Title	Export enhancing tariff protection with strategic precommitment
Authors(s)	Leahy, Dermot
Publication date	1994-03
Series	UCD Centre for Economic Research Working Paper Series; WP94/1
Publisher	University College Dublin. School of Economics
Item record/more information	http://hdl.handle.net/10197/1950
Notes	A hard copy is available in UCD Library at GEN 330.08 IR/UNI

CENTRE FOR ECONOMIC RESEARCH

Export Enhancing Tariff Protection With Strategic Precommitment

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Working Paper WP94/1

March 1994

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Export Enhancing Tariff Protection

with Strategic Precommitment

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Abstract

The import protection as export promotion thesis is examined from a positive and normative perspective in a series of two-stage games in which firms choose R&D and capacity in the first stage and quantity or price in the second. It is shown (i) that a tariff affects exports in two ways; firstly, with increasing marginal cost it crowds out exports; secondly by increasing R&D and/or capacity it raises exports indirectly, (ii) when firms choose R&D and quantities a small tariff will raise welfare. This result can be reversed under Bertrand competition.

JEL:F12, L13.

Keywords: Protection, Export Promotion, R&D, Oligopoly, Precommitment.

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* I would like to thank Peter Neary for many helpful comments. I would also like to thank Anthony Venables for comments on a previous draft. The usual disclaimer applies.

EXPORT-ENHANCING TARIFF PROTECTION WITH STRATEGIC PRECOMMITMENT

1. INTRODUCTION

There has long been a view among business people that protection against imports can help firms in their export markets. In particular it is often argued that import protection is one explanation for the export success of Japanese firms since the war[1]. What has economic theory to say on the issue? There is of course the traditional "infant industry argument" for protection: the temporary protection of an industry may allow it to grow and take advantage of economies of scale either of the static kind or the dynamic learning by doing variety, and so permit it to compete more successfully. In order to apply however, the traditional infant industry argument requires either the existence of capital market imperfections or that positive externalities will be generated by the protected industry[2].

Krugman (1984) puts forward a game-theoretic variant of the infant industry argument which does not require capital market imperfections or externalities. In his model import protection is in effect a strategic export policy. In persuading foreign firms to produce less it alters the subsequent course of the game in a way that benefits the home firm in all markets. The import protection as export promotion result is also obtained by Baldwin and Krugman (1988) in a simulation study of U.S. and Japanese rivalry in the semi-conductor industry.

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[1] See Yamamura (1986) for an economist's perspective on the role of import protection in the Japanese export success. He argues that Japan's industrial policy and trade policy of the "rapid growth phase" involved, among other things, this type of import protection as export promotion. He stresses that during the period, not only was the domestic economy heavily protected, but Japanese firms were able to exploit important economies of scale. This put firms under strong pressure to reduce unit costs, through increased sales, that could only come from exporting more.

[2] Baldwin (1969) provides an overview.

The purpose of this paper is to examine the issue of export-enhancing protection in a formal two-stage game framework and to isolate those market linkage effects that make it more or less likely. Even if import protection does lead to an expansion of exports it may not be desirable from a welfare point of view. Therefore a further purpose of this paper is to provide an explicit welfare analysis.

In the models I consider firms choose cost-reducing R&D or productive capacity non-cooperatively in the first stage of a game and then choose price or output in the second stage. The R&D or capacity level chosen, a commitment made prior to the output or price stage, cannot be subsequently modified. Although there is a growing literature on the two-stage game approach to modelling oligopolistic rivalry,[3] most of the papers so far, apart from notable exceptions such as Venables (1990) and Ben-Zvi and Helpman (1992), have been concerned with a single market.

For import protection to be export promotion it is essential that markets be in some way linked. Following much previous work on international oligopoly by Brander (1981), Brander and Krugman (1983), Dixit (1984) and Krugman (1984) which adopted a static single-stage game approach, I assume that markets are segmented. This means that arbitrage is ruled out, so that firms in equilibrium can charge different prices in different markets. This is both a plausible assumption and one that permits two-way trade in homogeneous products. In most of these papers, however (though not in Krugman (1984)) attention is restricted to the case of constant marginal cost. When this assumption is combined with that of segmented markets

[3] See for instance Kreps and Scheinkman (1983), and Davidson and Deneckere (1986) for capacity-price games and Spencer and Brander (1983), Brander and Spencer (1983), Reitzes (1991) and Besley and Suzumura (1992) for R&D-quantity games.

it implies that the game played between firms in one market is completely separate from the game played by the same firms in other markets. If it is further assumed that the number of firms is fixed, markets are unlinked. Import protection will not affect exports at all in that case. In contrast in the models I examine here markets are linked in two ways: Firstly, by assuming that marginal costs are increasing, domestic and export sales become substitutes in supply. Secondly, when a firm's competitive position is improved in one market it may invest in more R&D or capacity, so affecting its costs, and through this its sales everywhere. Using a two-stage game framework it is possible to view the impact of protection on exports at constant R&D and capacity as a short-run effect, and the total impact of the tariff when the first-stage variable can change, as a long-run effect.

This paper is organised as follows: In section 2 I consider a two-stage game in which R&D expenditures are chosen in the first stage and quantities are chosen for segmented markets in the second stage. The effects of a tariff on exports are examined. In section 3 I consider the welfare implications of a small tariff (i) when R&D is fixed, and (ii) when R&D is endogenous. In section 4, to check the robustness of results to changes in the first- and second-stage strategic variables, I examine the positive and normative implications of tariff protection as export promotion in a model in which firms can choose R&D <u>or</u> productive capacity in the first stage and quantity <u>or</u> price in the second stage. For tractability, attention is restricted to the case of linear demands and quadratic costs. In that section I also show that, when firms face an absolute constraint on total output in the second stage that import tariff protection is unlikely to promote exports.[4] The implications of product differentiation for the welfare analysis are also considered.

[4] This is the framework adopted in Ben-Zvi and Helpman (1992) and Venables (1990).

