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Import Protection as Export Promotion in Oligopolistic Markets with R & D

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I INTRODUCTION

Can import protection ever act as export promotion? One reason that this is an important question is that it has often been argued that import protection is an explanation of Japanese export success since the war. Yamamura (1986) for instance regards it as an essential part of Japanese policy during its "rapid growth phase". He argues that:

> As the firms expanded, the protected markets, which had served as hot houses for the fledgling industries, became export platforms easing the risks of aggressive expansion into export markets.

The idea that import protection is export promotion has been formalised by Krugman (1984) in a number of partial equilibrium non-cooperative oligopolistic trade models. The purpose of what follows is to re-examine the issue in a formal two-stage game framework in which firms choose R & D levels in the first stage and outputs in the second.

In this paper I look at international oligopolistic competition in segmented markets. This is the same approach as that adopted by Brander (1981), Brander and Krugman (1983), Dixit (1984) and Krugman (1984). To make the

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segmented markets assumption is to rule out arbitrage. Firms can in equilibrium charge different prices in different markets. When this no-arbitrage assumption is combined with the assumptions of a fixed number of firms and constant marginal costs, markets are unlinked. This means that a tariff, tax or subsidy imposed in one market does not affect any other market. There are no market spillover effects. Import protection does not help exports nor does it hinder them. The idea that markets are hermetically sealed in this way seems implausible, though it does seem reasonable to suppose that prices or quantities can be chosen at least somewhat independently for different national markets. Recent work by Ben-Zvi and Helpman (1988) and Venables (1990) has combined the segmented markets assumption with market linkage by using a two-stage game framework. In these papers firms choose capacity in the first stage of a two-stage game on a worldwide integrated basis. Then they choose prices in segmented markets. A tariff will have market spillover effects in models such as these (see Leahy (1991) for a further discussion).

Spencer and Brander (1983) also looked at firms playing a two-stage game. In their model firms compete in a single market, first choosing R & D and then quantity. They use this framework to examine optimal export and R & D subsidies.

The plan of the paper is as follows: After some preliminaries, Section II explores a model in which firms choose process R & D in the first stage of a two-stage game on a worldwide integrated basis and then follow this up by choosing the quantity for each market. The key result of the section is that import protection is export promotion. In Section III I consider a situation in which both governments have imposed tariffs. Bilateral trade liberalisation is then shown to lead to an increase in R & D expenditures and to an increase in exports.

II A TWO-STAGE GAME IN R & D AND OUTPUT

In this section I consider an imperfectly competitive model in which there are two firms. One of these is located in the home market, the other in a foreign market. They each sell in the home and the foreign market. To keep the analysis simple I will assume zero transport costs and linear inverse demands throughout the paper. The goods produced by the home and foreign firms are substitutes. Let

$$\begin{aligned} p(x, y) &= a - b(x + \varepsilon y) \\ q(x, y) &= a - b(\varepsilon x + y), \quad 0 < \varepsilon \leq 1 \end{aligned} \tag{2.1}$$

be the home market inverse demand functions for the home and foreign firms respectively. The home firm sells at the price p and the foreign firm at the price q. The domestic sales of the home firm are represented by x and the home market (export) sales of the foreign firm by y.

The parameter ε is a measure of product differentiation. When this parameter has a value of unity the goods are perfect substitutes and for any value less than unity but greater than zero the goods are imperfect substitutes.

The foreign market inverse demands are similarly:

$$\begin{aligned} p^*(x^*, y^*) &= a - b(x^* + \varepsilon y^*), \\ q^*(x^*,y^*) &= a - b(\varepsilon x^* + y^*), \end{aligned} \tag{2.2}$$

for the home and foreign firms respectively. The home firm's export price is p^*, and the quantity it exports is x^*. The foreign market (domestic) price of the foreign output is q^* and the quantity sold is y^*.

In this section the firms play a two-stage game. In the first stage they select process R & D expenditures at a global level. This then affects second-stage marginal production costs. The more R & D that takes place in the first stage the lower the second-stage marginal costs, which are assumed constant with respect to output. In the second-stage subgame, R & D levels are given and firms simply play Cournot in segmented markets.

Let N and N^* be the levels of home and foreign R & D respectively. C(N) is the home and $C^*(N^*)$ the foreign marginal cost which are restricted as follows:

$$\begin{aligned} &C(N) > 0, \;\; C_N(N) < 0, C_{NN}(N) > 0, \\ &C^*(N^*) > 0, \;\; C^*_{N^*}(N^*) < 0, \;\; C^*_{N^*N^*}(N^*) > 0. \end{aligned} \tag{2.3}$$

The need for the restriction on second derivatives will become clear later.

