intermediate product only at a higher (and increasing) marginal cost. Differences in costs, which give rise to the possibility of vertical supply (the supply of an intermediate product to a rival), occur most naturally in an international context because of differences in endowments and technologies across countries. A firm in one country may have control over a cheaper source of supply of raw material or, as in the above example, it may have a superior technology in the production of an important manufacturing component, such as a computer chip.

We consider the most extreme form of dependence on a vertically integrated supplier by assuming that a single vertically integrated firm controls the exports of both the intermediate and final products. If the rival firm in the importing country has no independent source of supply, vertical foreclosure would allow the exporting firm to enjoy a monopoly in the market for the final good. In this situation, the exporting firm will choose vertical foreclosure. However, even a small tariff imposed on the import of the final good will induce the export of some of the intermediate product. If the rival firm has access to the intermediate good either through its own production or through imports, then sales of the final good in the importing country are determined by Cournot competition. The implications of Bertrand behaviour in the export market for the final product are considered in Appendix A.

The exporting firm is assumed able to act first by committing to an export strategy (price or quantity) for the intermediate product prior to the decision of the high cost firm as to its own level of production of the intermediate good and to the resolution of the Cournot output game for the final good. This means that the exporting firm is aware of its rival's optimal reaction to an increase in the export price (or a decrease in the export quantity) of the intermediate product based on its rival's alternative costs of production. The low cost firm is essentially in the position of a 'dominant supplier with a competitive fringe' in the export market for the intermediate product, but not for the final product.

The assumption that a foreign supplier has 'dominance' is intended as a first approach in examining the consequence for the importing country of a substantial dependence on foreign supplies. It has the advantage that the vertical supply (or foreclosure) decision is made with a full understanding of its consequences. Also, this setting allows us to highlight the importance of differing cost conditions for the production of the intermediate product in the importing country. Both the absolute quantities and the responsiveness of these supplies are shown to be important factors in the vertical supply decision.

In assessing the likely consequences of dependence on foreign supplies, it is important to examine public as well as private incentives in the exporting country. If the low cost firm chooses to supply the foreign rival, will 'government foreclosure' (government policy to prevent exports of the intermediate product) be in the interest of the exporting country? We show that if the exporting firm initially enjoys a higher profit margin from the export of the intermediate than the final product (as a consequence of an import tariff on the final good), government policy amplifies this difference which tends to increase the extent of vertical supply. Perhaps surprisingly, this policy is achieved by a tax, not a subsidy, on the exports of the intermediate product, together with a (larger) tax on the exports of the final product. Indeed, it is never optimal to subsidize the exports of one good and tax the exports of the other.

The possibility that an export tax on the final good may increase national welfare may be somewhat unexpected given the Spencer and Brander (1983) result that an export subsidy increases national welfare in a Cournot duopoly with one domestic and one foreign firm. We set out some simple conditions under which the presence of the export market for the intermediate product switches optimal policy from an export subsidy on the final good to an export tax. Conversely, if there is Bertrand competition for the final differentiated products, we show that the existence of vertical supply may make it optimal to subsidize the export of the final good.

Vertical foreclosure has been an important issue in the antitrust literature and in industrial organization. Two very interesting recent papers, Salinger (1988) and Ordover, Saloner and Salop (1988), show that vertical merger for the purpose of vertical foreclosure can be an effective strategy when there is imperfect competition in the market for both the intermediate and final products. In both these papers, producers of the intermediate product have identical and constant costs and vertical merger results in a full cutting off of supplies to downsteam firms[3]. In contrast, the present model demonstrates that asymmetries in costs can make vertical supply profitable for a dominant firm. If the supply of the intermediate good in the importing country is sufficiently elastic, then vertical supply[4] by the low cost firm is an equilibrium strategy even in the absence of commercial policy intervention by either country.

This paper is also related to the international trade literature concerning the optimal choice of commercial policy to exploit the relationship between exports of a final good and exports of an input used in its production, (see for example Kemp (1966), Jones (1967) and Jones and Spencer (1989)). However, this literature applies only to perfect competition and there is no consideration of the issue of vertical foreclosure. Finally, this paper draws on the literature concerning trade policy under imperfect competition. Of special relevence are Dixit (1984), Eaton and Grossman (1986), Grossman and Dixit (1986), Venables (1985) and Brander and Spencer (1985).

Section 2 of the paper contains the basic model and the second stage Cournot output equilibrium is described in Section 3. Section 4 is concerned with the conditions for vertical supply of the intermediate good. The optimal trade policies for the exporting country are derived in Section 5 and Section 6 contains some concluding remarks.

2. The Model

A vertically integrated firm, firm 1, in country 1 (potentially) exports the quantity x of an intermediate good and the quantity y_1 of a final good to country 2. Firm 2 in country 2 purchases x from firm 1 at a price r and also uses some of its own supplies x_2 of the (homogeneous) intermediate good to produce y_2 of the final good for domestic sale. The price p of the final good in country 2 is given by the inverse demand curve $p = p(Y)$ where $p'(Y) < 0$ and $Y = y_1 + y_2$ represents aggregate output. We abstract from the possibility that the final good is also sold in country 1. If the two markets are segmented, this involves no loss of generality.

Technological relationships are simplified by assuming that one unit of the intermediate good is required to produce one unit of the final good and that there are no other factors of production[5]. Firm 1 produces the intermediate good (and the final good) at a constant marginal cost c_1, whereas firm 2 can produce its own supplies of the intermediate good only at at a higher (and increasing) marginal cost. This means that $c_2 > c_1$ where c_2 denotes firm 2's marginal cost of production of x_2 at $x_2 = 0$. We assume that firm 2 is vertically integrated, but this is not necessary. The intermediate good could be supplied by an increasing cost competitive industry in country 2.

Export policy by country 1 is expressed by a specific subsidy s to exports of the final good and a specific tax v to exports of the intermediate product. The subsidy s and the tax v may be either positive or negative. Country 2 imposes a specific tariff t on imports of the final good. We can now write the total profit of firm 1 from the export of y_1 and x as,

$$\pi^1 = (p - (t-s+c_1))y_1 + (r - v - c_1)x. \qquad (2.1)$$

Firm 2's profit from the sale of y_2 is given by

$$\pi^2 = p(Y)y_2 - rx - C^2(x_2) \qquad (2.2)$$

where $y_2 = x + x_2$, and $C^2(x_2)$ represents the total cost of production of x_2.

Marginal cost $C^2_x(x_2)$ is assumed to be strictly increasing: $C^2_{xx}(x_2) > 0$.

The structure of decisions is identified by stages. In stage 0, country 1 commits to its export policies s and v and country 2 commits to its import tariff t. In stage 1, firm 1 commits to the price r that it will charge for the export of the intermediate good. Subsequently, the quantities y_1 and y_2 of the final good are determined by a Cournot (quantity Nash) equilibrium in stage 2. Firm 2 is free to import its desired quantity of the intermediate good at this stage, and to produce its own supplies.

The equilibrium of the game played by firms is subgame perfect[6]. In setting the export price for the intermediate product in stage 1, firm 1 takes into account both the subsequent (Cournot) Nash equilibrium in the market for the final good and the response of firm 2 in the production of its own supplies. This means that firm 1 takes full account of the effect of the export price r on the profits that it can earn from the sale of the final good. In particular, firm 1 can choose not to export the intermediate product (vertical foreclosure) by setting r at a prohibitive level.

Support for the credibility of this structure can be found by considering an alternative form of our model in which firm 1 commits to the level of exports (rather that to the price) of the intermediate good in stage 1. With quantity commitment in the first stage, the price received for exports is determined by a market clearing condition in stage 2 ensuring that demand equals total supply (including the quantity of the intermediate good that is produced in country 2). Exporting of the intermediate good takes time and these exports must be available at the time of production of the final good. However, production of the intermediate product for local use can take place contemporaneously with production of the final good. The level of exports of the intermediate good might then naturally be determined prior to the production of the intermediate good in country 2.