2. R&D-QUANTITY GAME

2.1 The Model

Throughout the paper I consider imperfectly competitive models in which there are two firms. One of these firms is located in the home country, and I refer to this as the home firm. The other is located abroad and will be called the foreign firm. There are two national markets, referred to as the home and foreign market and the two firms sell in both of these. In this section the two firms play a two-stage game choosing process R&D in the first stage and quantity in the second. For tractability I assume that the good produced is homogeneous. The three-times continuously differentiable inverse demand functions for the two markets are:

(2.1)

$$p = p(Q), \text{ where } Q \equiv x + y,$$

$$p^* = p^*(Q^*), \text{ where } Q^* \equiv x^* + y^*,$$

and Q and Q* are the quantities sold on the home and foreign markets respectively[5]. The home market sales of the home firm are represented by x and the exports of the foreign firm to the home market are given by y. The home firm exports x* and the foreign firm sells y* on the foreign market (its own domestic market).

The home and foreign total production cost functions take the following form:

(2.2)

$$C = C(x + x^*, n),$$

$$C^* = C^*(y + y^*, n^*),$$

with marginal costs:

$$c = C_x(x + x^*, n), \quad c^* = C^*_y(y + y^*, n^*),$$

[5] I will often use stars to represent foreign or foreign market variables.

where n and n* are the levels of home and foreign R&D.

I shall impose the following restrictions on marginal costs:

(A1)

(i) $$0 \leq \mu < \infty,\ 0 \leq \mu < \infty.$$

$$\text{where } \mu \equiv c_x \text{ and } \mu^* \equiv c^*_y.$$

(ii) $$c_n < 0,\ c^*_{n^*} < 0.$$

$$c_{nn} > 0,\ c^*_{n^*n^*} > 0.$$

Part (i) of (A1) implies that for given levels of n and n* there are non-increasing returns to scale[6]. The assumption that μ and μ* are less than infinite implies that the firms are not capacity constrained. The case of a perfectly vertical marginal cost curve is considered in section 4. Part (ii) of (A1) implies that R&D is cost reducing at a diminishing rate and there are no spillover effects.

The firms' total costs are made up of total production costs, which are variable, and R&D costs which are fixed in the second stage. Transport costs are assumed to be zero for convenience.

Home and foreign profits are:

(2.3)

$$\pi = xp(Q) + x^*p^*(Q^*) - C(x + x^*) - n,$$

$$\pi^* = y[p(Q) - t] + y^*p^*(Q^*) - C^*(y + y^*) - n^*.$$

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[6] It is straightforward to extend the analysis to consider cases in which μ is negative that is when returns to scale are increasing at constant R&D levels. The algebra is unaffected though in order to ensure stability μ must not be too negative. For details of the stability conditions in that case see Leahy (1992).

The marginal cost of R&D is assumed to be constant and normalised at unity.

2.2 *The Second Stage*

Following standard practice I begin by analysing the second stage of the game. In the second stage R&D levels are given. Assuming an interior solution the following first-order conditions for profit maximisation by the home and foreign firms are obtained:

(2.4)

(i)

$$\frac{\partial \pi}{\partial x} = p + xp' - c = 0,$$

$$\frac{\partial \pi}{\partial x^*} = p^* + x^*p^{*\prime} - c = 0,$$

for the home firm and:

(ii)

$$\frac{\partial \pi^*}{\partial y} = p + yp' - c^* - t = 0,$$

$$\frac{\partial \pi^*}{\partial y^*} = p^* + y^*p^{*\prime} - c^* = 0,$$

for the foreign firm[7]. The equation system in (2.4) implicitly defines an equilibrium.

[7] The second-order conditions are standard:

(i) $\partial^2\pi/\partial x^2 < 0$, $\partial^2\pi/\partial x^{*2} < 0$, and

(ii) $(\partial^2\pi/\partial x^2)(\partial^2\pi/\partial x^{*2}) - \mu^2 > 0$,

for the home firm and analogous conditions for the foreign firm.

(A.2) Assume that all quantities are strategic substitutes.[8]

This assumption together with A1 (i) is sufficient to ensure that the equilibrium is locally asymptotically stable[9].

It will prove useful to introduce the following notation:

$$(\beta_h + \mu) = -\frac{\partial^2 \pi}{\partial x^2}, \quad (\beta_f + \mu) = -\frac{\partial^2 \pi}{\partial x*^2},$$

$$\phi_h = -\frac{\partial^2 \pi}{\partial x \partial y}, \quad \phi_f = -\frac{\partial^2 \pi}{\partial x* \partial y*},$$

and

$$(\beta*_h + \mu*) = -\frac{\partial^2 \pi*}{\partial y^2}, \quad (\beta*_f + \mu*) = -\frac{\partial^2 \pi*}{\partial y*^2},$$

$$\phi*_h = -\frac{\partial^2 \pi*}{\partial y \partial x}, \quad \phi*_f = -\frac{\partial^2 \pi*}{\partial y* \partial x*}.$$

All the βs and ϕs are positive from the strategic substitutes assumption[10]. The comparative-static effects of a tariff on outputs when R&D is fixed can be obtained by differentiating the equation system in (2.4) with respect to t holding n and n* constant. Straightforward calculations yield:

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[8] This terminology is due to Bulow *et al* (1985). Home output x is a strategic substitute for foreign output y if $\pi_{xy} < 0$ and a strategic complement for y if $\pi_{xy} > 0$. The strategic substitutability/complementarity of other outputs is defined similarly. The purpose of this assumption 2 is to avoid tedious listing of different cases. It is straightforward to extend the analysis to encompass the case of strategic complements.

[9] In fact strategic substitutes is an overly strong sufficient condition for stability. See Seade (1980) and Dixit (1986).

[10] It is useful to note that $\phi_h - \beta_h = \phi*_h - \beta*_h = p' < 0$, and that $\phi_f - \beta_f = \phi*_f - \beta*_f = p*' < 0$.

(2.5)

$$(i) \qquad \frac{\partial x}{\partial t} = x_t = \frac{\phi_h[(\beta_f + \mu)(\beta^*_f + \mu^*) - \phi_f\phi^*_f)] + \phi_f\mu\mu^*}{\Delta},$$

$$(ii) \qquad \frac{\partial x^*}{\partial t} = x^*_t = - \frac{\mu^*\phi_f(\beta_h + \mu) + \mu\phi_h(\beta^*_f + \mu^*)}{\Delta},$$

where the determinant Δ is positive A1(i) and A2. See the appendix for an explicit expression for Δ.

