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ABSTRACT

This paper models the international competition between a domestic firm and its vertically integrated foreign rival. The domestic firm has the choice of developing its own production capability for an intermediate input, or of importing it from the foreign firm at a price set by the latter. In this setting, and under reasonable cost assumptions, the foreign firm will always choose to supply the domestic firm as long as it cannot monopolize the final-good market by withholding supply. A tariff placed on the imports of the input by the home government will be borne entirely by the foreign firm, and will be welfare increasing. When the home government chooses to subsidize the domestic firm's fixed development costs for the input, the optimal subsidy will exceed the total fixed costs required, but will not have to be disbursed in equilibrium. A tariff on the final good will enhance the home firm's profits not only by increasing the costs of its rival, but also by reducing its own input costs.

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I. Introduction

Consider a domestic firm that competes with a foreign rival in a final-goods market. The latter is vertically integrated and produces its own intermediate input, while the home firm is not integrated, and must either import the input from its rival or develop its own (more costly) production capability. What is the outcome of the ensuing competition between the two firms, and is there a role for government policy in improving domestic welfare?

This stylized picture captures a situation that arises quite frequently in international trade, and perhaps most visibly in the context of Japan's trade. As many of Japan's leading exporters are integrated backwards, U.S. and European companies often encounter them as suppliers upstream and competitors downstream.[1] This has led to concerns that Japanese companies may have the incentive to raise their rivals' costs through exclusionary practices. For example, industry leaders and policymakers in the U.S. worry that the reduction in U.S. production capacity in semiconductors and electronics components will lead domestic firms to be dependent on supplies

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1. Between 1971 and 1985, the import content of finished manufactures has risen dramatically in the U.S. (from 9 to 24 percent), Germany (from 16 to 26 percent), U.K (from 12 to 29 percent), and France (from 17 to 27 percent). In Japan, by contrast, the analogous number has increased only from 4 percent to 6 percent during the same period (OECD, 1987, Table S.1).

from the very same Japanese companies which are downstream rivals. A representative account is worth quoting at some length:

> With a few exceptions, notably IBM and AT&T ... U.S. final product makers rely upon the purchase of chips on the open market. As independent U.S. producers of semiconductor chips are beaten in market competition, U.S. final product makers come to rely more and more on Japanese chip producers.... The problem for American manufacturers of final products is that the vertically integrated Japanese chip makers derive their principal business revenues by competing in the very same electronics-based final product markets: [the latter] also are sellers of computer and telecommunications equipment, electronic instruments, robots, industrial process controls, audio and video equipment, to name but a few final products, and are also often directly tied through cross-ownership and investment to other Japanese final product producers of antiskid braking systems, electrical equipment, machine tools, and the like. Simple business strategy dictates that Japanese chip producers will not sell their best chip technology on the open market to the American computer firms against which they compete in computer markets. At stake for the U.S. economy is not simply the $25 billion market for semiconductors, but the current $0.5 trillion market for the final products that incorporate semiconductors, soon to be a $1 trillion market. (Borrus, 1988, p. 66.)

As a result, a new "industrial intimacy" is said to be arising between upstream and downstream U.S. firms.[2] Many of the same issues arise in

emergent industries in developing countries as well. For example, Korean final-good producers that have begun to encroach on Japanese export markets worry about their reliance on intermediate inputs supplied by these Japanese firms. In all these cases the policy question is the extent to which the importation of parts and components from well-established, integrated companies abroad hampers the development of domestic capabilities and competitiveness in final-goods markets.

Domestic competition among companies with varying degrees of integration raises a number of anti-trust questions, and has mostly been addressed in that context (Salinger, 1988; see also the related papers by Vernon and Graham, 1971, Warren-Boulton, 1974, Katz, 1987, Mallela and Nahata, 1980). But when the companies involved have different national identities, a new set of issues come into play. From the standpoint of national welfare, the distribution of profits between domestic and foreign firms becomes as important as consumer benefits at home. Also, international competition widens the range of available policy instruments: in particular, tariffs and export subsidies can be used to discriminate against foreign firms.

A recent paper by Spencer and Jones (1988) provides a formal analysis of some of these issues in the context of international competition between two firms, one integrated and the other unintegrated. As Spencer and Jones explain, the vertically integrated firm trades off the rents it extracts on

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2. "Increasingly, US companies have adopted a strategy of 'virtual vertical integration' in which they form alliances with suppliers and customers to emulate the structure of Japanese electronics giants" (Financial Times, March 9, 1989, p. 4.

the sale of the intermediate input to its rival against the enhanced profits in the final-goods market when it forecloses. The assumption in their paper, as well as ours, is that the integrated firm has access to a cheaper technology for producing the input, and that it acts as a Stackelberg leader in the input market.[3] Spencer and Jones show how trade in the intermediate input can arise as an equilibrium in such a framework. They also analyze possible policy options for the home government of the integrated company, and discuss the possibility that an export tax (on both the input and the final good) will be desirable.[4]

This paper differs from Spencer and Jones in two key respects. The first difference is with respect to our formulation of the cost conditions facing the unintegrated company on the input side. We assume that developing a production capability for the input requires a sunk cost as well as a constant marginal cost which is at least as high as that for the integrated company. Having already access to the input, the integrated company does not face any fixed development costs. This is to be contrasted with the Spencer and Jones model in which the unintegrated firm faces an upwards-sloping domestic supply curve for the input; their framework has the advantage that domestic production of the input can coexist with imports. Our formulation, however,

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3. Or that the integrated firm moves first by setting a price for the input, which amounts to the same thing under subgame perfection.