Analysis of policy intervention in this section will focus on a tariff t imposed by the home government, though similar interesting market linkage effects would be obtained by looking at some other policy instrument, for instance an import quota. The home firm's profit function can be written as:

$$\pi = xp(x, y) + x^*p^*(x^*, y^*) - (x + x^*)C(N) - N \tag{2.4}$$

I am assuming that the marginal cost of R & D is constant and set equal to unity. The foreign firm has the following profit function:

$$\pi^* = y\{q(x, y) - t\} + y^*q^*(x^*, y^*) - (y + y^*)\ C^*(N^*) - N^* \tag{2.5}$$

Following standard practice, I first work out the Nash equilibrium of the second stage and then obtain the Nash equilibrium of the first stage subject to the second stage of the game being in equilibrium. The home and foreign firms are faced with the following second-stage optimisation problems with R & D levels fixed:

$$\begin{aligned} &\max_{x, x^*} \ \pi(x, y, x^*, y^*), \\ &\max_{y, y^*} \ \pi^*(x, y, x^*, y^*). \end{aligned} \tag{2.6}$$

This gives rise to four first-order conditions:

(i) $\pi_x(x, y; N) = 0 = xp_x + p - C(N),$ (2.7)

(ii) $\pi_{x^*}(x^*, y^*; N) = 0 = x^*p^*_{x^*} + p^* - C(N),$

(iii) $\pi^*_y(x, y, t; N^*) = 0 = yq_y + q - (C^*(N^*) + t)$

(iv) $\pi^*_{y^*}(x^*, y^*; N^*) = 0 = y^*q^*_{y^*} + q^* - C^*(N^*)$

Since N is fixed, (i) and (iii), which are home market equations, can be separated from (ii) and (iv) and solved independently.

Taking the home market sub-system and substituting from (2.1) yields the implicit reaction functions:

$$\begin{aligned} \pi_x &= a - b(2x + \varepsilon y) - C(N) = 0, \\ \pi^*_y &= a - b(\varepsilon x + 2y) - [C^*(N^*) + t] = 0, \end{aligned} \tag{2.8}$$

for the home and foreign firm in the home market. It is easy to solve these simultaneously for the Cournot-Nash equilibrium levels of x and y:

$$\begin{aligned} b(4 - \varepsilon^2)x &= (2 - \varepsilon)a - 2C(N) + \varepsilon(C^*(N^*) + t), \\ b(4 - \varepsilon^2)y &= (2 - \varepsilon)a + \varepsilon C(N) - 2(C^*(N^*) + t). \end{aligned} \tag{2.9}$$

From (2.9) the comparative static properties of this Nash equilibrium can be derived:

$$\begin{aligned} x_N &= -2C_N/b(4 - \varepsilon^2) > 0, & y_N &= \varepsilon C_N/b(4 - \varepsilon^2) < 0, \\ x_{N^*} &= \varepsilon C^*_{N^*}/b(4 - \varepsilon^2) < 0, & y_{N^*} &= -2C^*_{N^*}/b(4 - \varepsilon^2) > 0, \\ x_t &= \varepsilon/b(4 - \varepsilon^2) > 0, & y_t &= -2/b(4 - \varepsilon^2) < 0. \end{aligned} \tag{2.10}$$

Similarly for the foreign market:

$$
\begin{aligned}
&x_N^* = -2C_N/b(4-\varepsilon^2) > 0, && y_N^* = \varepsilon C_N/b(4-\varepsilon^2) < 0, && (2.11)\\
&x_{N*}^* = \varepsilon C_{N*}^*/b(4-\varepsilon^2) < 0, && y_{N*}^* = -2C_{N*}^*/b(4-\varepsilon^2) > 0,\\
&x_t^* = y_t^* = 0.
\end{aligned}
$$