3. The Final Goods Market

This section is concerned with the equilibrium in the second stage of the model. Substituting for $x = y_2 - x^2$ in (2.2), firm 2's profit can be written as,

$$\pi^2 = (p - r)y_2 + rx_2 - C^2(x_2) \tag{3.1}$$

We first consider firm 2's choice between its own production of the intermediate good and use of imported supplies. Firm 2 chooses $x_2 \geq 0$ to maximize (3.1) for given levels of y_1, y_2 and r. Since $C^2_{xx}(x_2) > 0$, the profit function is stricly concave in x_2 and the optimal choice of x_2 satisfies the first order condition:

$$r - C^2_x(x_2) \leq 0 \quad (= 0 \text{ if } x_2 > 0) \tag{3.2}$$

If $x_2 > 0$, (3.2) implicitly defines the supply of x_2 as an increasing function of r: $x_2 = x^2(r)$ where $x^2_r = 1/C^2_{xx}(x_2) > 0$. If the marginal cost of production of x_2 everywhere exceeds the import price r, $C^2_x(0) = c_2 > r$, then firm 2 sets $x_2 = 0$ and produces using imported supplies only. This includes the special case in which production of x_2 is prohibitively expensive so that production by firm 2 requires the use of imported supplies.

At the stage 2 Cournot equilibrium for the final good, Firm 1 chooses its output y_1 to maximize (2.1), given y_2, $x = y_2 - x_2$ and the prior committed values of r, t, s, and v. Similarly, firm 2 chooses y_2 to maximize (3.1), given y_1, x_2, r, t, s and v. If $x_2 = 0$, then $y_2 = x$. The first order conditions are:

$$\pi^1_1(y_1, y_2, r, t-s, v) = p + y_1p' - (t-s+c_1) = 0 \tag{3.3}$$

$$\pi^2_2(y_1, y_2, r) = p + y_2p' - r = 0 \tag{3.4}$$

Solving (3.3) and (3.4) simultaneously, we obtain the Cournot equilibrium levels of output as functions of r, and t - s:

$$y_1 = y^1(r,t-s) \text{ and } y_2 = y^2(r,t-s) \quad (3.5)$$

The value of v affects y_1 and y_2 only through its influence on r, the export price of the intermediate good.

Own marginal profit is assumed to decline with an increase in the output of the other firm. That is,

$$\pi^1_{12} = p' + y_1p'' < 0 \text{ and } \pi^2_{21} = p' + y_2p'' < 0 \quad (3.6)$$

his is equivalent to the assumption that reaction functions are downward sloping. These conditions guarantee that the second order conditions for profit maximization hold.

$$\pi^1_{11} = 2p' + y_1p'' < 0 \text{ and } \pi^2_{22} = 2p' + y_2p'' < 0 \quad (3.7)$$

Moreover, conditions (3.6) imply

$$H = \pi^1_{11}\pi^2_{22} - \pi^1_{12}\pi^2_{21} = p'(3p' + Yp'') > 0 \quad (3.8)$$

which ensures that the Cournot equilibrium is unique.

The comparative static effects of an increase in r on y_1 and y_2 can be obtained from total differentiation of the first order conditions (3.3) and (3.4). These effects are signed using (3.6), (3.7) and (3.8).

$$y^1_r(r,t-s) = -\pi^1_{12}/H > 0 \text{ and } y^2_r(r,t-s) = \pi^1_{11}/H < 0 \quad (3.9)$$

Similarly, the response of y_1 and y_2 to changes in s and t are given by

$$y^1_s = -y^1_t(r,t-s) = -\pi^2_{22}/H > 0 \text{ and } y^2_s = -y^2_t(r,t-s) = \pi^2_{21}/H < 0. \quad (3.10)$$

Also, from (3.9) and (3.10), industry output is decreasing in r, increasing in s and decreasing in t:

$$Y_r(r,t-s) = p'/H < 0 \text{ and } Y_s = -Y_t(r,t-s) = -p'/H > 0 \quad (3.11)$$

Finally, a unit increase in r increases the price of the final good but by less than one unit. From (3.6), (3.8) and (3.11),

$$d(r-p)/dr = 1-p'Y_r = p'(2p'+Yp'')/H > 0 \quad (3.12)$$

In otherwords, an increase in r increases $r-c_1 - (p-t-c_1) = r-p+t$, the difference between the profit margins that firm 1 earns from the export of the intermediate and final products. This difference in profit margins features prominently in the subsequent results.

4. The Intermediate Goods Market: Vertical Foreclosure or Vertical Supply

The demand by firm 2 for imports of the intermediate good from firm 1 is firm 2's output of the final good at the Cournot-Nash equilibrium less its own production (if any) of the intermediate good.

$$x(r,t-s) = y^2(r,t-s) - x^2(r) \tag{4.1}$$

The exporting firm, firm 1, is aware of this actual demand for imports when it chooses r in stage 1. An increase in r tends to reduce the demand for imports of the intermediate good, both because it decreases firm 2's final output and because it induces firm 2 to produce more of the intermediate good. Also, from (3.10), the demand for x is decreasing in s and increasing in t:

$$x_r(r,t-s) = y^2_r - x^2_r < 0 \text{ and } x_s = -x_t(r,t-s) = y^2_s < 0\,. \tag{4.2}$$

Vertical foreclosure occurs if firm 1 sets a prohibitive price r^p for the intermediate good. Setting $x(r^p,t-s) = 0$ implicitly defines $r^p = r^p(t-s)$ where,

$$r^p_s = -r^p_t(t-s) = -y^2_s/x_r < 0 \tag{4.3}$$

The prohibitive export price for the intermediate good is decreasing in s and increasing in t. An increase in s decreases firm 2's marginal profits from its output y_2 and therefore decreases firm 2's demand for imports x.

At $r = r^p$, firm 2 produces y_2 using only its own production of the intermediate good and, from (3.4), $y_2 = x_2$ satisfies,

$$p + x_2 p' = r^p \tag{4.4}$$

If the production of x_2 is prohibitively expensive at $r = r^p$, then (from (3.2) $x_2 = 0$ and (4.4) implies that $r^p = p$. Vertical foreclosure then gives firm 1 monopoly power in the market for the final good[7].

Firm 1's profit at stage 1 can be written directly as a function of the export price r and trade taxes and subsidies, t, s, and v set in stage 0. Let π^E represent this function (where E stands for the exporting firm), then

$$\pi^1 = \pi^E(r,t-s,v) = (p-t+s-c_1)y^1(r,t-s) + (r-v-c_1)x(r,t-s) \qquad (4.5)$$

From differentiation of (4.5) using (3.3), the effect of an increase in r on π^E is,

$$\pi^E_r = (r-v-c_1)x_r + x + y_1p'y^2_r \qquad (4.6)$$

The first two terms of (4.6) represent the direct effect of an increase in r on the profits of firm 1 from the export of the intermediate good. The third (positive) term captures the 'strategic effect' of r on the profits earned from the export of the final good. Since $y^1_r > 0$ and $Y_r < 0$, an increase in r increases both the volume and the price of exports of the final good.

In stage 1, firm 1 chooses r to maximize π^E subject to $r \leq r^p$. To obtain the conditions for a maximum, define the Lagrangean $L = \pi^E + \mu(r^p(t-s) - r)$ where μ represents the Lagrange multiplier. The first order conditions for a maximum are then,

$$L_r = \pi^E_r - \mu = 0 \text{ and } L_\mu = r^p(t-s) - r \geq 0,\ \mu \geq 0,\ L_\mu.\mu = 0 \qquad (4.7)$$

We assume that π^E is strictly concave[8] for all $r \leq r^p$, ensuring that π^E achieves a global maximum whenever the first order conditions are satisfied.

If $\pi^E_r(r^p,t-s,v) < 0$, a reduction in r below r^p increases π^E and, from (4.7), vertical supply occurs ($r < r^p$) and the Lagrange multiplier $\mu = 0$. At a vertical supply equilibrium, $\pi^E_r(r,t-s,v) = 0$ implicitly defines $r = r(t-s,v)$ with partial derivatives,

$$r_s(t-s,v) = -r_t(t-s,v) = \pi^E_{rt}/\pi^E_{rr} \text{ and } r_v(t-s,v) = -\pi^E_{rv}/\pi^E_{rr} > 0. \qquad (4.8)$$

The sign of r_v follows from $\pi^E_{rv} = -x_r < 0$. An increase in the export tax v increases the price r paid by firm 2 for imports of the intermediate product[9].

If $\pi^E_r(r^p,t-s,v) = 0$, then $r(t-s,v) = r^p(t-s)$ with $\mu = 0$ and vertical foreclosure occurs. Finally, if $\pi_r^2(r^p, t-s, v) > 0$, then $\mu > 0$, and r is constrained at the foreclosure level $r^p(t-s)$.