PROPOSITION 1: *A tariff imposed* <u>*after*</u> *firms have chosen their R&D levels (i) will increase the domestic sales of the home firm; (ii) will reduce its exports provided either μ or μ^* is strictly positive; (iii) may or may not increase total worldwide sales of the home firm.*

Parts (i) and (ii) of proposition 1 are straightforward from inspection of (2.5). Part (ii) of proposition 1 is what I will call a "crowding out effect" (COE) on home exports: The tariff, in bringing about an expansion of the home firm's total level of production, leads to its marginal costs rising in its export market so causing it to reduce sales there. In addition the tariff reduces total foreign output thus reducing their marginal cost and improving their competitive position in the foreign market. For the tariff to have such a COE it is necessary that exports and domestic sales are substitutes in supply for at least one of the firms (this is the case here for $\mu > 0$ or $\mu^* > 0$). Because of the COE, a tariff introduced between the first and second stages of the game will hurt exports. In this case import protection is not export promotion. The quantity of exports crowded out as a result of the tariff is: - x^*_t, (a positive quantity from (2.5).

In order to prove part (iii) of proposition 1, combine the two equations in (2.5) to get:

(2.6)

$$\frac{\partial(x - x*)}{\partial t} = \frac{\phi_h(\beta_f\beta*_f - \phi_f\phi*_f) + \mu*(\beta_f\phi_h - \beta_h\phi_f)}{\Delta}.$$

I will refer to this as an "output creation effect" (OCE), for the home firm. The term in ϕ_h in the numerator must be positive but the term in μ* is ambiguous in sign and as a result the OCE can take on either sign. If constant marginal costs or linear demands are imposed, two assumptions frequently made in the literature, then the term in μ* vanishes and a negative OCE can be ruled out. This is the intuitive result: there is a presumption that the worsening of the foreign firm's competitive position brought about by the tariff should lead to an increase in the total output of the home firm. See the appendix for a detailed analysis of factors that make a negative OCE more likely.

The tariff has a negative output creation effect for the foreign firm:

(2.7)

$$\frac{\partial(y + y*)}{\partial t} = -\frac{\{\beta*_f[\beta_h\beta_f + \mu(\beta_h + \beta_f)] - \phi*_f[\phi_f(\beta_h + \mu) + \phi_h\mu]\}}{\Delta}.$$

It is straightforward to show that this must be negative.

Next consider the effects of changes in R&D. Differentiating (2.4) with respect to n, holding n* and t constant, it is possible to obtain the following comparative static results:

(2.8)

$$\frac{\partial x}{\partial n} = -c_n \frac{\beta*_h(\beta_f\beta*_f - \phi_f\phi*_f) + \mu*[\beta_f(\beta*_h + \beta*_f) - \phi*_f(\phi_h + \phi_f)]}{\Delta}$$

$$\frac{\partial x*}{\partial n} = -c_n \frac{\beta*_f(\beta_h\beta*_h - \phi_h\phi*_h) + \mu*[\beta_h(\beta*_h + \beta*_f) - \phi*_h(\phi_h + \phi_f)}{\Delta}$$

$$\frac{\partial y}{\partial n} = c_n \frac{\phi*_h(\beta_f\beta*_f - \phi_f\phi*_f) + \mu*(\beta_f\phi*_h - \beta_h\phi*_f)}{\Delta}$$

$$\frac{\partial y*}{\partial n} = c_n \frac{\phi*_f(\beta_h\beta*_h - \phi_h\phi*_h) + \mu*(\beta_h\phi*_f - \beta_f\phi*_h)}{\Delta}$$

PROPOSITION 2: *(i) An increase in a firm's R&D expenditure will lead to an increase in the firm's* *<u>total</u>* *output and a fall in that of its rival. (ii) Linear demand* *<u>or</u>* *constant marginal costs are sufficient for an increase in R&D to lead to an increase in the firm's output in* *<u>both</u>* *markets and to a fall in rival output in both markets.*[11]

For the case of an increase in home R&D, it is straightforward to use (2.8) to show that $\partial(x+x*)/\partial n$ is positive and that $\partial(y+y*)/\partial n$ is negative. Similar calculations show that $\partial(y+y*)/\partial n*$ is positive and that $\partial(x+x*)/\partial n*$ is negative. So a small increase in home R&D has a positive output creation effect for the home firm. I turn now to Part (ii) of proposition 2. It follows from (2.8) that provided $\mu*(\beta_f\phi*_h - \beta_h\phi_f*)$ is not too negative then $\partial y/\partial n < 0$. Similarly provided that $\mu*(\beta_h\phi*_f - \beta_f\phi_h*)$ is not too negative $\partial y*/\partial n$ must be negative. These conditions are discussed in the appendix. From now on I impose the following assumption:

(A.3) An increase in own R&D will reduce all rival outputs:

$$\partial y/\partial n < 0,\ \partial y*/\partial n < 0,\ \partial x/\partial n* < 0,\ \partial x*/\partial n* < 0.$$

Assumption (A.3) implies that all own outputs increase in own R&D. (See appendix for details.)

[11] Linear demands or constant marginal costs are by no means necessary for this result which could be regarded as the most plausible outcome.

2.3 The First Stage

I turn now to the first stage of the game where firms choose their R&D taking into account how these will affect second-stage variables. R&D affects profits in two ways; directly through its impact on costs and indirectly through its effect on outputs. In the first stage of the game the home and foreign firms face the following optimisation problems respectively:

(2.9)

$$(i) \qquad \max_{n} \pi[n, x(n,n*,t), y(n,n*,t), x*(n,n*,t) y*(n,n*,t)],$$

$$(ii) \quad \max_{n*} \pi*[t, n*, x(n,n*,t), y(n,n*,t), x*(n,n*,t), x*(n,n*,t)].$$

Profit maximisation implies the following first-order conditions:

(2.10)

$$\pi_n = c_n M - 1 = 0,$$

$$\pi^*_{n*} = c^*_{n*} M^* - 1 = 0,$$

where:

$$M \equiv (B_h x + B_f x*) < 0, \quad M* \equiv (B*_h y + B*_f y*) < 0,$$

and $B_h \equiv p'(y_n/c_n)-1$, $B_f \equiv p^{*\prime}(y^*_n/c_n)-1$, $B^*_h \equiv p'(x_{n*}/c^*_{n*})-1$, and $B^*_f \equiv p^{*\prime}(x^*_{n*}/c_{n*})-1$.