The equations in (2.10) and (2.11) summarise the comparative statics of the second stage. A tariff imposed after R & D levels have been chosen will have no foreign market effects, that is to say markets are unlinked. However, if the tariff is in place before the R & D expenditures are made, then it will affect these levels and through this route the outputs of both firms in both markets. To see how this happens it is necessary to consider the first-stage equilibrium. In the first stage the home and foreign firms face the following optimisation problems respectively:

$$\max_N \pi[x(N, N^*, t), y(N, N^*, t), x^*(N, N^*), y^*(N, N^*), N], \qquad (2.12)$$

$$\max_{N^*} \pi^* [x(N, N^*, t), y(N, N^*, t), x^*(N, N^*), y^*(N, N^*), N^*, t],$$

yielding the following first order conditions:

$$\text{(a)} \qquad \pi_N \equiv \frac{d\pi}{dN} = \pi_y\, y_N + \pi_{y*}\, y_N^* - [(x + x^*)C_N + 1] = 0 \qquad (2.13)$$

$$\text{(b)} \qquad \pi_{N*}^* \equiv \frac{d\pi^*}{dN^*} = \pi_x^*\, x_{N*}$$

$$+ \pi_{x*}^* x_{N*}^* - [(y + y^*)\, C_{N*}^* + 1] = 0.$$

The envelope theorem having been invoked in order to eliminate terms in π_x, π_{x*}, π_y^*, and π_{y*}^*.

The equations in (2.13) can be rearranged as follows:

$$\text{(a)} \qquad (x + x^*)C_N + 1 = \pi_y\, y_N + \pi_{y*}\, y_N^* > 0, \qquad (2.14)$$

$$\text{(b)} \qquad (y + y^*)C_{N*}^* + 1 = \pi_x^*\, x_{N*} + \pi_{x*}^*\, x_{N*}^* > 0.$$

The terms on the LHS of (2.14) represent the effects of R & D on costs, at constant outputs. If there was no rival firm these terms would be set equal to zero, firms choosing R & D levels to minimise costs. The presence of a rival means that firms spend *more* than the direct cost minimising amount on

R & D, so as to exploit its "strategic effect". This strategic effect of R & D is the effect it has in reducing foreign sales in both markets and so shifting rent to the home firm. This was pointed out by Spencer and Brander (1983). The strategic effect is represented by the terms on the RHS of (2.14).

Using (2.10) and (2.11) the first order conditions can also be rewritten in the form:

$$\pi_N = \frac{-4}{4-\varepsilon^2}(x + x^*)C_N - 1 = 0, \tag{2.15}$$

$$\pi^*_{N^*} = \frac{-4}{4-\varepsilon^2}(y + y^*)C^*_{N^*} - 1 = 0.$$

The second order condition for the home firm is:

$$\pi_{NN} = \frac{-4}{4-\varepsilon^2}[(x_N + x^*_N)C_N + (x + x^*)C_{NN}] < 0. \tag{2.16}$$

For stability it is necessary that the overall term in parentheses is positive. The term $(x_N + x^*_N)C_N$ is negative and so must be dominated by the term $(x + x^*)C_{NN}$. It must therefore be the case that C_{NN} is strictly positive. Hence the restriction on the second derivative of marginal cost given in (2.3) above. The cross effect of foreign R & D on the marginal profitability of home R & D is:

$$\pi_{NN^*} = \frac{-4}{4-\varepsilon^2}(x_{N^*} + x^*_{N^*})C_N < 0. \tag{2.17}$$

So R & D expenditures are strategic substitutes: reaction functions are negatively sloped in strategy space. See Bulow *et al* (1985).
The slope of the home reaction function in R & D space is:

$$dN^*/dN = -\pi_{NN} / \pi_{NN^*} < 0,$$

that of the foreign firm is:

$$dN^*/dN = -\pi^*_{N^*N} / \pi^*_{N^*N^*} < 0,$$

and the stability requirement is:

$$\Delta = \pi_{NN}\,\pi^*_{N^*N^*} - \pi_{NN^*}\,\pi^*_{N^*N} > 0. \tag{2.18}$$

Stability in the model is ensured so long as the own effects of R & D on profits dominate the cross effects.

In order to examine the comparative statics of the first stage totally differentiate the first stage first-order conditions to get:

$$\pi_{NN}\,dN + \pi_{NN^*}\,dN^* + \pi_{Nt}\,dt = 0, \tag{2.19}$$

$$\pi^*_{N^*N}\,dN + \pi^*_{N^*N^*}\,dN^* + \pi^*_{N^*t}\,dt = 0.$$

Then rearrange this to give:

$$\begin{bmatrix} \pi_{NN} & \pi_{NN^*} \\ \pi^*_{N^*N} & \pi^*_{N^*N^*} \end{bmatrix} \begin{bmatrix} \dfrac{dN}{dt} \\ \dfrac{dN^*}{dt} \end{bmatrix} = \begin{bmatrix} -\pi_{Nt} \\ -\pi^*_{N^*t} \end{bmatrix} \tag{2.20}$$

which yields solutions for the impact of the tariff on home and foreign R & D:

$$\Delta\frac{dN}{dt} = \pi^*_{N^*t}\,\pi_{NN^*} - \pi_{Nt}\,\pi^*_{N^*N^*} > 0. \tag{2.21}$$