To examine the conditions underlying the vertical supply or foreclosure decision, it is useful to rearrange (4.6), using (4.2) and (3.3), to obtain,

$$\pi_r^2 = (r-p+t-(s+v))y_r^2 + x - (r-v-c_1)x_r^2 \qquad (4.9)$$

Let $\epsilon_r = rx_r^2/x_2 \geq 0$ represent the elasticity of supply of x_2 in country 2. Also define $\eta_r = -ry_r^2/y_2 > 0$ to be the (positive) elasticity (with respect to an increase in r) of the derived demand for the intermediate product. Then, from (4.7) and (4.9), firm 1 chooses vertical supply if and only if

$$\pi_r^2(r^p, t-s, v) = -(y_2/r^p)[(r^p-p+t-(s+v))\eta_r + (r^p-v-c_1)\epsilon_r] < 0 \qquad (4.10)$$

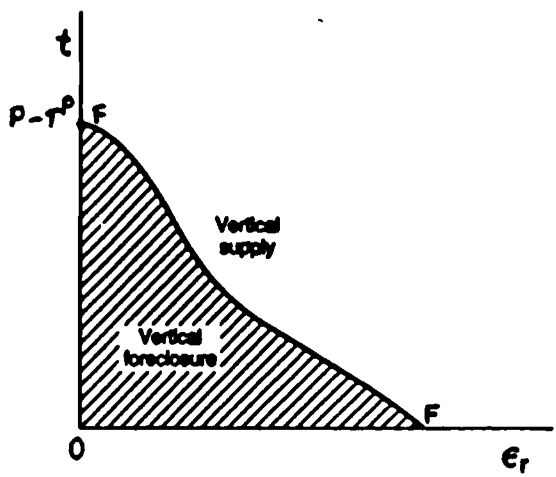

Figure 1

Prior to the imposition of trade policy by the exporting country (s=v=0), from (4.10), the boundary at which vertical foreclosure just occurs is given by

$$t = p - r^p - (r^p-c_1)\epsilon_r/\eta_r \qquad (4.11)$$

This boundary condition is illustrated by the curve FF in Figure 1. Along the horizontal axis of Figure 1, the supply curve for x_2 is assumed to shift so as to increase ε_r at r^p, but to maintain $x_2 = x^2(r^p)$ fixed. That is, the supply curve for x_2 is assumed to rotate clockwise at $r = r^p$ ensuring that, as ε_r is increased, r^p and the values of x_2, p, and η_r evaluated at r^p do not change. FF is negatively sloped if demand is not too non linear[10]. The region of vertical foreclosure is shown by the shaded area to the left of FF. The area strictly to the right of FF represents the region of vertical supply.

Whether vertical foreclosure occurs is heavily influenced by production conditions for the intermediate good in the importing country as well as by the tariff. We consider two important aspects of local production conditions: the total quantity $x^2(r^p)$ of supplies available at the foreclosure point and the responsiveness of these supplies as measured by ε_r.

From (4.4), $p - r^p = -x^2(r^p)p'$ and the quantity $x^2(r^p)$ affects the size of the price spread $p - r^p$. From (4.11), this price spread in turn determines the point at which the boundary FF intersects the vertical axis of Figure 1. If $t > p - r^p$, then firm 1 earns a strictly higher profit margin from the export of the intermediate than the final good at $r = r^p$ and firm 1 chooses vertical supply.

If country 2 has no independent source of supply of the intermediate product, then $x_2 = 0$, the price difference $p - r^p = 0$ and FF reduces to a point at the origin of Figure 1. If the tariff $t = 0$, then the equilibrium is at the origin and firm 1 chooses vertical foreclosure. However, any positive tariff will induce vertical supply. A small tariff on exports of the final good decreases the profit margin on sales of the final good and gives firm 1 an incentive to get 'under' the tariff wall by supplying the good produced at a lower stage of production.

If country 2 can produce a positive but fixed quantity of x_2 at the foreclosure point (that is if the supply curve $x^2(r^p)$ is vertical[11] at r^p), firm 1 may choose vertical foreclosure even if t is positive. An exogenous increase in the fixed quantity of supplies shifts up the point at which FF intersects the vertical axis in Figure 1 increasing the range of t at which there is vertical foreclosure (with $\epsilon_r = 0$). This occurs because a higher level of x_2 lowers the value of r^p at which firm 2 chooses not to import x reducing the profit margin that firm 1 can earn from the export of the intermediate product. Vertical foreclosure is thus more likely if an importing country has a larger (but fixed) quantity of its own supplies of the intermediate product.

These results are reported in Proposition 1 together with the sign of the profit margin condition $r(t,0)-p+t$ at the vertical supply equilibrium should it occur. As shown in the next section, the sign of this profit margin condition is important for optimal export policy by country 1.

<u>Proposition 1</u> (assume $s=v=0$)

Suppose that the importing country can produce only a fixed quantity $x_2 \geq 0$ of the intermediate good ($\epsilon_r = 0$), then

(i) The condition $r^p-p+t > 0$ is necessary and sufficient for vertical supply. At a vertical supply equilibrium, firm 1 earns a higher profit margin from the export of the intermediate good than the final good: $r(t,0)-p+t > 0$.

(ii) In the absence of a tariff, firm 1 will vertically foreclose.

(iii) If $x_2 = 0$, a small tariff will induce vertical supply.

(iv) An exogenous increase in x_2 increases the range of tariff values at which vertical foreclosure occurs.

<u>Proof</u>: (i) With $\epsilon_r = 0$, and $s=v=0$, (4.10) holds if and only if $r^p-p+t > 0$. At a vertical supply equilibrium, $\pi^E_r(r(t,0),t,0) = 0$ and (4.9) with $x^2_r = 0$ and $s=v=0$ implies $r(t,0)-p+t > 0$. (ii) From (4.4), $r^p-p+t = x_2p'+t \leq 0$ at $t = 0$ for any $x_2 \geq 0$

and vertical foreclosure occurs from Proposition 1(i). (iii) If $x_2 = 0$ and $t > 0$, $r^p - p + t = t > 0$ and vertical supply occurs from Proposition 1(i). (iv) If $\varepsilon_r = 0$ at r^p, the boundary condition (4.11) becomes $t = p(Y(r^p, t)) - r^p$ where $r^p = r^p(t, x_2)$ as defined by $y^2(r^p, t) - x_2 = 0$. An increase in x_2 increases the boundary value of t since $dt/dx_2 = -(1-p'Y_r)dr^p/dx_2/(1-p'Y_t+(1-p'Y_r)r^p_t) > 0$. The sign follows since $1-p'Y_r = 1-p'Y_t > 0$ from (3.11) and (3.12), $r^p_t > 0$ and $dr^p/dx_2 = 1/y^2_r < 0$. ***

Now consider the case where $\varepsilon_r > 0$ and supplies of the intermediate good are responsive to price. As illustrated in Figure 1, an increase in the responsiveness of supplies in country 2 or a higher tariff tends to move the equilibrium towards vertical supply.

__Proposition 2__ (assume $s=v=0$ and $\varepsilon_r > 0$)

(i) For any given t, an increase in ε_r, holding $x^2(r^p)$ fixed, moves the equilibrium towards vertical supply. Vertical supply occurs if $\varepsilon_r > -(r^p - p + t)\eta_r/(r^p - c_1)$.

(ii) A sufficiently large value of t will induce the export of the intermediate product.

__Proof__: (i) From (4.10), with t and $x^2(r^p)$ fixed, $d\pi^E_r(r^p(t), t, 0)/d\varepsilon_r = -x^2(r^p)(r^p - c_1)/r^p < 0$. At the boundary FF, $\pi^E_r(r^p, t, 0) = 0$, and an increase in ε_r will make $\pi^E_r(r^p, t, 0) < 0$ inducing vertical supply. The stated condition for ε_r follows from (4.10). (ii) Since $1-p'Y_r = 1-p'Y_t > 0$ from (3.11) and (3.12), $d(r^p(t)-p+t))/dt = r^p_t(1-p'Y_r) + 1-p'Y_t > 0$. Hence, a sufficiently large value of t will make $r^p(t) - p + t \geq 0$, which, from (4.10), is a sufficient condition for vertical supply.***

Proposition 2(i) indicates that if ε_r is sufficiently large, the equilibrium wil be one of vertical supply even in the absence of a tariff. Why does a larger value of ε_r tend to move the equilibrium towards vertical supply? Generally, a reduction in r below r^p increases firms 2's level of output boosting its demand for x, but, at the same time, reducing the production of x_2. As ε_r becomes larger, the extent of the substitution between the two sources of supply of the intermediate good increases. For a given reduction in r, firm 1 achieves a greater increase in its sales of x for the same increase in firm 2's output of the final good.