4. Briefly, the explanation is as follows. The export tax on the final good may be desirable so as to increase the demand for the integrated firm's output of the intermediate good, and hence its profits. This is profitable when the profit margin on the intermediate good exceeds that on the final-good. The tax on the intermediate, in turn, is to prevent the firm from charging too low a price on the intermediate.

is a useful benchmark case in its own right,[5] and has the added advantage that it yields a number of strong, sharp results. Our consideration of fixed development costs makes the analysis perhaps most relevant to instances where the unintegrated firm is the clear technological newcomer.

The second difference is that we carry out the analysis from the perspective of the unintegrated company and its home government. Spencer and Jones consider policies for the government of the integrated company. We ignore these,[6] and look instead at three types of policies available to the other government: an import tariff on the input; a capital subsidy to the unintegrated firm to cover product development costs; and an import tariff on the final good. We show that each one of these has a substantial role to play in improving home welfare.

II. The Framework

There are two firms, home and foreign, and the foreign firm is merged vertically with its upstream supplier. Let i=1 and 2 index the home and foreign firm, respectively. The two firms share a common technology in producing a final homogeneous good for sale in a unified market. (The case of

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5. Ours seems to be the natural symmetric assumption to make, given the constant marginal cost of the integrated firm, and is a common ingredient of partial-equilibrium models of oligopoly. Besides, it probably reflects more accurately the way businessman think of their environment.

6. It may be interesting to look at the policy interactions between the two governments when both are trying to improve domestic welfare, but that would be the subject of another paper.

differentiated products will be considered only briefly.) The inverse demand function for the final good is given by $p(x_1+x_2)$, where x_i denotes the output of good i and $p'(.)<0$. With only slight loss of generality, we assume that each firm needs exactly one unit of the intermediate good to produce a unit of the final product.[7] The foreign firm produces the intermediate good at a constant cost, c. The home firm is the technological laggard in the intermediate-good market, and can produce that good at a constant marginal cost, v ($\geq$ c), but only after a fixed amount of K is spent on research and development.[8] When the foreign firm does not foreclose, the home firm can also choose to import the input when the price set by the foreign firm, w, makes it advantageous to do so.

As in Spencer and Jones (1988), we conceptualize the interaction between the two firms as a two-stage game. In the first stage, the foreign firm sets w, and in the second stage the two firms play Nash-Cournot in output. In the second stage, the home firm takes w as given and can import as much as it wants.[9] But the foreign firm takes full account of the implications of its

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7. The assumption of unit input requirements is for convenience only. The more restrictive assumption is with regard to the lack of substitutability between the input and other factors of production. When the unintegrated firm can substitute away from the input, the output effects of input-price increases would be alleviated through such substitution.

8. These assumptions on the cost side are identical to those made by Katz (1987). Katz focuses on the incentives of an unintegrated upstream supplier to price discriminate between downstream producers which operate at different scale. The analysis is carried out in the domestic context.

9. Since information is perfect and complete, the integrated firm would never want to ration the home firm.

choice of w in the subsequent output game, and the equilibrium is subgame perfect.

The second-stage Cournot equilibrium can be characterized by the equilibrium output levels $x_i(w, c)$ or $x_i(v, c)$, i=1, 2, depending on whether the home firm imports the input or develops it domestically. These output levels solve the following pair of first-order conditions:

$$(1) \quad \begin{cases} p'(x_1+x_2)x_1 + [p(x_1+x_2) - w] = 0 \\ p'(x_1+x_2)x_2 + [p(x_1+x_2) - c] = 0, \end{cases}$$

or, alternatively, when domestic inputs are used:

$$(2) \quad \begin{cases} p'(x_1+x_2)x_1 + [p(x_1+x_2) - v] = 0 \\ p'(x_1+x_2)x_2 + [p(x_1+x_2) - c] = 0. \end{cases}$$

Notice that K does not affect the equilibrium levels of output. The corresponding profit functions are given by $\pi_i(w,c)$ or $\pi_i(v,K,c)$, i=1, 2:

$$(3) \quad \begin{cases} \pi_1(w, c) = [p(w,c) - w]x_1(w,c) \\ \pi_2(w, c) = [p(w,c) - c]x_2(w,c). \end{cases}$$

Or:

$$(4) \quad \begin{cases} \pi_1(v, K, c) = [p(v,c) - v]x_1(v,c) - K \\ \pi_2(v, c) = [p(v,c) - c]x_2(v,c), \end{cases}$$

where $p(w,c) = p(x_1(w,c) + x_2(w,c))$, and $p(v,c) = p(x_1(v,c) + x_2(v,c))$. Since the properties of such an equilibrium are well-known (see for example Dixit, 1986), we will not go into any detail here. We just note some results which we will need for the analysis that follows.