The positive sign of the derivative $\frac{dN}{dt}$ is guaranteed because π_{Nt} is positive and $\pi^*_{N^*t}$ is negative. Similarly the response of foreign R & D to the tariff is given by:

$$\Delta\frac{dN^*}{dt} = \pi_{Nt}\,\pi^*_{N^*N} - \pi^*_{N^*t}\,\pi_{NN} < 0. \tag{2.22}$$

Now differentiation of $x(N, N^*, t)$, $x^*(N, N^*)$, $y(N, N^*, t)$ and $y^*(N, N^*)$ yields the following results:

(i) $$\frac{dx}{dt} = x_N\frac{dN}{dt} + x_{N^*}\frac{dN^*}{dt} + x_t > 0, \tag{2.23}$$

(ii) $$\frac{dx^*}{dt} = x^*_N\frac{dN}{dt} + x^*_{N^*}\frac{dN^*}{dt} > 0,$$

(iii) $$\frac{dy}{dt} = y_N\frac{dN}{dt} + y_{N^*}\frac{dN^*}{dt} + y_t < 0,$$

(iv) $$\frac{dy^*}{dt} = y^*_N\frac{dN}{dt} + y^*_{N^*}\frac{dN^*}{dt} < 0.$$

From (2.23 (ii)) it is possible to obtain the main result of this section.

Proposition 1: A tariff imposed before firms play a two-stage game, choosing R & D globally in the first stage and sales for segmented markets in the second stage, will be export promoting.

III A FOREIGN TARIFF

In the previous section I demonstrated that import protection can help exports through its effect on R & D expenditure levels. Suppose now that both governments are using tariffs to protect their own firm, then a question arises: How would an agreed *reduction* in tariffs affect exports?

In this section the foreign government imposes the tariff t^*. The home profit function is now:

$$\pi = x\, p(x, y) + x^* \{p^*(x^*, y^*) - t^*\} - (x + x^*)C(N) - N. \qquad (3.1)$$

The foreign profit function is still given in (2.5).

As before I begin by considering the second stage in which the firms choose quantities, given R & D levels. The first-order conditions are:

$$\begin{array}{lll} \text{(i)} & \pi_x = a - b(2x + \varepsilon y) - C(N) = 0, & (3.2) \\ \text{(ii)} & \pi_{x^*} = a - b(2x^* + \varepsilon y^*) - [C(N) + t^*] = 0, & \\ \text{(iii)} & \pi^*_y = a - b(\varepsilon x + 2y) - [C^*(N^*) + t] = 0, & \\ \text{(iv)} & \pi^*_{y^*} = a - b(\varepsilon x^* + 2y^*) - C^*(N^*) = 0. & \end{array}$$

As in Section II the system is separable into one sub-system for the home market and one for the foreign market. The Equations (i) and (iii) represent the home market reaction functions of the home and foreign firms respectively. They yield the home market outputs which are represented in (2.9). The foreign market sub-system (ii) and (iv) can be solved to give:

$$\begin{array}{lll} \text{(i)} & b(4 - \varepsilon^2)x^* = (2 - \varepsilon)a - 2(C(N) + t^*) + \varepsilon C^*(N^*), & (3.3) \\ \text{(ii)} & b(4 - \varepsilon^2)y^* = (2 - \varepsilon)a + \varepsilon(C(N) + t^*) - 2C^*(N^*). & \end{array}$$

The foreign market comparative static derivatives are now:

$$\begin{array}{llll} x^*_N & = -2C_N/b(4 - \varepsilon^2) > 0, & y^*_N & = \varepsilon C_N/b(4 - \varepsilon^2) < 0, \qquad (3.4) \\ x^*_{N^*} & = \varepsilon C^*_{N^*}/b(4 - \varepsilon^2) < 0, & y^*_{N^*} & = -2C^*_{N^*}/b(4 - \varepsilon^2) > 0, \\ x^*_{t^*} & = -2/b(4 - \varepsilon^2) < 0, & y^*_{t^*} & = \varepsilon/b(4 - \varepsilon^2) > 0. \end{array}$$

Turning now to the first-stage, the first-order conditions for choice of R & D are still represented by the equation in (2.15). The only difference is now that π_N and $\pi^*_{N^*}$ both depend on t^*.