The equations in (2.10) represent R&D reaction functions in implicit form. Comparative-static analysis of (2.10) poses difficulties because the derivatives of M(n,n*,t) and M*(n,n*,t) depend on the third derivatives of the inverse demand functions and second derivatives of the marginal cost functions. Further assumptions are therefore necessary.

(A.4) R&D expenditures are strategic substitutes.

Algebraically: $M_{n*} > 0$, $M^*_n > 0$.

Since an increase in rival R&D reduces a firm's total production it seems plausible to assume that it will reduce the marginal profitability of own R&D. Note that if linear demands and marginal costs are imposed this is always the case. For the same reasons the following is a natural assumption[12]:

(A.5) $$M^*_t > 0 \text{ and } M_t < 0.$$

The second-order conditions for profit maximisation are:

(2.11)

$$\pi_{nn} = Mc_{nn} + M_n c_n < 0.$$

$$\pi^*_{n^*n^*} = M^*c^*_{n^*n^*} + M^*_{n^*}c^*_{n^*} < 0.$$

If the same argument that was used to justify (A.4) and (A.5) is employed here it is reasonable to assume M_n and $M^*_{n^*}$ are negative. To ensure that the second-order conditions hold the marginal cost functions must then be strictly convex in R&D as in (A.1).

As a final preliminary to comparative-static analysis I assume that the Routh-Hurwitz condition for reaction function stability holds:

(A.6) $$A \equiv \pi_{nn}\pi^*_{n^*n^*} - \pi^*_{n^*n}\pi_{nn^*} > 0.$$

This implies that the own effects of R&D on marginal profits dominate the cross effects. If this condition holds globally it implies that the equilibrium is unique.

Now I will assume that the home government can credibly precommit to a tariff before the firms choose their R&D levels. It is then possible to examine the total effect of a tariff on the equilibrium of the game. The tariff affects output both directly, and indirectly via changes in the levels of R&D chosen.

Proceed by totally differentiating (2.10) to get expressions for the impact of the tariff on home

[12] There is a presumption that tariff increases home output at constant R&D (see Proposition 1) so it is plausible to assume that it raises the marginal profitability of home R&D.

and foreign R&D:

(2.12)

(i) $$A(dn/dt) = \pi^*_{n^*t}\pi_{nn^*} - \pi_{nt}\pi^*_{n^*n^*} > 0,$$

(ii) $$A(dn^*/dt) = \pi_{nt}\pi^*_{n^*n} - \pi^*_{n^*t}\pi_{nn} < 0.$$

PROPOSITION 3: *Given A4-A6, a tariff raises home R&D and reduces foreign R&D.*

Differentiation of $x(n,n^*,t)$, $x^*(n,n^*,t)$, $y(n,n^*,t)$ and $y^*(n,n^*,t)$ yields the following results:

(2.13)

(i) $$dx/dt = x_n(dn/dt) + x_{n^*}(dn^*/dt) + x_t > 0,$$

(ii) $$dx^*/dt = x^*_n(dn/dt) + x^*_{n^*}(dn^*/dt) + x^*_t,$$

(iii) $$dy/dt = y_n(dn/dt) + y_{n^*}(dn^*/dt) + y_t < 0,$$

(iv) $$dy^*/dt = y^*_n(dn/dt) + y^*_{n^*}(dn^*/dt) + y^*_t.$$

These comparative static derivatives are signed using (A.3) and (2.12). The derivatives dx^*/dt and dy^*/dt are in general ambiguous in sign.

PROPOSITION 4: *Assuming A1-A6 are imposed; a tariff put in place before firms play a two-stage game, choosing R&D in the first stage and output for segmented markets in the second stage, will lead to an increase in the home firm's domestic sales and will have an ambiguous effect on home exports.*

The slope of the marginal cost function plays a crucial role in determining whether or not tariff protection promotes exports in this model. In the important special case of $\mu = 0$, constant marginal costs, the tariff must be export promoting as the term x^*_t disappears.[13] Constant marginal costs also imply that dy^*/dt is negative.

3. WELFARE EFFECTS OF A TARIFF IN THE R&D-QUANTITY GAME

I turn now to the welfare implications of a small tariff in the R&D output game. Assume the following standard welfare function:

(3.1)

$$W = \int_0^Q p\,dQ - Qp + \pi + ty.$$

The first two terms on the right-hand side represents the consumer surplus from consumption of the good. The third term is home firm profits and the fourth is tariff revenue. Welfare is the unweighted sum of consumer surplus, profits and tariff revenue.

To prevent the analysis from becoming intractable I will impose the following assumption:

(A.7) Symmetric equilibrium $\rightarrow x = y = x^* = y^*$.[14]

I will consider the effects of a small tariff starting from an initial symmetric equilibrium. The

[13] I have discussed this special case in detail elsewhere (see Leahy (1991)), where I also impose linear demands.

[14] Equality of outputs is a consequence of (A.7). The primitive assumption in full is:
(i) Identical cost functions:
If $n = n^*$ and $x + x^* = y + y^*$ $\rightarrow$ $C(x + x^*, n) = C^*(y + y^*, n^*)$
With identical first second and third derivatives with respect to output and first and second derivatives with respect to R&D.
(ii) Identical demand functions in the two countries:
If $Q = Q^* \rightarrow p(Q) = p^*(Q^*)$ with identical first second and third derivatives.

use of (A.7) in the total derivative of (3.1) yields:

(3.2)
$$\frac{dW}{dt} = y - Qp'(x_t + y_t) + xp'(y_t + y*_t)$$
$$- 2xp'\left\{(x_n + y_n)\frac{dn}{dt} + y_n\frac{dn*}{dt}\right\}.$$

The first line of the right-hand side represents the effect of the tariff at <u>constant</u> R&D while the second line captures the welfare effect of the resulting change in R&D expenditures. It is easy to show that the second line terms are positive. This implies that the welfare increase resulting from a small tariff is larger under endogenous R&D than fixed R&D.

Now consider the effect of the tariff on welfare at constant R&D. The first term represents the effect of the tariff on government revenue: the second term, which can be shown to be negative,[15] represents its effect on consumer surplus; while the third, which must be positive, is the impact on profits. The overall result of a small tariff at constant R&D is:

(3.3)
$$\left.\frac{dW}{dt}\right|_{\bar{n},\bar{n}*} = y\left(\frac{2\phi}{\beta + \phi} + \xi\right) - xp'(x_t - y*_t) > 0,$$
$$\text{where} \qquad \xi = \mu\frac{(\beta - \phi)(\beta - \phi + 2\mu)}{(\beta + \phi)[\beta^2 - \phi^2 + 4\mu(\beta + \mu)]} > 0.$$

Although the term in $(x_t - y*_t)$ could be positive or negative it will never be negative enough to reverse the sign of $(dW/dt)|_{n,n*}$.