It is useful to consider the special case in which $\varepsilon_r = \infty$ (infinitely elastic supply). In this case, the marginal cost of production of x_2 is constant at c_2 and firm 2 sets $x_2 = 0$, using imports x only, if $r < c_2$ and produces y_2 using its own supplies otherwise. The prohibitive export price r^p of the intermediate good equals c_2. Firm 1 can always gain (relative to vertical foreclosure) by supplying the intermediate product at a price r just below c_2, since it then earns positive profits from the export of x and this supply has no effect on firm 2's marginal cost of production of the final good[12]. This implies that there is always vertical supply in equilibrium even without a tariff.

This result is related to a Katz and Shapiro (1985) proposition concerning the licensing of a superior technology by a Cournot duopolist under constant returns to scale. They show that an innovating firm will always licence a superior technology to its rival provided the license contract can include a per unit royalty charge as well as a fixed fee. The per unit royalty charge can be set so as to leave the rival's marginal cost unaffected (as in our model) and the fixed fee can be used to distribute the net gain from the reduction in the cost of the rival's production. Katz and Shapiro (1985) do not analyse the implications of increasing costs of production in the rival firm or the effects of trade policy.

Also, in this special case with $\varepsilon_r = \infty$, the equilibrium outcome is the same as would occur if there were a Bertrand equilibrium in the market for the homogeneous intermediate product in Stage 1 and a Cournot equilibrium (as before) in Stage 2. The Bertrand supplier in country 2 sets its price equal to its marginal cost c_2, but it supplies zero in equilibrium since it is in the interests of firm 1 to undercut. However, there is Edgeworth instability and no pure strategy equilibrium under Bertrand competition if $\varepsilon_r < \infty$.

Returning to our main case where $0 < \varepsilon_r < \infty$ and s=v=0, Proposition 3 sets out the conditions under which the equilibrium is one of vertical supply or, alternatively, vertical foreclosure. Note that in Proposition 3(ii), the firm engages in vertical supply despite the fact that the profit margin from the export of the intermediate product at the foreclosure point falls short of the profit margin from the export of the final product. Proposition 3 also characterizes the conditions under which firm 1 earns a higher (or lower) profit margin from the export of the intermediate product than the final product at a vertical supply equilibrium. Generally, this difference in profit margins is negative only at high values of ε_r.

<u>Proposition 3</u> (assume s=v=0 and $\varepsilon_r > 0$)

(i) if $r^p(t)-p+t \geq 0$, then firm 1 chooses vertical supply and at the vertical supply equilibrium (a) $r(t,0)-p+t > 0$ if $\varepsilon_r < rx/(r-c_1)x_2$ and (b) $r(t,0)-p+t < 0$ if $\varepsilon_r > rx/(r-c_1)x_2$.

(ii) if $r^p(t)-p+t < 0$ and $\varepsilon_r > (r^p(t)-p+t)\eta_r/(r^p(t)-c_1)$, then firm 1 chooses vertical supply and $r(t,0)-p+t < 0$ at the vertical supply equilibrium.

(iii) if $r^p(t)-p+t < 0$ and $\varepsilon_r \leq (r^p(t)-p+t)\eta_r/(r^p(t)-c_1)$, then firm 1 chooses vertical foreclosure.

<u>Proof</u>: i) From (4.10), $r^p(t)-p+t \geq 0$ is a sufficient condition for vertical supply. From (4.9) at s=v=0, $r(t,0)-p+t > 0$ if $x - (r(t,0)-c_1)x_r^2 > 0$. Rearrangement of this last expression yields parts (a) and (b). (ii) Condition (4.10) holds under these conditions. Also since $d(r-p+t)/dr > 0$ from (3.12), and $r(t,0) < r^p$, we have $r(t,0)$-

$p+t < 0$. (iii) Under these conditions, from (4.10), $\pi^E_r(r^P(t),t,0) \geq 0$.***

5. Optimal Export Policy by Country 1

This section is concerned with the implications of the vertical connection between export markets for welfare maximizing export policies in country 1.

The welfare or objective function in country 1 is,

$$W(r,t-s,v) = \pi^E(r,t-s,v) - sy_1(r,t-s) + vx(r,t-s) \tag{5.1}$$

where $r = r(t-s,v) \leq r^P(t-s)$ (with the Lagrange multiplier $\mu = 0$ from (4.7) and vertical supply if strictly less than) or $r = r^P(t-s)$ (with $\mu > 0$ and vertical foreclosure). Since all of y_1 and x is exported, country 1 gains by maximizing the profit of firm 1 less any net subsidy (or plus any net tax payment).

Although $W(r,t-s,v)$ is continuous, the total derivatives, dW/ds and dW/dv are not continuous at $r = r^P(t-s)$. This arises from the fact that if a change in s or v maintains r at $r^P(t-s)$ (with $\mu \geq 0$) then exports x remain at zero:

$$dx(r^P,t-s)/ds = x_r r^P_s + y^2_s = 0 \text{ and } dx(r^P,t-s)/dv = 0 \tag{5.2}$$

whereas if $\mu = 0$ and r is reduced below r^P, then $dx(r^P,t-s)/ds = x_r r_s(t-s,v) + y^2_s$ and $dx(r^P,t-s)/dv = x_r r_v(t-s,v)$, which are not generally zero. It is therefore convenient to consider optimal export policies in situations of vertical supply separately from optimal policies under vertical forceclosure. This is done in subsections A and B respectively. Finally, we examine globally optimal policy in subsection C allowing for the possibility that the government in country 1 may shift the equilibrium from vertical supply to vertical foreclosure or vice versa.

A. Policy under Vertical Supply

We first consider the effect of an export subsidy to the final good on the profit earned by firm 1 and on welfare in the exporting country. Differentiating (4.5) assuming y_1 is chosen optimally, and imposing $\pi^E_r = 0$, the total effect of an increase in s on π^E is

$$\pi^E_s(r,t-s,v) = (r(t-s,v)-v-c_1)y^2_s + y_1 + y_1p'y^2_s > 0 \qquad (5.3)$$

From (5.1), and (5.3) substituting for y_1p'(from (3.3)), the total effect of an increase in s on welfare in country 1 is

$$dW/ds = [(r-c_1 - (p-t+s-c_1)]y^2_s - sy^1_s - (sy^1_r - vx_r)r_s = 0 \qquad (5.4)$$

The standard role for an export subsidy (originally derived by Spencer and Brander (1983)) can be seen by considering equation (5.4) when $v = 0$ and s is initially zero. Ignoring the presence of the intermediate good market (as reflected by the term $(r-c_1)y^2_s$), it can be seen that a small subsidy to the final good raises welfare because it reduces the output of the rival firm in a market where firm 1 enjoys a positive profit margin. As Spencer and Brander (1983) show, the optimal export subsidy for a Cournot (duopoly) firm makes it credible for the exporting firm to produce what would have been the Stackelberg leader level of output in the absence of a subsidy.

However, the export market for the intermediate product introduces an opposing effect of s on profit and welfare. A positive value of s causes a contraction in demand by the rival firm for the intermediate product reducing the profits that firm 1 earns from vertical supply. As revealed by (5.4), if firm 1 earns a higher profit margin from the export of the intermediate than the final product, then welfare is increased by a small tax on exports of the final product. For any given r, this serves to switch sales from the final goods market to the more profitable market for intermediates.

We now consider country 1's optimal policy towards the exports of the intermediate product. From (5.1), using $\pi^E_v = -x$ and $\pi^E_r = 0$, the first order condition for the choice of the export tax v is $dW/dv = (vx_r-sy^1_r)r_v = 0$. This defines the optimal value[13] of v as a function of s:

$$v(s) = sy^1_r/x_r \qquad (5.5)$$

If there were no tax or subsidy to final goods trade, (5.5) indicates that there would be no gain from government intervention in the market for intermediates. Also, active commercial policy requires a subsidy to both exports or a tax to both exports. It is never optimal to subsidize exports of the final product and to tax exports of the intermediate product or vice versa.