I now wish to examine the impact of change in t and t^*. In order to keep the analysis manageable I will impose the following Assumptions A.1 and A.2:

Identical cost functions: (A.1)

$$\text{if } N = N^* \qquad \begin{aligned} C(N) &= C^*(N^*) \\ C_N(N) &= C^*_{N^*}(N^*) \\ C_{NN}(N) &= C^*_{N^*N^*}(N^*) \end{aligned}$$

Identical tariffs: (A.2)

$$t = t^* = \tau.$$

Taken together with the other assumptions of the model these imply a symmetrical equilibrium, i.e., $x = y^*$, $x^* = y$ and $N = N^*$.

The home and foreign second order conditions for optimal choice of R & D are now equal.

$$\pi_{NN} = \pi^*_{N^*N^*} \tag{3.5}$$

The cross effects of rival R & D on marginal profitability of own R & D must also be the same for the home and foreign firm:

$$\pi_{NN^*} = \pi^*_{N^*N} \tag{3.6}$$

The impact of an equal change in tariff levels on the marginal profitability of R & D is captured by the following:

(i) $$\pi_{N\tau} = -4C_N\,(x_t + x^*_{t^*})/(4 - \varepsilon^2) \tag{3.7}$$

(ii) $$\pi^*_{N^*\tau} = -4C^*_{N^*}\,(y_t + y^*_{t^*})/\,(4 - \varepsilon^2).$$

The use of (2.10) and (3.4) together with (A.1) and (A.2) yields:

$$\pi_{N\tau} = \pi^*_{N^*\tau} = 4C_N/b(4 - \varepsilon^2)(2 + \varepsilon) \tag{3.8}$$

Now totally differentiate the first-order conditions for R & D choice and solve for the impact of tariff changes on R & D:

$$\frac{dN}{d\tau} = \frac{dN^*}{d\tau} = -\frac{\pi_{N\tau}}{\pi_{NN} + \pi_{NN^*}} < 0. \tag{3.9}$$

Differentiation of $x^*(N, N^*, \tau)$ and $y(N, N^*, \tau)$ yields:

$$\frac{dx^*}{d\tau} = x^*_N \frac{dN}{d\tau} + x^*_{N^*} \frac{dN^*}{d\tau} + \frac{\partial x^*}{\partial \tau}, \tag{3.10}$$

$$\frac{dy}{d\tau} = y_N \frac{dN}{d\tau} + y_{N^*} \frac{dN^*}{d\tau} + \frac{\partial y}{\partial \tau}.$$

The use of (2.10), (3.4) and (3.9) in (3.10) gives:

$$\frac{dx^*}{d\tau} = \frac{dy}{d\tau} = \frac{\pi_{N\tau}}{(\pi_{NN} + \pi_{NN^*})} \frac{C_N}{b(2+\varepsilon)} - \frac{2}{b(4-\varepsilon^2)} < 0. \tag{3.11}$$

Proposition 2: Starting at a symmetrical equilibrium an equal increase in both the home and foreign tariff (i) reduces R & D expenditures, (ii) reduces exports.

IV CONCLUDING REMARKS

Krugman (1984) was the first work to analyse theoretically the "import protection as export promotion thesis". In this paper I extended that work examining the thesis within the framework of a formal two-stage game. I have shown that the thesis continues to hold for a unilateral tariff when firms choose R & D expenditures before outputs. However, if both governments impose tariffs and they agree to change these bilaterally, then import protection is not export promotion.

The main result of the paper (Proposition 1) concurs with the results in Krugman (1984). However it is worth exploring what happens under different assumptions about strategic variables and firms' behaviour. For instance it is at least as plausible to suppose that firms choose price and let demand determine sales as it is to suppose they choose quantity. Recently firms have been modelled choosing their productive capacity in the first stage and following this up by choosing price in the second stage. Papers by Kreps and Scheinkman (1983), Ben Zvi and Helpman (1988) and Venables (1990) have all adopted that framework. I have examined the implications of this elsewhere. In Leahy (1991) I show that when firms play a two-stage game choosing R & D in the first stage and price in the second that the "import protection export promotion" result continues to hold, but that in a capacity-price game tariff protection actually hurts exports.

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