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$$-p'(x_t + y_t) = p'\left(\frac{(\beta - \phi + \mu)(\beta^2 - \phi^2 + 2\beta\mu) - 2\phi\mu^2}{\Delta}\right) < 0$$

Note that $\beta = \beta_h = \beta_f = \beta*_h = \beta*_f$, $\phi = \phi_h = \phi_f = \phi*_h = \phi*_f$ and $\mu = \mu*$ in a symmetric equilibrium.

PROPOSITION 5: *In the neighbourhood of a symmetric equilibrium a small tariff will raise home welfare if it is imposed before firms play a two-stage game choosing R&D in the first stage and output in the second* <u>*or*</u> *if it is imposed after the first stage but before the second. The increase in welfare is larger when the tariff is imposed before the first stage than between the first and second stage.*

In this section I have shown that if firms choose R&D in the first stage and play Cournot in homogenous products in the second stage then a small tariff in the neighbourhood of a symmetric equilibrium (which may or may not be export promoting) must be desirable from a welfare point of view.

4. R&D V CAPACITY AND PRICE V QUANTITY COMPETITION

4.1 Differentiated Product Oligopoly

The primary purpose of the following analysis is to check the robustness of results to changes in the first and second stage strategic variables. In this section the firms play a two-stage game choosing R&D <u>or</u> productive capacity in the first stage and output <u>or</u> price in the second. Given the generality of the model, the analysis can soon become rather complicated and results difficult to interpret in an intuitive way. So in order to permit a unified treatment of R&D and capacity under both Cournot and Bertrand competition some sacrifices in generality must be made. Therefore to keep the analysis relatively transparent I assume that inverse demand curves are linear[16]. One advantage of this is that it is then possible to solve explicitly for equilibrium outputs. The goods produced by the firms are substitutes and the

[16] It is standard practice in models such as this to combine the differentiated products assumption with that of linear demands. See for instance Dixit (1988).

home market inverse demand functions are:

$$p(x,y) = a - b(x + \varepsilon y), \tag{4.1}$$

$$q(x,y) = a - b(\varepsilon x + y),$$

$$0 < \varepsilon \leq 1,$$

where a and b are positive constants. The home firm sells at a price p and the foreign firm at a price q. The parameter ε is a measure of product differentiation. When this has a value of unity the goods are homogeneous and for values less than this they are imperfect substitutes[17]. Letting stars denote foreign market variables, that market's inverse demands are:

$$p^*(x^*,y^*) = a - b(x^* + \varepsilon y^*), \tag{4.2}$$

$$q^*(x^*,y^*) = a - b(\varepsilon x^* + y^*).$$

I assume that increases in R&D or capacity both reduce second-stage marginal costs. When the marginal cost curve is upward sloping but not vertical increases in both R&D and capacity shift the curve downwards to the right. If the marginal cost curve is constant in output then capacity choice will have no effect while R&D will shift the curve downwards in a parallel manner. In the situation in which the marginal cost curve is perfectly vertical (the absolute capacity constraint case) however, it is R&D that will be completely ineffective while an increase in capacity will shift the marginal cost rightwards. In order to capture the different effects of R&D and capacity on the firm's second-stage costs, I will assume that the marginal production cost function takes the following form for the home and foreign firms respectively:

$$c(n,X,x,x^*) = \gamma(n) - \mu[X - (x + x^*)], \tag{4.3}$$

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[17] For the case in which price is chosen in the second stage I will assume that ε is strictly less than unity. This means that firms are producing differentiated products. This is necessary if we are to conduct policy analysis without resorting to mixed-strategy Nash equilibria. Homogeneous products need not be ruled out if firms choose quantity in the second stage.

$$c^*(n^*,Y,y,y^*) = \gamma^*(n^*) - \mu[Y - (y + y^*)],$$

where $X > 0$, represents a measure of the home firm's productive capacity and Y a measure of foreign capacity. Total production-cost is assumed to be quadratic in output and $\mu \geq 0$, is now a parameter. Assumption (A.1) will be imposed throughout.

The home and foreign profit functions can now be written as:

(4.4) $\pi = xp(x,y) + x^*p^*(x^*,y^*) - C(x,x^*,n,X) - n - kX,$

$$\pi^* = y[q(x,y) - t] + y^*q^*(x^*,y^*) - C^*(y,y^*,n^*,Y) - n^* - k^*Y,$$

where k and k* are the constant home and foreign marginal capacity cost.

In order to facilitate comparison of the alternative quantity and price equilibria, the second-stage subgame can be modelled using a conjectural variations approach. This approach involves modelling each firm as choosing quantity while conjecturing a particular quantity response v, from the rival. The Cournot quantity conjectural variation is $v = 0$, because the firms are taking rival output as given. Alternatively if they are playing Bertrand they take the rival price as given. This can be modelled as firms choosing quantity while conjecturing an adjustment of the rival output sufficient to keep rival price constant[18]. The home firm's "Bertrand quantity conjectural variation" (BQCV) can be obtained by totally differentiating the rival inverse demand function and setting this equal to zero. Rearrangement of this yields:

(4.5) $$v \equiv (dy/dx)|_c = - \varepsilon.$$

It is straightforward to verify that the home firm's foreign market BQCV, as well as the

[18] Note that only Cournot and Bertrand conjectures can be rigorously justified. Due to the fact that firms move simultaneously in the second stage of the game they cannot react to one another. Therefore to conjecture that the rival will react is to make a mistake. Because of this, only the Cournot and Bertrand conjectures will be considered here.

foreign firm's home and foreign market BQCV are all equal to - ε.