(5) $dx_1(w,c)/dw < 0, \quad dx_2(w,c)/dw > 0, \quad dp(w,c)/dw > 0,$

(6) $d\pi_1(w,c)/dw < 0, \quad d\pi_2(w,c)/dw > 0$

These follow from restrictions imposed by second-order and stability conditions, and the usual assumption regarding the negative slope of reaction functions in a Cournot equilibrium (Dixit, 1986). They imply that an increase in the price paid by the home firm for its intermediate input will, provided the home firm continues to import it, reduce home output and profits and increase foreign output and profits.

Now consider the first-period choices of the foreign firm. It has to decide whether to sell the input to its rival, and if it does, what price to charge. A moment of reflection should convince the reader that a necessary and sufficient condition for the foreign firm to supply the home firm is that $\pi_1(v, K, c) \geq 0$.

Proposition 1: An equilibrium with trade in the intermediate input exists if and only if $\pi_1(v, K, c) \geq 0$.

The proof is straightforward. When $\pi_1(v, K, c) < 0$, the foreign firm can monopolize the final-good market by refusing to supply the home firm with the intermediate input. Using domestic technology, the home firm makes losses in the second-stage Cournot game, and it would choose not to enter. The foreign firm in turn always prefers a monopoly to a duopoly irrespective of any level of w, as the duopoly level of output is always at least as high as the monopoly level. Therefore, when it has the ability to acquire a monopoly by charging a prohibitive price on the input, it certainly will choose to do so. When $\pi_1(v, K, c) \geq 0$, on the other hand, the domestic firm cannot be deterred

from entry. Then the foreign firm always has the incentive to prevent the home firm from developing the domestic technology by supplying the input at an appropriate price. At the very least, the foreign firm can charge $w = v$, which does not alter the output game--compared to the case with foreclosure[10]--while increasing profits on account of intermediate-good sales.

In fact, the foreign firm can do better than that. To see this, denote by $\bar{w}$ the level of the input price which leaves the home firm indifferent between developing its own technology and importing it. This is defined implicitly by:

$$\pi_1(\bar{w}, c) = \pi_1(v, K, c).$$

As long as $w \leq \bar{w}$, the home firm will choose to import. Denote in turn the foreign firm's optimal choice of input price by w^*. Now, increases in w have potentially conflicting effects: past a point, rents in the input market accruing to the foreign firm would start to diminish as the home firm's demand for the input is progressively reduced. Nonetheless, provided foreclosure does not pay, the foreign firm will always charge the limit price $w = \bar{w}$.

Proposition 2: When foreclosure is not optimal (i.e., $\pi_1(v, K, c) \geq 0$), the foreign firm will always select an input price w which leaves the home firm indifferent between developing domestic technology and importing the input.

Proof: In the first stage of the game, the foreign firm selects w^* to maximize its second-period profits (inclusive of rents on intermediate-good

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10. That is because the Cournot game is unaffected by K, provided that the home firm remains in the market.

sales) subject to the constraint that the home firm continues to import the input. The associated Lagrangean expression is given by:

(7) $\mathcal{L} = (w - c)x_1(w,c) + \pi_2(w,c) + \lambda[\pi_1(w,c) - \pi_1(v,K,c)]$.

The necessary conditions for an optimum are:

(8) $d\mathcal{L}/dw = x_1(w,c) + (w - c)dx_1(w,c)/dw + d\pi_2(w,c)/dw + \lambda d\pi_1(w,c)/dw = 0$,

(9) $\lambda[\pi_1(w,c) - \pi_1(v,K,c)] = 0$, with complementary slackness.

To see that the optimum requires a corner solution where the constraint is always binding (with $\lambda > 0$), suppose to the contrary that $\lambda = 0$. Then rewriting (8) using (3), we have

(10) $d\mathcal{L}/dw = x_1 + (w - c)dx_1/dw + (p - c)dx_2/dw + x_2dp/dw$,

where the arguments of the functions have been omitted. Noting that $dp = p'(dx_1+dx_2)$, and that $w-c = p'(x_1-x_2)$ from the first-order conditions (1), this simplifies to

(11) $d\mathcal{L}/dw = x_1[1 + p'dx_1/dw] > 0$,

which establishes the required contradiction.□

The reason for this corner solution can be understood by considering the profit margins of the foreign firm on intermediate- and final-good sales. For each unit of intermediate good produced, the foreign firm gets in equilibrium (p-c) when it uses it internally to produce the final good, and (w-c) when it

exports it to its competitor. For the home firm to be in the market to begin with, it must be the case that $p > w$. This implies that the profit margin on final-good sales (p-c) exceeds that on intermediate-good sales (w-c).[11] Therefore at the margin the foreign firm would like to sell more in the output market and less in the input market. This leads it all the way to a corner solution where any further increase in w would drive the home firm to develop its own technology.