A subsidy to exports of the final product creates a wedge between firm 1's objective function and welfare in country 1, distorting firm 1's choice of the export price r. Firm 1 ignores the effect of an increase in r on the net cost of the subsidy to taxpayers. The export price r is set above the optimal level so as to increase y_1 and the total subsidy received. Since $r_v > 0$ (see (4.8)), this is corrected by setting $v < 0$, that is by also subsidizing the export of the intermediate product. At the optimal value of v, a small change in r has no effect on the total subsidy payment for both exports ($d(vx-sy_1)/dr = vx_r - sy_r^1 = 0$) and there is no distortion in the choice of r. A small increase in r increases the subsidy payment by increasing y_1 but this is just offset by a lower subsidy payment because of the reduction in exports x.

If both s and v are chosen optimally then from (5.4) and (5.5), the optimal value of s satisfies the first order condition,

$$dW/ds = [r(t-s,v(s)) - p + t]y_s^2 - sY_s = 0 \qquad (5.6)$$

That is, at the optimum, $s = (r - p + t)y_s^2/Y_s$. Proposition 4 sets out Country 1's jointly optimal policy towards the exports of firm 1 given initial vertical supply.

<u>Proposition 4</u> (assume vertical supply at s=v=0)

It is optimal for country 1 to

(i) tax the exports of both products if firm 1 earns a higher profit margin from the export of the intermediate than the final product at s=v=0:

$$s < 0 \text{ and } v = v(s) > 0 \text{ if } r(t,0) - p + t > 0 \qquad (5.7)$$

(ii) subsidize the exports of both products if firm 1 earns a lower profit margin from the export of the intermediate than the final product at $s=v=0$:

$$s > 0 \text{ and } v = v(s) < 0 \text{ if } r(t,0) - p + t < 0 \qquad (5.8)$$

Proof: From (5.4) at $s=v=0$, $dW/ds < 0$ if $r(t,0)-p+t > 0$ and $dW/ds > 0$ if $r(t,0)-p+t < 0$.***

Given initial vertical supply, we know from Propositions 1(i) and 3(i) that $r(t,0)-p+t > 0$ if independent supplies x_2 are not too responsive to price and t is positive. From Proposition 4, it is optimal to tax both exports in this case. High values of ε_r are associated with the subsidization of both exports.

Since s is larger than v in absolute value (from (5.5) and $|y_r^1/x_r| < 1$), the direction in which commercial policy aims to switch trade flows is generally indicated by the sign of s. There is some ambiguity in the response of exports to a change in s when v is set optimally, but under linear demand and supply conditions, an increase in s, maintaining $v = v(s)$, causes a net expansion in exports of the final product and a reduction in exports of intermediates[14]. If s is positive, then both exports are subsidized, but sales of the final good are given relatively more encouragement since, with $s + v > 0$, firm 1's enjoys a greater increase in its profit margin from the export of the final than the intermediate good.

Since s is positive if and only if firm 1 initially earns a lower profit margin from the export of the intermediate than the final good ($r(t,0)-p+t < 0$), it follows that the net effect of government intervention is to widen or amplify the initial difference in relative returns. With linear demand and supply, optimal policy then serves to expand the export of the good with the higher profit margin and to contract the export of the good with the lower profit margin.

B. **Policy Under Vertical Foreclosure**

We now consider optimal policy for the case where $\mu \geq 0$ and $r = r^P(t-s)$. From (4.7), $\mu \geq 0$ implies $\pi_r^E(r^P,t-s,v) \geq 0$ in equilibrium. From differentiation of (5.1), using (4.6),(5.2),(5.3) and $\pi_v^E = -x$, the first order conditions for a local maximum of welfare reduce to:

$$dW/ds = y_1p'dy_2/ds - sdy_1/ds = 0 \text{ and } dW/dv = 0 \text{ for all } v \qquad (5.9)$$

where $dy_2/ds = y_r^2r_s^P + y_s^2 = x_r^2r_s^P \leq 0$ ($= 0$ if $x_2 = 0$), and $dy_1/ds = y_r^1r_s^P + y_s^1 > 0$. If $y_2 = x_2(r^P) > 0$, an increase in s reduces the Cournot equilibrium level of y_2 holding r constant ($y_s^2 < 0$), but r^P and marginal cost $C_x^2(x_2) = r^P$ also falls with the cut back in x_2. The net effect is a reduction in y_2 and an increase in y_1 so that the optimal value of s satisfies: $s = y_1p'(dy_2/ds)/(dy_1/ds) > 0$. This is the Spencer and Brander (1983) result that an export subsidy increases profit in a Cournot duopoly. If $x_2 = 0$, vertical foreclosure gives firm 1 a monopoly of the market for the final good and no policy intervention is called for.

C. **Globally Optimal Policy**

The previous sections have been concerned with optimal policy towards exports given the vertical supply or vertical foreclosure decision of firm 1 at s=v=0. However, the discontinuities in dW/ds and dW/dv at $r = r^P(t-s)$ mean that these local policies may not be globally optimal. This section develops globally optimal policy for country 1. A main question is whether 'government foreclosure' could be in the interests of the exporting country. Could country 1 gain by inducing foreclosure in situations where firm 1 chooses vertical supply. In addition to our usual assuption that $C_{xx}^2 > 0$, we assume throughout this section that demand for the final good and supply of the intermediate good in country 2 is linear ($p''(Y) = 0$ and $x_{rr}^2 = 0$), much simplifying the analysis.

In order to link the two branches of policy, it is useful to define a critical value of $s = \bar{s}$, satisfying $\pi_r^E(r^P, t-\bar{s}, v(\bar{s})) = 0$, at which vertical foreclosure just occurs. Maintaining $r = r^P(t-s)$ and $v = v(s)$ as in (5.5), from differentiation of (4.9), using $x = 0$, $Y_s = -Y_r$, $y_{rs}^2 = 0$, $x_{rr}^2 = 0$ and $r_s^P < 0$,

$$d\pi_r^E(r^P, t-s, v(s))/ds = (y_r^2(1-p'Y_r) - x_r^2)r_s^P + Y_s(1-p'y_r^2) > 0 \qquad (5.11)$$

From (5.11), a reduction in s below $\bar{s}$ reduces $\pi_r^E(r^P, t-s, v(s))$ making it negative and inducing vertical supply. Similarly, it can be shown that an increase in s above $\bar{s}$, with $v = v(\bar{s})$ fixed, increases $\pi_r^E(r^P, t-s, v(s))$ and maintains vertical foreclosure. If $s < \bar{s}$ and $v = v(s)$, we have a vertical supply equilibrium and the effect of a change in s on welfare is given by (5.6). Alternatively, if $s \geq \bar{s}$, we have vertical foreclosure, and holding v fixed at $v = v(\bar{s})$, the effect of an increase in s on welfare is given by (5.9)[15].

Propositions 5 and 6 are concerned with the globally optimal policy for country 1, taking into account that a suitable choice of policy could result in either vertical foreclosure or vertical supply in equilibrium. The proofs of these propositions are in Appendix B.

<u>Proposition 5</u>: (Assume $p''(Y) = 0$ and $x_{rr}^2 = 0$)

(i) The globally optimal policy for country 1 is to tax the exports of both goods ($s < 0$ and $v = v(s) > 0$), and to maintain vertical supply if, at $s=v=0$, (a) $\varepsilon_r = 0$ and $r^P-p+t > 0$, or (b) $r^P(t)-p+t \geq 0$ and, at the initial vertical supply equilibrium, $0 < \varepsilon_r < rx/(r-c_1)x_2$.

(ii) The globally optimal policy is to subsidize the exports of both goods ($s > 0$ and $v = v(s) < 0$) and to maintain vertical supply if, at $s=v=0$, $r^P(t)-p+t \geq 0$ and, at the initial vertical supply equilibrium, $\varepsilon_r > rx/(r-c_1)x_2$.***

Proposition 5 shows that for a wide class of cases where there is initial vertical supply, either taxes or subsidies may be optimal, but it is not in country 1's interest to induce vertical foreclosure. If there is initial vertical supply and the elasticity of supply of x_2 is small, the profits of firm 1 are increased by taxing the exports of both goods. At a larger elasticity of supply of x_2, the globally optimal policy switches to an export subsidy for both goods, but as long as $r^p(t)-p+t \geq 0$, the subsidy to the final good is not so large as to cause vertical foreclosure.