4.2 The Second Stage

The second-stage first order conditions now imply that firms set "perceived" marginal profits equal to zero[19]:

(4.6)

(i) $\pi_x|_c = a - \beta x - \phi y - \gamma(n) - \mu(x + x^* - X) = 0,$

(ii) $\pi_{x^*}|_c = a - \beta x^* - \phi y^* - \gamma(n) - \mu(x + x^* - X) = 0,$

(iii) $\pi^*_y|_c = a - \phi x - (\beta+t)y - \gamma(n^*) - \mu(y + y^* - Y) = 0$

(iv) $\pi^*_{y^*}|_c = a - \phi x^* - \beta y^* - \gamma^*(n^*) - \mu(y + y^* - Y) = 0,$

where the interpretation of β, modified slightly from that used in section 2, is now: $\beta = b(2 + v\varepsilon) > 0$. The difference here is that β now represents the derivative of perceived rather than actual marginal profits, with respect to own sales, and:

$$-(\beta + \mu) = \frac{\partial(\pi_x|_c)}{\partial x} = \frac{\partial(\pi_{x^*}|_c)}{\partial x^*} = \frac{\partial(\pi^*_y|_c)}{\partial y} = \frac{\partial(\pi^*_{y^*}|_c)}{\partial y^*},$$

All the ϕs are also equal under the linear demand assumption and $\phi = b\varepsilon > 0$. The linear demand and marginal cost assumptions permit the derivation of explicit expressions for the four second-stage endogenous variables: x, y, x*, and y* (see appendix). It is then straightforward to obtain the following result:

PROPOSITION 6: *Independently of whether firms are choosing quantity or price, a tariff imposed <u>after</u> firms have chosen their R&D levels will (i) increase the domestic sales*

[19] The c subscript will be used as follows:
$(d\pi/dx)|_c \equiv \pi_x|_c = (\partial\pi/\partial x) + v(\partial\pi/\partial y).$

of the home firm, (ii) reduce its exports, provided that $\mu > 0$, (iii) increase total worldwide sales of the home firm.

For a proof see the appendix. It is interesting to compare proposition 1 and proposition 6. There are two senses in which proposition 6 is more general than proposition 1. It is an extension to (i) a general conjectural variations model and (ii) a differentiated product oligopoly. However the results are obtained with demand and cost functions that are considerably less general.

Once again the tariff has a positive OCE for the home firm: the improvement in its competitive position brought about by the tariff increases its <u>total</u> sales. It is straightforward to show that this OCE is larger under Bertrand competition than when firms play Cournot. Again there is also a COE on exports. The quantity of exports crowded out as a result of the tariff is[20]:

(4.7) $$- x^*_t = 2\mu\phi(\beta + \mu)/D(\beta^2 - \phi^2).$$

where $D \equiv (\beta + \phi + 2\mu)(\beta - \phi + 2\mu) > 0$. It is straightforward to show that the crowding out effect is larger under price competition than under quantity competition for $\mu > 0$.

4.3 R&D as the First-Stage Strategic Variable

Assume that firms choose R&D in the first stage and quantity or price in the second holding constant the measures of capacity, X and Y. The first-stage optimisation problems are given in (2.9) and yield first-order conditions:

[20] The OCE and COE are derived in the appendix.

(4.8)

(i) $$(x + x^*)\gamma' + 1 = -(x + x^*)\gamma'[(\phi/D)(\phi + v(\beta + 2\mu))],$$

(ii) $$(y + y^*)\gamma^{*\prime} + 1 = -(y + y^*)\gamma^{*\prime}[(\phi/D)(\phi + v(\beta + 2\mu))].$$

The terms on the left-hand side of (4.8(i)) and (4.8(ii)) are the effects of R&D on costs at constant outputs. If there was no rival firm these would be set equal to zero, firms choosing R&D levels to minimise costs. The terms on the right-hand side of the two equations are the strategic effects of home and foreign R&D spending respectively. It can be checked that these are positive in the case of second-stage Cournot competition but negative when firms play Bertrand in the second stage[21].

Total differentiation of the first-stage first-order conditions in (4.8) yields expressions that have the same form as those in (2.12). Given the linearity assumptions dn/dt must be positive and dn*/dt must be negative independently of whether firms play Cournot or Bertrand in the second stage. It is then possible to obtain expressions of the form found in (2.13). It is the case (see appendix) that all outputs increase in own R&D and fall in rival R&D independently of the nature of second stage competition. The following result is then obtained:

PROPOSITION 7: *Assuming linear demands and marginal cost, a tariff imposed before firms play a two-stage game, choosing R&D in the first stage and output or price for*

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[21] The presence of a Cournot competitor means that the firms spend more than the cost-minimising amount on R&D in order to exploit its strategic effect. For the home firm the strategic effect in the case of second-stage Cournot competition, is the effect that it has in reducing foreign sales in both markets and so shifting profits to the home firm. To use the taxonomy of business strategies developed by Fudenberg and Tirole (1984), the firms adopt "top dog" strategies. In the case of Bertrand second-stage competition R&D expenditures are kept below their cost-minimising level. The intuition behind this result is that more home R&D causes home prices to fall in the second stage and, because prices are strategic complements rival prices also fall, which cuts into the demand for home output and hence profits. The "puppy dog" strategy of "underinvestment" in R&D is called for.

segmented markets in the second stage, will lead to an increase in the home firm's domestic sales and will have an ambiguous effect on home exports.

If in addition constant marginal costs are imposed import protection as export promotion is guaranteed independently of whether firms play Cournot or Bertrand in the second stage.

4.4 Welfare in the R&D-Quantity/Price Game

I turn now to a normative analysis of the R&D-quantity/price games. Since differentiated products are now assumed the welfare function in (3.1) must be modified as follows:

(4.9)

$$W = \int_0^y q\,dy - yq + \int_0^x p\,dx - xp + \pi + ty.$$

Impose the symmetric equilibrium assumption (A.7) and totally differentiate (4.9), making use of the home firm's first- and second-stage first-order conditions to get:

(4.10)

$$\frac{dW}{dt} = x[1 - p_x\{(x_t + y_t) + \epsilon(x_t - y*_t) + \epsilon v(x_t + x*_t)\}]$$
$$- xp_x\left\{(1 + \epsilon)(x_n + y_n)\frac{dn}{dt} + [1 + \epsilon(1 + 2v)]\ y_n\frac{dn*}{dt} + (1 - \epsilon)x_n\frac{dn*}{dt}\right\}.$$

First consider the second line on the right hand side of (4.10). This line captures the effects of the tariff on welfare via its impact on R&D. Unlike in the homogenous product Cournot case examined in the previous section the sum of these terms is now ambiguous in sign. In particular for ε zero, that is for the monopoly case, it must be negative. To see this, note that dn/dt and y_n both go to zero in that case while the remaining term in x_n(dn*/dt) is negative. The intuition is that the tariff unambiguously reduces R&D, which increases the foreign firm's costs and tends to worsen the home terms of trade.