The conclusion is that the profits of the home firm will be squeezed all the way down to its "reservation level": the level that would obtain in a Cournot equilibrium in which home-grown technology is used, $\pi_1(v, K, c)$. Even though this home technology is not utilized in equilibrium, it still exercises a determining influence on home profits.

This unequivocal result is partly due to the homogeneous-goods assumption. When the two final goods produced by the firms are imperfect substitutes for each other, a second type of equilibrium can emerge. To see this, we first need some new notation. We now have two inverse-demand functions, written as $p^1(x_1, x_2)$ and $p^2(x_1, x_2)$, with p^j_i denoting the partial derivative of the jth firm's inverse demand function with respect to the ith firm's output. We leave the appropriate recasting of equations (1)-(4) to the interested reader. Notice, though, that (5) and (6) continue to hold. This gives us:

Proposition 3: When the two firms' final goods are imperfect substitutes for

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11. This is diametrically opposite to most of the cases considered in Spencer and Jones (1988).

each other, an equilibrium with $w^* < \bar{w}$ is possible only if

$$(12) \quad x_1[1 + p_1^1(dx_1/dw)] + [(p^1 - p^2) + (p_1^2 - p_2^2)x_2]dx_1/dw = 0,$$

for some $w < \bar{w}$.

Proof: Equations (7)-(9) continue to hold with imperfect substitutes. Expression (12) follows from substituting the appropriately amended first-order conditions of the two firms in (10).□

Notice that since the term in square brackets in (12) cannot be signed in general, an interior solution is now a real possibility. The interpretation is that, past a certain level of w, the losses on rents to the foreign firm in the input market would offset the profit gains in the output market. Notice that the likelihood of this scenario increases with the price gap in favor of the home firm $(p^1 - p^2)$, and with the relative sensitiveness of the foreign firm's price to own output $(p_1^2 - p_2^2)$. The implication is that when the home firm possesses a separate market niche of its own, it is more likely to be able to prevent its profits from being squeezed down to its reservation level.

III. The Role for Home-Country Policy

We now consider what role, if any, government policy in the home country can play in improving domestic welfare. In keeping with usual practice, we take the government to set its policies before either of the two firms act. We consider three policies in turn: (a) an import tariff on the imported input; (b) a capital subsidy to the domestic firm; (c) an import tariff on the final good. In all cases, we limit the analysis to situations where the

foreign firm cannot monopolize the domestic market, so chooses not to withhold supplies of the input. The monopoly case does not add any original insights.[12] Also, we will concentrate on the homogeneous-goods case, with only passing references to the implications when w^* is not at a corner.

(i) A tariff on the intermediate input. In perfectly competitive markets, a tariff on the input would make no sense whatsoever since it would simply cripple the ability of the home firm(s) to compete with foreign rivals. In the present context, this intuition turns out to be extremely misleading. The reason is that it does not take into account the response of the foreign firm to the imposition of the tariff.

Let the specific tariff on the input be denoted by τ. Assume for the moment that the input continues to be traded. Then, a simple calculation shows that the analogue of expression (11) when $\lambda = 0$ is:

$$(11') \quad d\ell/dw = x_1[1 + p'dx_1/dw] - \tau dx_1/dw > 0,$$

The new term at the end shows that the input tariff creates an additional reason for the foreign firm to select a corner solution for w^*. The tariff makes the input market an even worse conduit for added profits (relative to the output market), so the foreign firm once again chooses the highest w^* consistent with exports of the input. Hence, the foreign firm's reaction to

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12. When the foreign firm can monopolize the final-good market, there will be the usual case for welfare-improving entry-promotion strategies. The difference here is that a credible threat to promote entry via subsidization may lead the foreign firm to supply the input, and may actually never have to be carried out. See the discussion below on capital subsidies.

the tariff ensures that the home firm's profits remain at their reservation level. This requires:

(13) $\pi_1(w^*+\tau, c) = \pi_1(v, K, c)$

Since the right-hand side of the equality is invariant to τ, we have:

Proposition 4: As long as vertical supply continues, an input tariff is borne in its entirety by the foreign firm.