An important element in the proof of Proposition 5 is to show that the profit margin from the sale of the intermediate good exceeds the profit margin from the sale of the final good at $s = \bar{s}$, the point at which foreclosure just occurs: $r^p(t-\bar{s})-p+t > 0$. If $\bar{s} > 0$, this is a sufficient condition for the global optimality of vertical supply. It is possible that this condition does not hold for the one case of initial vertical supply not covered by Proposition 5. This is the case listed in Proposition 3(ii) in which ϵ_r is sufficiently large to induce vertical supply at $s=v=0$ even though the profit margin on the final good exceeds the profit margin on the intermediate good at $r = r^p(t)$. It is then possible that $r^p(t-\bar{s})-p+t < 0$, and, from (5.6), we may have $dW/ds > 0$ at $s = \bar{s}$ if $\bar{s}$ is small. In this eventuality, government foreclosure is the globally optimal policy.

Proposition 6 shows that if firm 1 has chosen vertical foreclosure initially, then it is always in country 1's interest to maintain foreclosure.

<u>Proposition 6:</u> (Assume $p''(Y) = 0$ and $x^2_{rr} = 0$)

If there is vertical foreclosure at $s=v=0$, it is optimal for country 1 to maintain foreclosure. (a) If $x_2 = 0$ and $t = 0$, no policy intervention is called for. (b) If $\epsilon_r > 0$, and $\pi^E_r(r^p(t),0,0) \geq 0$, then the optimal policy is to subsidize the export of the final good.***

<u>6. Conclusion</u>

Many large manufacturing firms have secured their access to important intermediate products by integrating backwards so as to produce the intermediate product within the corporation. If the intermediate product can be produced more cheaply in one country than another, then vertical integration can give firms in one country a cost advantage relative to foreign rivals. Such differences of cost are a natural consequence of differences in endowments and technology across countries. This leads to the question as to whether high cost manufacturers need be concerned about dependence on imports of a key intermediate input from a country that is also a major exporter of the final manufactured product.

This paper addresses this issue by first examining the conditions under which a low cost vertically integrated manufacturer will export an intermediate product, lowering the costs of a rival producer of the final product. We show that the tendency towards vertical supply is increased both by a greater responsiveness of supplies in the importing country and (more surprisingly) by a reduction in the total (fixed) quantity of supplies available at the foreclosure point. Also, an import tariff on the final good increases the incentive for vertical supply. In Appendix A, we show that these general tendencies continue to hold if there is Bertrand rather than Cournot competition for the final differentiated products.

Secondly, we consider the implications of optimal government policy in the exporting country for the vertical supply decision. Although the exporting firm can optimize on its own by setting the export price for the intermediate product prior to the determination of the second stage levels of production of the final good, there is still a role for government. With Cournot competition in the market for the final good, this role is partly a consequence of the fact that an export subsidy increases domestic welfare in a Cournot duopoly. However, the vertical connection between markets opens up the possibility that final export sales should be taxed instead of subsidized. Such an outcome is a consequence of a higher profit margin from the export of the intermediate than the final good (arising from a sufficiently high tariff on imports of the final good). Although the optimal commercial policy in such a case is to tax both exports, the relatively higher tax on final goods serves to divert sales to the more profitable market for intermediates increasing the extent of vertical supply.

Overall, our results indicate that in a broad class of cases a high cost firm need not be concerned about full vertical foreclosure. Nevertheless, the price at which foreign supplies of the intermediate product can be imported may be high. The analysis is based on the assumption that a single vertically integrated firm controls the exports of both products from country 1. If this assumption is relaxed, allowing for more than one vertically integrated exporter from the low cost country, then it seems reasonable to conjecture that increased competition from exporters would increase the extent of vertical supply.

Another direction in which the results could be generalized would be to consider the potential for bargaining between the low cost and high cost firm concerning the price and quantity of exports of the intermediate product. If there is a tariff on the import of the final good, the joint profit maximizing solution would be for firm 1 to export the intermediate product only, giving firm 2 a monopoly of the market for the final good in country 2. However, this solution would require non linear pricing and may be difficult to enforce.

Merger between the two firms would seem to be a better means of achieving this outcome, but it may be ruled out by antitrust policy. If the possibility is admitted that there may be more than one rival firm in the importing country, it may not be possible to monopolize the industry fully making the merger solution less attractive. Even if remains profitable to merge, there is then still the issue of whether to supply the remaining rival firms.

Appendix A

It is useful to consider briefly the implications of Bertrand rather than Cournot competition in the market for the final product. The demand curves for the final differentiated products y_1 and y_2 are assumed to be linear and are represented by

$$y_1 = a - b_1p_1 + d_1p_2 \text{ and } y_2 = a - b_2p_2 + d_2p_1. \tag{A.1}$$

The outputs y_1 and y_2 have prices p_1 and p_2 respectively and the constants a, b_1, b_2, d_1, d_2 are all positive with b_1 and b_2 strictly greater than d_1 and d_2. For reasons of brevity, we consider only the policies t and s. From (A.1) and (2.1) with p replaced by p_1, the first order condition for the second stage choice of p_1 by firm 1 given p_2 and r, t and s is,

$$\pi_1^1(p_1, p_2, r, t-s) = y_1 - (p_1-c_1-t+s)b_1 + (r-c_1)d_2 = 0 \tag{A.2}$$

The presence of the export market for the intermediate product has a fundamental effect on firm 1's choice of its export price p_1 under Bertrand competition. As shown by the positive third term of (A.2), firm 1 recognizes that an increase in its export price p_1 will increase its profits from the export of the intermediate product by raising its rival's level of production of the final good.

The second stage choice of p_2 by firm 2 satisfies the standard Bertrand first order condition: $\pi_2^2 = y_2 - (p_2-r)b_2 = 0$. This condition, together with (A.2) defines the equilibrium prices $p_1 = p^1(r, t-s)$ and $p_2 = p^2(r, t-s)$ with partial derivatives $p_r^1 = b_2(d_1+2d_2)/\alpha > 0$, $p_r^2 = (2b_1b_2+(d_1)^2)/\alpha > 0$, $p_s^1 = -p_t^1 = -2b_1b_2/\alpha < 0$ and $p_s^2 = -p_t^2 = -b_1d_2/\alpha < 0$ where $\alpha = 4b_1b_2 - d_1d_2 > 0$. At these equilibrium prices, firm 1's profit can be written as $\pi^1 = \pi^E(r, t-s)$ and, using (A.2), we can show

$$\pi_r^E(r, t-s) = \beta p_r^1 + x - (r-c_1)x_r^2 \text{ and } \pi_s^E = \beta p_s^2 + y_1 \tag{A.3}$$

where $\beta = -(r-c_1)b_2 + (p_1-c_1-t+s)d_1$. By a similar argument as in (4.7), firm 1 chooses vertical supply if $\pi_r^E(r^P, t-s) < 0$ where r^P is defined by $x = 0$. From

(A.3), the condition $\beta < 0$ is sufficent (but not necessary) for vertical supply. As is the case with Cournot competition, both a tariff on the import of the final good and a responsive supply of the intermediate product in country 2 tend to increase the likelihood of vertical supply. Also, if the supply curve $x^2(r^P)$ is vertical at r^P, an exogenous increase in these supplies tends to move the equilibrium towards vertical foreclosure. (At the vertical intercept of FF in Figure 1 for the Bertrand case, from (A.3), $\beta = 0$ and and an exogenous increase in x_2 increases the boundary level of t : $dt/dx_2 = (d_1p_r^1 - b_2)dr^P/dx_2/d_1(1-p_t^1) >$ 0. The sign of dt/dx_2 follows from $p_r^1 < 1$, $p_t^1 < 1$ and $d_1 < b_2$).