The first line of the right-hand side represents the effect of the tariff on welfare at constant R&D. It is instructive to rewrite this as follows:

(4.11)

$$\left.\frac{dW}{dt}\right|_{\bar{n},\bar{n}*} = \frac{bx}{\Delta}\{\lambda_1 + (1 - \epsilon)\lambda_2 + v\epsilon\lambda_3\},$$

where:

$$\lambda_1 = 3\phi(\beta^2 - \phi^2 + 2\beta\mu) + 2\mu\phi(\beta + 4\mu) > 0,$$

$$\lambda_2 = (\beta + \mu)(\beta^2 - \phi^2 + 4\beta\mu) + 2\mu(\beta + \phi)(\phi + \mu) > 0,$$

$$\lambda_3 = (\beta + \phi)\{(\beta + \phi + 2\mu)(\beta - \phi + 2\mu) + \phi(\beta - \phi)\} > 0.$$

It is now possible to consider some special cases. For Cournot competition the term in $v\varepsilon$ vanishes (and for homogeneous products the term in $(1-\varepsilon)$ also vanishes). It is clear that the remaining terms are positive. Therefore the tariff has an unambiguously beneficial effect on welfare when R&D is fixed and firms play Cournot. This holds irrespective of the degree of product differentiation. This result complements proposition 5 above. In the case of Bertrand competition the third term which will now be negative must be included. It can be shown (see appendix) that for Bertrand competition the tariff could reduce welfare at constant R&D. In the monopoly case λ_1 and $v\varepsilon\lambda_1$ both vanish and this implies that the tariff raises welfare when the level of R&D is constant.

Overall it is clear from an analysis of (4.10) and (4.11) that the welfare enhancing effect of the tariff under homogeneous product Cournot competition is not very robust.

PROPOSITION 8: *Assume a symmetric equilibrium. (i) A small tariff imposed after R&D has been sunk will raise home welfare under Cournot competition but have an ambiguous effect on welfare under Bertrand competition. (ii) A small tariff imposed before R&D has been sunk has an ambiguous effect on welfare under differentiated product Cournot and Bertrand competition.*

For proofs see above and appendix.

4.5 Capacity as the First-Stage Strategic Variable

So far I have assumed that marginal costs are less than infinitely sloped. I now wish to examine how the export enhancing effect of protection is affected when firms are absolutely capacity constrained. As mentioned earlier this renders R&D expenditures useless, so instead I will assume that firms choose capacities in the first stage.[22]

This analysis draws on the work of Venables (1990), who showed that a small tariff raises welfare in the two-stage games in which capacity is chosen first. I will examine the implications for market linkage and the Krugman (1984) result "import protection is export promotion".

In the first stage of the game the home and foreign firms choose their total capacities X and Y respectively. In the second stage they choose either the sales, or prices for each market.

[22] It is clear that with constant marginal cost, that is $\mu = 0$, X and Y will have no effect on the second-stage output levels (see equation a.3) in the appendix). It is also straightforward to show that when μ lies between zero and infinity, X and Y affect outputs in the same direction as n and n* affect them. Therefore capacity and R&D choice can be analysed in essentially the same way when μ lies in that particular range. For these reasons I will restrict attention to the special case that arises as μ goes to infinity, that of an absolute capacity constraint.

As usual the second stage is solved first. In the second stage with capacity given output can be produced at zero marginal cost up to the capacity constraint, when marginal costs become infinite. The outcome is a special case of that analysed earlier as μ goes to infinity. In this case (4.6) yields:

(4.12) $$x + x^* = X,$$

and $$y + y^* = Y.$$

Provided that perceived marginal revenue net of any taxes is always positive the capacity constraint will hold with equality in equilibrium. As can be seen from (4.12) the firms cannot choose outputs for each market independently now. All they can do now in the second stage is allocate sales between markets. Second-stage outputs for the special case of vertical marginal costs are derived by taking the limits as μ tends to infinity of the outputs in (a.3) in the appendix. From these the second-stage comparative static derivatives can derived:

(4.13)

$$x_t = -x^*_t = \phi/2(\beta^2 - \phi^2) > 0,$$

$$y_t = -y^*_t = -\beta/2(\beta^2 - \phi^2) < 0.$$

As (4.12) implies, the increase in home market sales of the home firm brought about by the tariff crowds out an equal amount of export sales.

I turn now to the first stage of the game and the case in which a tariff is imposed before capacity is chosen. The tariff will now have an effect on the total capacity installed as well as the relative attractiveness of the home and foreign markets.

The home and foreign firm's first-order conditions are:[23]

(4.14)

(i) $d\pi/dX = a - k - b[X + (\varepsilon/2)Y] = 0,$

(ii) $d\pi^*/dY = a - k^* - b[Y + (\varepsilon/2)X] - t/2 = 0.$

The implicit capacity reaction functions in (4.14)) yield the equilibrium levels of X and Y. It is then possible to derive the following comparative-static derivatives:

(4.15)

$$X_t = \varepsilon/b(4 - \varepsilon^2) > 0,$$

$$Y_t = -2/b(4 - \varepsilon^2) < 0.$$

To derive the total effect of the tariff on outputs proceed by totally differentiating: $x(X(t),t)$, $x^*(X(t),t)$, $y(Y(t),t)$ and $y^*(Y(t),t)$. In the case of second-stage Cournot competition this yields:

(4.16)

$$dx/dt = x_t + x_X X_t = \varepsilon/b(4 - \varepsilon^2) > 0,$$

$$dx^*/dt = x^*_t + x^*_X X_t = 0,$$

and for the case of second-stage Bertrand behaviour it yields:

(4.17)

$$dx/dt = x_t + x_X X_t = \varepsilon(2 - \varepsilon^2)/2b(4 - \varepsilon^2)(1 - \varepsilon^2) > 0,$$

$$dx^*/dt = x^*_t + x^*_X X_t = - \varepsilon^3/2b(4 - \varepsilon^2)(1 - \varepsilon^2) < 0.$$

PROPOSITION 9: *When firms have vertical marginal cost curves and choose productive capacity in the first stage, a tariff will (i) raise the home firm's domestic sales under both Cournot and Bertrand competition, (ii) leave its exports unaffected when firms play Cournot in the second stage, and (iii) reduce its exports when firms play Bertrand in the*

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[23] This home first-order condition is obtained from:

$$d\pi/dX = (\partial\pi/\partial x)x_X + (\partial\pi/\partial x^*)x^*_X + \partial\pi/\partial X = 0.$$

Note that y_X and y^*_X are equal to zero.

second stage.