Proof: It follows immediately from (13) that $dw^*/d\tau = -1$, and that the tariff-inclusive price of the input stays constant at $\bar{w}$.□

The next question is: at what point does the tariff become so onerous that the foreign firm stops supplying the home firm? At first sight, it might seem that the switch-over comes at the point where the foreign firm starts making losses on its sales of the input, i.e. when $w = c$. But that is not quite right. The foreign firm will generally prefer to make some losses on input sales to having the home firm develop its own technology. This paradoxical result holds whenever K is strictly positive, that is whenever a fixed cost of product development is required. Notice that when $K > 0$, it must be the case that $v < \bar{w}$, which follows from the definition of $\bar{w}$: $\pi_1(\bar{w}, c) = \pi_1(v, K, c)$. Hence, the marginal cost of employing the domestic technology has to be lower than the tariff-inclusive price of the imported input. Since the output level of the home firm is determined by its marginal, rather than total, costs[13], this renders it a more "aggressive" competitor

13. Provided, of course, that it does enter the market.

vis-a-vis the foreign firm when it uses its own input (see [4] and [5]). Therefore, over a certain range, the foreign firm would prefer to supply the input below cost to ensure that the home firm is restrained by its higher marginal cost. The larger is K, the bigger is the margin between v and $\bar{w}$, and the greater the advantage to preventing technological substitution.

Proposition 5: Define τ^c as the critical level of the input tariff at which the foreign firm stop supplying the input, and τ^s ($= \bar{w}-c$) as the level at which the foreign firm just breaks even on its sales of the input. τ^c always exceeds τ^s whenever $K > 0$.

Proof: τ^c is defined implicitly by the following relationship:

$$(14) \quad (\bar{w}-\tau^c-c)x_1(\bar{w},c) + \pi_2(\bar{w},c) = \pi_2(v,c).$$

This equates profits with vertical supply (the left-hand side) to the profits with foreclosure (the right-hand side). Since $\pi_2(\bar{w},c) > \pi_2(v,c)$ whenever $K > 0$, it must be the case that $\tau^c > \bar{w}-c$ (see Figure 1).□

Hence the foreign firm will be willing to go a long way before it chooses to stop exports of the input. This creates a role for the home government to squeeze some of its profits. As long as $\tau \leq \tau^c$, and therefore the tariff-inclusive price of the input remains unchanged, the equilibrium in the final-goods market is unaffected by an increase in τ. The input tariff acts as a pure profit-shifting device. This implies that a tariff on the intermediate input is always welfare improving. The next proposition characterizes the optimal level of the tariff, τ^*.

Proposition 6: (a) When the final good is not consumed domestically, the optimal tariff on the input is set only slightly below the level which leaves

the foreign firm indifferent between supplying the input and letting the home firm develop the domestic technology; i.e., $\tau^* = \tau^c - \epsilon$, where ϵ is arbitrarily small. (b) When the final good is consumed domestically, a prohibitive tariff ($\tau^* > \tau^c$) will instead be optimal if and only if:

$$(15) \quad \tau^c x_1(\bar{w},c) < -q(v,c)\Delta p + \tfrac{1}{2}p'(q(v,c))[\Delta q]^2,$$

where $q(.)$ = level of domestic consumption;

$\Delta p \equiv p(v,c) - p(\bar{w},c) < 0$;

$\Delta q \equiv q(v,c) - q(\bar{w},c) > 0$.

Proof: (a) In the absence of domestic consumption of the final good, domestic welfare is maximized by maximizing government revenues, since home profits remain unchanged at $\pi_1(\bar{w},c) = \pi_1(v,K,c)$. This is achieved by setting τ equal to its highest level compatible with vertical supply.[14] (b) In the presence of domestic consumption of the final good, considerations of consumer surplus enter the picture. When the home firm shifts over to domestic technology, its profits are unaffected, but, as discussed above, its lower marginal cost leads to a higher level of aggregate sales and a lower market price. Hence, there is a one-time increase in consumers' surplus. The right-hand side of (15) is a second-order Taylor approximation of this increase. The left-hand side is the loss in tariff revenues at the point where the tariff becomes prohibitive. When the latter is smaller than the former, a prohibitive tariff becomes optimal.□

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14. For an analogous result regarding a limit-pricing foreign monopolist, see Brander and Spencer (1981).

Hence it is clear that the limit-pricing result (proposition 2) buys us a number of strong predictions with respect to the effects of policy. In particular, an input tariff serves as a pure rent-shifting device, and its optimal level is either the highest level consistent with trade or the prohibitive level. Both of these conclusions contradict intuition deriving from perfectly competitive models.

To conclude our analysis of the input tariff, we consider briefly the case of differentiated products. In this case the profit squeeze on the home may not be total, and an interior solution for w^* will result whenever

$$(12') \quad x_1[1 + p_1^1(dx_1/dw)] + [(p^1 - p^2) + (p_1^2 - p_2^2)x_2 - \tau]dx_1/dw = 0,$$

for some $w < \bar{w}$ (cf. proposition 3). It can be checked that when this is the case, $d(w^*+\tau)/d\tau > 0$ so that part of the tariff will now be borne by the home firm. This reduces the benefits of an input tariff. The problem becomes the familiar one of designing optimal trade policy when facing a foreign monopolist.