Welfare in the exporting country can be represented by $W = \pi^E - s_1$. Using $\pi_r^E = 0$, it can be shown that $dW/ds = \beta p_s^2 - sdy_1/ds$ at a vertical supply equilibrium. Since $p_s^2 < 0$, if the profit margin $r - c_1$ from the export of the intermediate product is small then $\beta > 0$, and W is increased by a small tax to the export of the final good. This is a gereralization of the Eaton and Grossman (1986) result that an export tax increases welfare in the exporting country under Bertrand duopolistic competition. However, β may be negative and optimal policy then switches to a subsidy to the export of the final good.

In choosing its export price p_1, firm 1 takes the price p_2 as given. Since p_2 increases in response to an increase in p_1, considering the market for the final good alone, firm 1 is not sufficiently 'aggressive' in raising its price. However an increase in p_1 increases profits from the export of the intermediate good by less than a fixed level of p_2 would imply. Firm 1 therefore tends to be 'overly agressive' in raising p_1 so as to obtain profits from the sale of x. If $\beta <$ 0, firm 1 is 'overly aggressive' on balance and welfare in country 1 is improved by reducing the equilibrium levels of p_1 and p_2 by a positive export subsidy s.

Appendix B

Proof of Proposition 5:

(i) If $\varepsilon_r = 0$ and r^p-p+t>0, or if $r^p(t)$-p+t ≥ 0 and, at the initial vertical supply equilibrium, $0 < \varepsilon_r < rx/(r-c_1)x_2$ then, from Propositions 1(i) and 3(i) part (a), $r(t,0)-p+t > 0$ at the vertical supply equilibrium. From Proposition 4(i), the locally optimal policy is to set $s < 0$ and $v = v(s) > 0$. (ii) If $r^p(t)-p+t \geq 0$ and $\varepsilon_r > rx/(r-c_1)x_2$, then Proposition 3(i) part (b) applies and $r(t,0)-p+t < 0$ at the vertical supply eqilibrium. From Proposition 4(ii), the locally optimal policy is to set $s > 0$ and $v = v(s) < 0$. From (4.9) and (5.5), $\bar{s} = ((r^p-p+t)y_r^2-(r-c_1)x_r^2)/Y_r$. At $s = \bar{s}$, from (5.6), the (left hand side) derivative of W with respect to s is then

$$dW/ds = [(r^p(t-\bar{s})-p+t)(y_s^2Y_r - y_r^2Y_s) + (r(t-\bar{s})-c_1)x_r^2Y_s]/Y_r \tag{B1}$$

Since there is vertical supply at s=v=0, $\bar{s}$ is strictly positive. Also, $r^p(t)-p+t \geq 0$ and $d(r^p(t-s)-p+t)/ds = -x_r^2/3x_r > 0$ for $p''(Y) = 0$ implies that $r^p(t-\bar{s})-p+t > 0$ ensuring that (B1) is negative. An increase in s to the vertical foreclosure point reduces welfare.

It remains to show that welfare would be reduced by a policy of increasing s above the vertical foreclosure point (for both parts (i) and (ii)). For $s \geq \bar{s}$, from $\pi_r^E(r^p(t-s),t-s,v) \geq 0$, $r_s^p < 0$, (4.9) and $y_r^2r_s^p = x_r^2r_s^p - y_s^2$,

$$\pi_r^E r_s^p = -(p-t-c_1)x_r^2r_s^p - sy_r^2r_s^p - (r^p(t-s)-p+t)y_s^2 - vx_r r_s^p \leq 0 \tag{B2}$$

From (5.9) and (3.3), if $s \geq \bar{s}$,

$$dW/ds = -(p-t-c_1)x_r^2r_s^p - s(Y_r r_s^p + Y_s) \tag{B3}$$

Therefore, from (B2) and (B3), for $s \geq \bar{s}$,

$$dW/ds \leq (r^p(t-s)-p+t)y_s^2 - s(y_r^1r_s^p + Y_s) + vx_r r_s^p \tag{B4}$$

Since, $y_r^1r_s^p + Y_s > 0$, $r^p(t-s)-p+t > 0$ and $v(\bar{s}) < 0$ for $s \geq \bar{s} > 0$, (B4) is negative at $v = v(\bar{s})$, and an increase in s above $\bar{s}$ reduces welfare.***

<u>**Proof of Proposition 6:**</u>

If $x_2 = 0$ and $t = 0$, or if $\varepsilon_r > 0$ and $\pi_r^E(r^P(t),0,0) \geq 0$ at $s=v=0$, we have initial vertical foreclosure, implying that $\bar{s} \leq 0$ ($\bar{s} = 0$ if $x_2 = 0$) and $v(\bar{s}) \geq 0$. If $x_2 = 0$, then $dy_2/ds = 0$ and it follows from (5.9) that $dW/ds < 0$ for $s > \bar{s} = 0$ and it is locally optimal to set $s=v=0$. If $\varepsilon_r > 0$, from (5.9), $dW/ds > 0$ at $s = 0$ and it is locally optimal to set $s > 0$ and $v = v(s) < 0$.

It remains to show that vertical supply reduces welfare in both cases. Since $\pi_r^E(r^P(t),0,0) \geq 0$, from (4.9), we have $r^P(t)-p+t \leq 0$ ($= 0$ for $x_2 = 0$ and $t = 0$) at $s=v=0$. Since $\bar{s} \leq 0$ and (from (3.5) and $p''(Y) = 0$, $d(r^P(t-s)-p+t)/ds = x_r^2 p' r_s^P > 0$ this implies that $r^P(t-\bar{s})-p+t \leq 0$. Using $dr/ds = -y_s^2(1-p'Y_r)/\pi_{rr}^E < 0$ (see footnote 14) and $\pi_{rr}^E = (5y_r^2/3)-2x_r^2 < 0$ it can be shown that $d[r(t-s,v(s))-p+t]/ds = (2-6p'x_r^2)/9p'\pi_{rr}^E > 0$. Hence, $r(t-s,v(s))-p+t < 0$ for all $s < \bar{s}$. From (5.6), this implies that $dW/ds > 0$ for all $s < \bar{s} \leq 0$ and the result follows.***

Footnotes

* We would like to thank Gene Grossman, Murray Frank and Ruth Raubitschek for helpful comments. This paper has benefitted from presentation at the N.B.E.R. 1988 Summer Institute in International Trade and at a number of seminars at Universities in the U.S. and Canada. Barbara Spencer gratefully acknowledges financial assistance from the National Bureau of Economic Research and the Ford Foundation, SSHRC grant no. 410-88-0074 and the Centre for International Business Studies at U.B.C..

1. This action was facilitated by a U.S. anti-dumping action against certain computer chips from Japan. However the price increase for DRAM computer chips was more than required by the trigger price anti-dumping measure. The American policy encouraging the Japanese to restrict the export of computer chips is hard to defend on the basis of the analysis developed in this paper. Another exercise of U.S. commercial policy that fits the main lines of our model is the 1986 imposition of a 35% duty on final cedar shakes and shingles from Canada, in part motivated by a desire to coax out greater Canadian exports of raw cedar blocks and logs.

2. The idea that vertical foreclosure can increase profits is related to the general idea that a firm in an oligopoly can gain by increasing the costs of its rivals. Salop and Scheffman (1983) and (1987) show that a dominant firm may gain by raising the costs of its rivals through such means as union contracts or overbuying of inputs that also serve to raise its own costs. Our model differs since it concerns the tradeoff between the direct profits earned from the export of a unit of the intermediate product with the loss from the reduction in the rival's costs in the market for the final good.

3. In Ordover, Saloner and Salop (1988), if the upstream or intermediate good is supplied by the vertically integrated firm, then its price is determined by Bertrand competition with one other supplier of the homogeneous good. Since the price of the intermediate product equals the common level of marginal costs, there is no potential for profits to be made from vertical supply. Salinger (1988) assumes a Cournot type market for the intermediate product as well as Cournot competition for the final product. Since one unit of the intermediate product is required to produce one unit of the final product, the vertically integrated firm conjectures that the sale of an additional unit of the intermediate product will increase its rivals' output of the final good by one unit. The sale of the intermediate product is then viewed as unprofitable if the vertically integrated firm can earn a higher profit margin from the sale of the final good than the intermediate good. Our approach allows the low cost firm to recognize the extent to which the importing firm will substitute imported supplies for its own production.