The intuition is that the output creation effect which increases exports is not strong enough to outweigh the crowding out effect of the tariff. This crowding out effect is stronger when firms hold the more aggressive Bertrand conjectures in the second stage. In the Cournot case the positive OCE for exports is just matched by the negative COE, leaving exports independent of the tariff. In the Bertrand case the stronger COE leads to a net fall in exports.

5. Concluding Remarks

In this paper I have examined the "import protection as export promotion" thesis within the framework of a formal two-stage game. I have shown that a tariff affects exports in two ways: firstly, assuming that marginal production costs are increasing, by raising home sales directly it leads to some crowding-out of exports; secondly by increasing R&D and/or capacity it increases exports indirectly. The first effect always works against, and the second effect always works in favour of import protection as export promotion. I have shown in the case of constant marginal cost that the crowding-out effect vanishes. In that case exports will rise if R&D is chosen in the first stage. In contrast, if the marginal production-cost curve is vertical then R&D is completely ineffective. I also demonstrated that when the marginal cost curve is vertical and firms choose capacities in the first stage, the tariff cannot raise exports. On the normative side I have shown for the case of an R&D quantity game with homogenous goods, that a small tariff imposed in the neighbourhood of a symmetric equilibrium will raise welfare, but that this result is not very robust. So, even if import protection is export promotion it may not be desirable.

It is possible to interpret the effects of the tariff on exports at constant R&D and capacity as occurring in the short run, while the total effect of the tariff when the first-stage variable can change can be thought of as occurring in the long run. In the short run the tariff will tend to reduce exports as firms respond by selling more in the market that has become relatively more attractive. In the long run however, the protected firm will engage in more R&D or install more capacity than its rival. If looked at in this way import protection as export promotion only occurs in the long run.

Appendix

The determinant Δ can be written explicitly as:

$$\Delta = \begin{vmatrix} \beta_h + \mu & \mu & \phi_h & 0 \\ \mu & \beta_f + \mu & 0 & \phi_f \\ \phi^*_h & 0 & \beta^*_h + \mu^* & \mu^* \\ 0 & \phi^*_f & \mu^* & \beta^*_f + \mu^* \end{vmatrix} > 0$$

That this is positive is a necessary condition for stability. As mentioned in the text this is guaranteed from A1(i) and A2.

Explanation of proposition 1 (iii)

(2.6) will be negative if:

(a.1) $$\mu^*(\beta_f\phi_h - \beta_h\phi_f) = \mu^*(xp^{*\prime}p'' - x^*p'p^{*\prime\prime})$$

is sufficiently negative. It is clear that constant marginal cost, or symmetric equilibrium (A.7) will rule this out. It is also ruled out if home demand is non-convex <u>and</u> foreign demand is non-concave. A special case of this is linear demands in the two countries.

Explanation of proposition 2 (ii)

A necessary condition for $\partial x/\partial n < 0$ or $\partial y/\partial n > 0$, is that: $\mu^*(\beta_f\phi^*_h - \beta_h\phi_f^*)$ be negative. The term in parentheses can be rewritten as:

(a.2) $$(\beta_f \phi^*_h - \beta_h \phi^*_f) =$$

$$p' p^{*\prime\prime}(x^* - 2y^*) + p^{*\prime} p''(2y - x) + p'' p^{*\prime\prime}(x^* y - x y^*)$$

It is clear that any one of linear demands, constant foreign marginal costs or the symmetric equilibrium assumption (A.7) is sufficient to rule out this possibility. Note too that $\partial y/\partial n > 0$, is a necessary condition for $\partial x/\partial n < 0$. It is also easy to check that $\mu^*(\beta_f \phi^*_h - \beta_h \phi_f^*)$ positive is a necessary condition for $\partial x^*/\partial n < 0$ or $\partial y^*/\partial n > 0$. R&D increases will raise own output in at least one of the markets and reduce rival output in at least one of the markets.

Proof of proposition 6

The second-stage outputs under general conjectural variations are:

(a.3)

(i) $x^o = \{[\beta + 2\mu][a - \gamma(n) + \mu X] - \phi[a - \gamma^*(n^*) + \mu Y]$

$+ t\phi[\beta^2 - \phi^2 + 2\mu(\beta + \mu)]/(\beta^2 - \phi^2)\}/D,$

(ii) $x^{*o} = \{[\beta + 2\mu][a - \gamma(n) + \mu X] - \phi[a - \gamma^*(n^*) + \mu Y]$

$- 2t\mu\phi(\beta + \mu)/(\beta^2 - \phi^2)\}/D,$

(iii) $y^o = \{[\beta + 2\mu][a - \gamma^*(n^*) + \mu Y] - \phi[a - \gamma(n) + \mu X]$

$- t(\beta + \mu)(\beta^2 - \phi^2 + 2\beta\mu)/(\beta^2 - \phi^2)\}/D,$

(iv) $y^{*o} = \{[\beta + 2\mu][a - \gamma^*(n^*) + \mu Y] - \phi[a - \gamma(n) + \mu X]$

$+ t\mu(\beta^2 + \phi^2 + 2\beta\mu)/(\beta^2 - \phi^2)\}/D.$

Parts (i) and (ii) of proposition 6 are straightforward from inspection of (3.3(i)) and (3.3(ii)). In order to prove part (iii) combine (3.3(i)) and (3.3(ii)) and differentiate with respect to t to get:

(a.4) $$d(x + x^*)/dt = \phi/D \geq 0.$$

Proof of Proposition 8 (i):

In order to prove that the tariff has an ambiguous effect on welfare under Bertrand competition it is sufficient to show that $dW/dt|_{nn^*}$ is positive for some parameter values and negative for others. For ε arbitrarily close to zero the term in λ_3 will vanish and welfare must be increasing in the tariff at fixed levels of R&D. For μ close to zero and ε close to unity the negative third term on the right hand side of (4.11) will dominate and $dW/dt|_{nn^*}$ will be negative.

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