(ii) A capital subsidy. While the input tariff is a useful profit-shifting device, it has one shortcoming: domestic consumers get no benefit from it as long as it is not set at a prohibitive level ($\tau > \tau^c$). We now consider a direct subsidy to cover the home firm's fixed (product development) costs, K. To anticipate the results, we will show that the optimal subsidy exceeds total fixed costs, and, moreover, that it will never have to be disbursed in equilibrium. The right way to think of the subsidy policy, then, is as a credible commitment on the part of the government to provide the subsidy if

the home firm chooses to develop home technology.

As in the previous section, we first derive the foreign firm's optimal response to the capital subsidy. Let S denote the subsidy, and S^c the critical level of the subsidy at which the foreign firm will start withholding supplies of the input. Since the capital subsidy affects only the constraint in the Lagrangean expression (7), w^* will remain at a corner as long as the input continues to be traded. The reservation level of home-firm profits continues to act as a binding constraint:

(16) $\pi_1(\bar{w}, c) = \pi_1(v, K-S, c)$.

This defines a <u>decreasing</u> function $\bar{w} = \bar{w}(S)$. Since the constraint always binds when the input is exported, this also defines the optimal input price $w^* = \bar{w}(S)$, for $S < S^c$. The interpretation is that, in the presence of the subsidy, the foreign firm has to reduce the input price to prevent the home firm from switching over to the domestic technology. Notice that an increase in the subsidy increases home profits one-for-one via the effect on w^*, even though the subsidy will not be disbursed as long as the input continues to be imported. We note also that as long as $S < S^c$, the subsidy is unambiguously welfare improving: home profits rise; consumers benefit from the induced reduction in prices as w is reduced; and the government does not have to spend a penny.[15]

Proposition 7: Let S^* denote the optimal level of the capital subsidy. (a)

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15. If this appears of dubious practical importance, that is probably a reflection of the inability of governments to pre-commit themselves in such a fashion.

$S^* = S^c \geq K$. (b) $w^* = \bar{w}(S^*) \geq c$.

The proposition states that (a) the optimal subsidy will more than cover the home firm's fixed costs, and (b) the foreign firm will continue to earn rents on input sales even when S is set optimally.

To understand the first part of the proposition, consider the foreign firm's profits when $S = K$. From (16), $\bar{w}(K) = v \geq c$. Therefore, when the home government finances the fixed cost in its entirety, the foreign firm earns rents of $(v - c)$ on its input sales, while the profits in the output game are identical to those that would obtain with foreclosure. The profits made on the final good must fall sufficiently for the foreign firm to foresake the rents on the input. Formally, S^c is defined implicitly by the relationship that equates total profits with foreclosure to those without:

$$(17) \quad \pi_2(v, K-S^c, c) = [\bar{w}(S^c) - c]x_1(\bar{w}(S^c), c) + \pi_2(\bar{w}(S^c), c).$$

At $S=K$, $[\bar{w}(S) - c] = [v - c] \geq 0$ and $\pi_2(v, K-S, c) = \pi_2(\bar{w}(S), c)$, which leaves the right-hand side larger than the left-hand side. Therefore $S^c \geq K$. Moreover, when $S > K$, $v > \bar{w}(S)$ and therefore $\pi_2(v, K-S^c, c) \geq \pi_2(\bar{w}(S^c), c)$ This implies, in turn, that $[\bar{w}(S^c) - c] > 0$. Moreover, all these relationships hold as strict inequalities when $v > c$.

Would the home government ever want to increase S beyond S^c? The answer is no. Note that at S^c there is a discrete increase in the output price as the home firm's marginal cost switches from $\bar{w}(S^c)$ to the larger v. Beyond S^c, the input is no longer imported--(16) no longer holds--and the equilibrium

in the final-good market remains unchanged with further increases in S. In this region, the behavior of the home firm is unaffected by the lump-sum subsidy. All that takes place is a transfer from the government to the home firm.

Finally, consider briefly the effects of the capital subsidy when the condition of proposition 3 is satisfied and $w^* < \bar{w}$. In this case, equation (16) no longer holds, as the foreign firm's constraint is not binding; the home firm's profit level exceeds its reservation level. As long as this continues to be true, a small enough capital subsidy has no effect whatsoever. The reason is that s affects the outcome only through its influence on the reservation level of home-firm profits.