4. Quirmbach (1986) shows that vertical supply (or partial forward vertical integration) by an upstream monopolist can be an equilibrium strategy if the downstream industry is perfectly contestable and the monopolists's downstream subsidiary faces diminishing returns. Since downstream firms just break even, the monopolist's profit is the industry profit. The monopolist then has an incentive to supply some independent downstream firms so as to lower industry costs of production. This motive for vertical supply does not arise in our model since the exporting firm can produce the downstream product at constant marginal cost.

In most of the literature all the downstream producers are included in the merger, so that the issue of vertical foreclosure (or supply) of unintegrated fir[illegible] does not arise. For example, see Vernon and Graham (1971) and Mallella and

Nahata (1980) and Dixit (1983). An exception to this is Greenhut and Ohta (1979), who consider vertical integration by a subset of oligopolists, but vertical supply is not an issue. An excellent discussion of the literature is available in Tirole (1988).

5. Allowing for other factors of production (but maintaining the fixed proportions assumption) would reduce the impact of changes in the price of the intermediate good, but otherwise would not generally affect the results. With substitutability between inputs, an increase in the price of the intermediate good would cause the rival firm to substitute away from the higher priced input making such price increases less profitable for the vertically integrated firm. However, the ability of the rival firm to produce its own supplies of the intermediate good plays a similar role under fixed proportions technology so that introducing subsitutability between inputs should not change the general nature of the results.

6. The choice of s and v by country 1 also satisfies the requirements for a subgame perfect equilibrium. The entire structure could be made subgame perfect by consideration of country 2's optimal choice of the tariff t. We do not do this because the results do not seem sufficiently new or interesting.

7. There is no discontinuity in $x(r,t-s)$ at $r = r^P$ even if $x_2 = 0$ so that $y^2(r^P,t-s) = 0$. Given (3.7) and (3.8), the implicit function theorem implies that $y^1(r,t-s)$ and $y^2(r,t-s)$ defined by (3.3) and (3.4) are continuous with continuous partial derivatives for $r \leq r^P$. If $x_2 = 0$, $y^2(r,t-s)$ (as well as $x(r,t-s)$) reduces continuously to zero as r increases to r^P.

8. From (4.9), $\pi^E_{rr} = y^2_r(2-p'Y_r) - 2x^2_r - (r-v-c_1)x^2_{rr} + (r-p+t-(s+v))y^2_{rr}$. If $p''(Y) = 0$ and $x^2_{rr} = 0$ then $\pi^E_{rr} = y^2_r(2-p'Y_r) - 2x^2_r < 0$. We have $x_2 > 0$ if $r > c_2$ and $x_2 = 0$ and $x^2_r = 0$ if $r \leq c_2$. In this linear case, π^E is also strictly concave in r

at $r = c_2$, since the left hand derivative π^E_{rr} (evaluated for a reduction in r below c_2) is less negative than the right hand derivative.

9. The signs of r_s and r_t are ambiguous in general. See Spencer and Jones (1988) for further analysis.

10. Along FF, $r^P(t)$ changes with t. From (4.10), FF is negatively sloped if $d\pi^E_r(r^P,t,0)/dt = \pi^E_{rr}r^P_t + (1-p'Y_t)y^2_r + (r^P-p+t)y^2_{rt} < 0$. Since $\pi^E_{rr} < 0$, $r^P_t > 0$ and $1-p'Y_t > 0$, this holds if y^2_{rt} is small. Under linear demand, $y^2_{rt} = 0$.

11. In keeping with our assumption that $c_2 > c_1$, the supply curve $x^2(r)$ could have a positive but less than infinite slope for a range of values of r below r^P.

12. If $\varepsilon_r = \infty$, the value of r follows from (4.9) with $x = y_2$ and $x^2_r = 0$. Firm 1 sets a value of r just below c_2 if (4.9) is strictly positive at this value of r. A lower value of r determined by setting (4.9) equal to zero may be optimal if, with $s=v=0$, the tariff is sufficiently high to make $r^P-p+t = c_2-p+t > 0$.

13. It can be shown that the second order conditions, $d^2W/ds^2 < 0$, $d^2W/dv^2 < 0$, and $d^2W/ds^2.d^2W/dv^2 - (d^2W/dsdv)^2 > 0$ for the optimal choice of s and v are satisfied provided that $p''(Y) = 0$ and $\pi^E_{rr} < 0$. If demand is non linear these expressions depend on third derivatives of demand. We assume that demand is sufficiently close to linear for the second order conditions to hold.

14. An increase in s, maintaining $v = v(s)$ affects y_1 and x partly through its effect on r and this effect is ambiguous. An increase in s tends to reduce the demand for x but r does not necessarily fall. There is a similar ambiguity in the pricing response of a monopolist to an increase in demand. If $p''(Y) = 0$, from (4.8), (4.9), (3.9) and (3.10), $dr/ds = r_s + r_v v'(s) = -y^2_s(1-p'Y_r)/\pi^E_{rr} < 0$. If $p''(Y)$ 0 and $x^2_{rr} = 0$, using π^E_{rr} as in footnote 8, we obtain $dy_1/ds = y^1_s[7y^2_r(1 - p'Y_r) - 8x^2_r]/4\pi^E_{rr} > 0$ and $dx/ds = y^2_s(x_r - x^2_r p'Y_r)/\pi^E_{rr} < 0$.

15. Setting $v = v(\bar{s})$ is reasonable since v has no effect on welfare for $s \geq \bar{s}$.

References

Brander James A. and Barbara J. Spencer, "Export Subsidies and International Market Share Rivalry," Journal of International Economics, 18, No.1/2, (February 1985), 83-100.

Dixit, Avinash K., "Vertical Integration in a Monopolistically Competitive Industry," International Journal of Industrial Organization 1, (1983), 63-78.

Eaton, Jonathan and Gene M. Grossman, "Optimal Trade and Industrial Policy under Oligopoly," Quarterly Journal of Economics, (May 1986), 386-406.

Greenhut, M.L. and H. Ohta, "Vertical Integration of Successive Oligopolists," American Economic Review 69 (March 1979), 137-141.

Grossman, Gene M. and Dixit, Avinash K., "Targeted Export Promotion with Several Oligopolistic Industries" Journal of International Economics 21 (1986) 233-249.

Jones, Ronald W. "International Capital Movements and the Theory of Tariffs and Trade," Quarterly Journal of Economics, 81 (1967), 1-38.

Jones, Ronald W. and Barbara J. Spencer, "Raw Materials, Processing Activities and Protectionism," Canadian Journal of Economics, (1989) forthcoming

Katz, Michael L. and Shapiro, Carl, "On the Licensing of Innovations", Rand Journal of Economics, 16, No. 4, (Winter 1985), 504-520.

Kemp, Murray C., "The Gain from International Trade and Investment: A Neo-Heckscher-Ohlin Approach" American Economic Review, 56, (1967), 788-809

Mallela, Parthasaradhi and Babu Nahata, "Theory of Vertical Control with Variable Proportions," Journal of Political Economy 88, No. 5, (1980), 1009-1025.

Ordover, Janusz A., Saloner Garth and Steven C. Salop, "Equilibrium Vertical Foreclosure," Sloan School of Management, M.I.T., working paper # 1978-88, (1988)

Quirmbach, Herman C., "Vertical Integration:Scale Distortions, Partial Integration and the Direction of Price Change", Quarterly Journal of Economics, CI (1986), 131-47

Salinger, Michael A., "Vertical Mergers and Market Foreclosure," Quarterly Journal of Economics, CIII No.2 (May 1988),345-356.

Salop, Steven C. and David T. Scheffman, "Raising Rivals Costs," American Economic Review, Papers and Proceedings, 73 No.2, (May 1983), 267-271.

Salop, Steven C. and David T. Scheffman, "Cost Raising Strategies", Journal of Industrial Economics 36 (1987) 19-34.

Spencer, Barbara J. and James A. Brander, "International R&D Rivalry and Industrial Strategy," Review of Economic Studies L No.4, (October 1983), 707-722.

Spencer, Barbara J. and Ronald W. Jones, "Protectionist Policies and Vertically Related International Markets", working paper 1988.

Tirole, Jean, The Theory of Industrial Organization, 1988, the MIT Press

Vernon, John M. and Daniel L. Graham, "Profitability of Monopolization by Vertical integration," Journal of Political Economy LXXIX (1971),924-25.

Venables, A. J., "Trade and Trade Policy with Imperfect Competition: the Case of Identical Products and Free Entry", Journal of International Economics 19 (1985), 1-19.