(iii) A tariff on the final good. The final policy we consider is a tariff, t, imposed on imports of the final good. Suppose, for simplicity, that the home market is the only outlet that the two firms have for the final good. For reasons analogous to those given for proposition 5, the foreign firm will continue to supply the input past the point where w just covers c, provided K > 0. Denote by w_{min} the lowest w that the foreign firm is willing to charge before it gives up supplying the input altogether. Notice also that the tariff is formally identical to an increase in the marginal costs of the foreign firm. The Lagrangean of the foreign firm can then be written as:

$$(18) \quad \mathcal{L} = (w - c)x_1(w,c+t) + \pi_2(w,c+t) + \lambda[\pi_1(w,c+t) - \pi_1(v,K,c+t)].$$

Suppose that the constraint does not bind ($\lambda = 0$). Then, the analogue of (11) becomes:

(11") $d\ell/dw = x_1[1 + p'dx_1/dw] + tdx_1/dw.$

Notice that since the last term is now negative, it is conceivable that we may have an equilibrium where the constraint does not bind and where (11") is set equal to zero. Intuitively, the tariff on the final good hurts the output market as a conduit for excess profits, and therefore w^* may now be set below $\bar{w}$. (In the limit, when the output market is closed to the foreign firm, the foreign firm will simply maximize its input rents.) An interior solution for w^* will be the result whenever the rent-maximizing level of w falls short of the level of w which squeezes the home firm down to its reservation level.

It is not possible to say much more regarding when the constraint may cease to be binding. Denote by $\bar{t}$ the level of the tariff, when such exists, at which (11") just becomes zero. Now there are two regions to be analyzed: (a) $t \leq \bar{t}$, in which case $\pi_1(w,c+t) = \pi_1(v,K,c+t)$; and (b) $t > \bar{t}$, in which case $\pi_1(w,c+t) > \pi_1(v,K,c+t)$. We take up each region in turn.

(a) $\underline{t \leq \bar{t}}$. The response of w to changes in t is now determined exclusively by the binding constraint $\pi_1(w,c+t) = \pi_1(v,K,c+t)$. The level of w that maintains this equality is defined by $\bar{w} = \bar{w}(t)$. Notice that the tariff increases both of the terms in the constraint, as the profits of the home firm increase both with and without vertical supply. But since $\bar{w} \geq v$, there is a presumption that, with w kept unchanged, the level of profits with vertical supply increases by a <u>lower</u> absolute amount than the reservation level of profits. That is because the output level of the home firm is lower in the case where the input is imported (as its marginal cost is higher). The general expression for the response of profits to the increase in tariffs is

given by

$$d\pi_1/dt = x_1 p'(dx_2/dt),$$

which, in the linear demand case for example, is simply proportional to x_1 as p' and dx_2/dt are then both constant. The implication is that $dw^*/dt = d\bar{w}/dt < 0$: the foreign firm has to lower its input price to offset the differential gain in profitability in favor of the domestic technology.

In the region where $t \leq \bar{t}$, then, the home government will have two motives for placing a tariff on imports of the final good. First, there will be the well-known Brander-Spencer (1984) motive of shifting profits to the home firm by increasing the costs of the foreign firm in servicing the home market. By trading off these profit gains against consumer-surplus losses, one can determine the optimal level of the tariff. The second motive is specific to the present context. This additional effect, which is beneficial to the home firm and consumers alike, is the reduction in costs of the home firm. On account of this second effect, the optimal level of the tariff is generally higher than that considered by Brander and Spencer (1984). Figure 2 shows the outcome in the final goods market: the shift in the reaction curve of the foreign firm is due to the first effect, while the shift in the reaction curve of the home firm is due to the second effect.

(b) $\underline{t > \bar{t}}$. In this region, the constraint no longer binds and the response of w^* to t is determined by setting the first-order condition (11") equal to zero. Note that, when t first crosses into this region, there is a discrete fall in w, corresponding to this different condition. The comparative-statics of (11") then determines the response of w to further

increases in t. In this region dw^*/dt cannot be signed in general. Increases and decreases are both possible within the bounds set by $\bar{w}(t)$ and w_{min}. But something more specific can be said in the case of the linear demand function $x_1 + x_2 = A - Bp$: $dw^*/dt < 0$ if and only if $(B^4 - 6) > 0$.

What can be said about the globally optimal level of the tariff, t^*? Without more specific parameters on the demand and cost side, it is not possible to determine whether t^* will lie below $\bar{t}$ or above it, or even if t^* is strictly positive. In each case, the potential loss in consumer surplus has to be traded against profit gains by the home firm. What can be said is that the input-cost effect strengthens the case for the tariff compared to the situation where the two firms do not interact in the market for the intermediate good.

IV. Concluding Remarks

The framework used here demonstrates that there is a strong case for policy intervention when a home firm purchases intermediate inputs from its oligopolistic rival abroad. Our assumptions on the cost side yield a number of strong results, some that are counter-intuitive at first sight. First, in the absence of policy, the foreign firm will always supply the input to its rival provided it cannot monopolize the final-goods market by withholding it. Second, under a wide range of circumstances, the foreign firm will charge a price for the input that leaves the home firm indifferent between importing it and manufacturing it locally. Third, as long as vertical supply continues, a tariff placed on the input will be borne entirely by the foreign firm. Fourth, when the domestic firm has to incur a fixed development cost for the

input, the home government can always drive the foreign firm to charge a price below cost for the input. Fifth, a prohibitive tariff on the input can be welfare-increasing. Sixth, when optimally set, a capital subsidy to the home firm will more than cover the home firm's fixed development costs (provided $v > c$). Finally, a tariff on the final good will enhance the home firm's profits not only through the familiar channel of increasing the costs of its rival, but now also through the reduction in its own input costs.

Some of these results may need qualification, and some even be reversed, under different scenarios with respect to the home firm's costs of developing indigenous technology for the input. So some extension in that direction seems desirable. But the combination of a fixed cost with constant marginal cost represents a useful benchmark in its own right, and one that may be particularly relevant to nascent domestic industries that have to compete against well-established and integrated foreign firms.

Note finally that the analysis of the paper applies equally well to cases where the home firm competes in the intermediate-good market instead, with the downstream monopolized by the rival. Frequently, the development of a separate customer base downstream requires a one-time investment (in marketing channels, customer loyalty, and so forth). The unintegrated firm has the choice of supplying the downstream monopolist or establishing its own capability in the final-good market. The integrated firm, in turn, has to decide whether to buy the intermediate good from its rival. It should be clear that, with an appropriate re-labeling, the model used here will yield identical results when applied to this case. While the final-good tariff does not have a direct analogue, the two other policies considered above do: the

input tariff can now be thought of as an export tax for the intermediate, and the capital subsidy becomes a subsidy to cover downstream investment costs.

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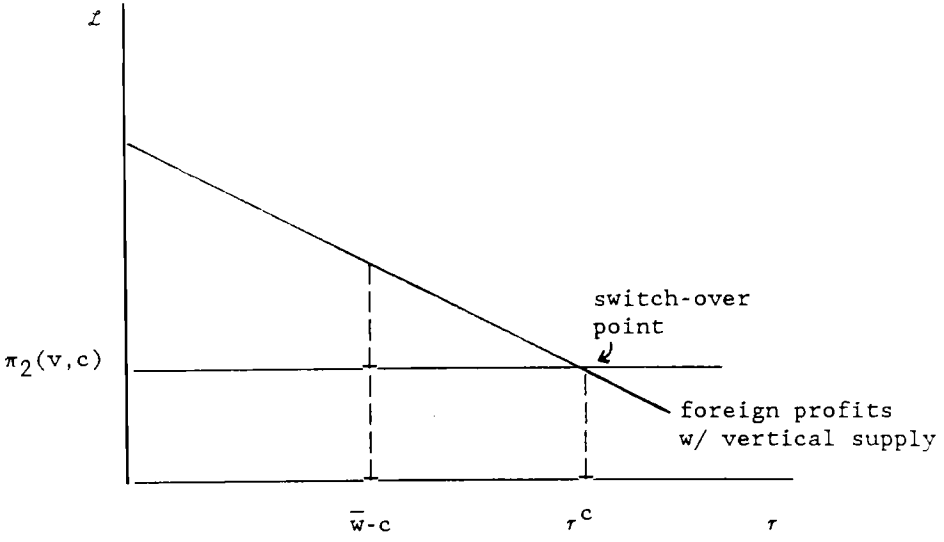
$\mathcal{L}$
switch-over
point
$\pi_2(v,c)$
foreign profits
w/ vertical supply
$\bar{w}$-c
r^c
r

Figure 1

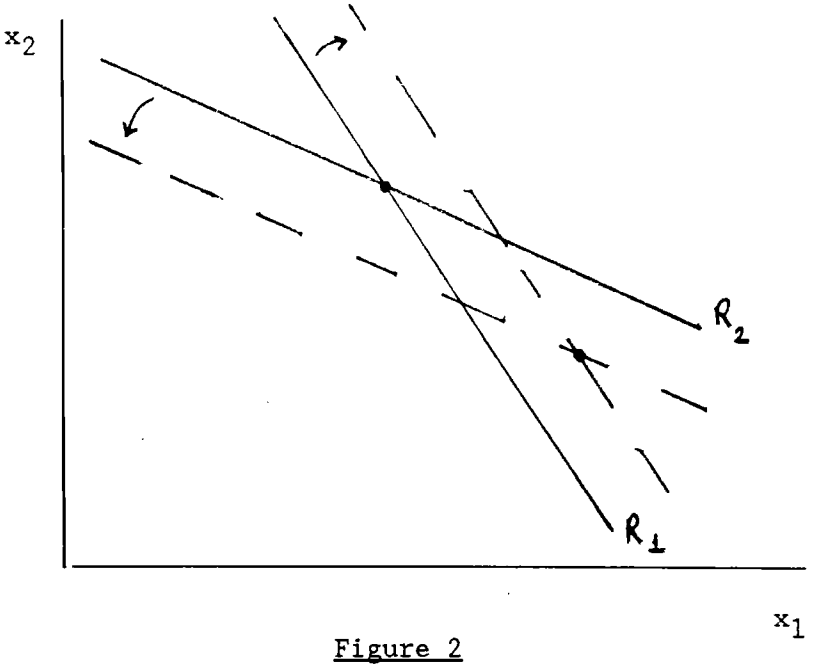

Figure 2