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James R. Markusen

This paper contains preliminary findings from research work still in progress and should not be quoted without prior approval of the author.

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TRADE IN PRODUCER SERVICES AND IN OTHER SPECIALIZED
INTERMEDIATE INPUTS

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ABSTRACT

Many producer services are knowledge intensive, requiring a high initial investment in learning, after which the knowledge can be provided to additional users at a very low marginal cost. Other specialized inputs similarly require high fixed costs relative to marginal costs. This paper develops a monopolistic-competition type model to analyze these producer services and specialized inputs. Two results are of particular interest. First, permitting trade only in final goods is an imperfect and inferior substitute for permitting trade in the specialized inputs. Second, even for a country with monopoly power in trade, a tariff on inputs can "derationalize" production, fail to protect domestic producers of specialized inputs, and lower domestic welfare. The key to both results is the complementarity between domestic and foreign specialized inputs, or alternatively the gains from an increased division of labour.

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1. Introduction

It has long been observed that over half of international trade occurs in intermediate goods. Much of this is in foodstuffs, raw materials, and so forth, but much of the trade in intermediates is also in produced intermediate manufacturers. A rapidly growing category of trade in intermediates is producer services, which include such things as management consulting, engineering consulting, banking, insurance, marketing, and financial services.

Many of the intermediate manufactures and producer services that enter into international trade are probably characterized by significant degrees and scale economies and/or product differentiation. Factor intensity data suggest, for example, that intermediate manufactured goods are on average significantly more capital intensive than final manufactured goods (Markusen and Melvin (1984)). Many producer services are both differentiated and knowledge intensive. Knowledge intensity in turn suggests strong scale economies in that knowledge must be acquired at a intial learning cost, after which the knowledge-based services can be provided at a very low marginal cost (as in an engineering consultant selling the same blueprints to different firms).

The theory of international trade today consists of a relatively small literature on intermediate inputs (e.g., Jones and Sanyal (1982)) and a literature on scale economies and imperfect competition in final goods production (many references are found in Helpman and Krugman (1986)). The two are combined in Ethier (1982) and Romer (1987). These authors have a simple model in which intermediate inputs, produced with increasing returns to scale are assembled to produce final output.

The purpose of this paper is to develop a model of trade in
differentiated intermediate inputs along the lines proposed by Ethier. I will be particularly interested in normative issues not dealt with by Ethier and Romer. In the model, each of two countries has a competitive sector \((Y)\) and a sector \((X)\) which produces a composite good from intermediate inputs or services \((S)\). The latter are produced with increasing returns and are complementary in production.

The results demonstrate that allowing trade in specialized inputs is superior to allowing trade in final goods only in two distinct senses. First, free input trade guarantees that both countries will be made better off relative to autarky while, due to the distortion between prices and marginal costs, goods trade only does not guarantee that free trade will be Pareto improving. Second, free input trade is superior to free trade in goods from the point of view of the world as a whole, although not necessarily from the point of view of both countries.

The results also demonstrate that the welfare effects of a tariff may be opposite to those in traditional models (including those with scale economies in final goods production). It is easy to find parameter values such that a small tariff on imported foreign specialized inputs derationalizes domestic production, resulting in a fall in the domestic production of specialized inputs and a fall in domestic welfare despite the usual favorable terms-of-trade effect. Both results follow from the complementarity of domestic and foreign specialized inputs in final goods production.

These results have a good deal of policy relevance given the current discussions on liberalizing trade in producer services. These services generally face higher trade barriers than do commodities since the former intrude on immigration and foreign investment policies which are in turn more restrictive than goods-trade policies.
2. **Producer Services, Specialized Inputs, and the Division of Labour**

Consider a two-sector general-equilibrium model with a competitive sector $Y$. Good $Y$ is produced with labour ($L$) and sector-specific capital ($K$) by a competitive industry with constant returns to scale.

(1) \[ Y = G(L_Y, K); \quad G_L > 0, \quad G_{LL} < 0. \]

To keep things very simple, suppose that production in the $X$ sector consists of costlessly assembling (as in Ethier (1982)) the produced inputs $S_1, \ldots, S_n$. The identical production functions for the competitive firms in the $X$ industry are given by

(2) \[ X_i = X_i(S_{i1}, \ldots, S_{in}) \]

where the $S_j$ will be referred to as producer services or specialized inputs. The production functions in (2) have constant returns to the $S_j$ for a fixed $n$.

Each $S_j$ is produced by a single firm and, for simplicity, we assume that the production of $S_j$ requires only labour. $S$ producers and $X$ producers are disjoint, and the $S_j$ are produced with increasing returns under technology and behavioral assumptions discussed below. Given constant returns in (2), we can then aggregate the individual firm outputs to arrive at an industry production function identical to (2) with the $i$ subscript deleted. In order to keep the problem tractable, we assume that the $S$ production functions are identical and that the $S_j$ are symmetric but imperfect substitutes in producing $X$. Assume in particular that the $X$ industry production function is given by

(3) \[ X = \left[ \sum_j S_j^B \right]^{1/B} \quad 0 < B < 1 \]

Production of $S_j$ uses only labour, and requires a fixed cost plus a
constant marginal cost. For simplicity, the marginal cost of $S_j$ is assumed to be one in terms of labour. Letting $Y$ be numeraire, the cost of producing $S_j$ in terms of $Y$ is then

$$C_j = wS_j + wF$$

where $w$ is the wage rate in terms of $Y$ and $F$ is the fixed cost (in units of labour).

Let $p$ denote the price of $X$ in terms of $Y$. For a given $p$ and $w$, the socially optimal allocation in the $X$ industry is found by solving the following programming problem, equating price and marginal costs.

$$\text{Max } \pi = p[\sum S_i^\beta]^{1/\beta} - \sum (wS_i + wF) \quad \text{with respect to } S_i, n.$$  

We can take advantage of the fact that the symmetry of the $S$ ensure that each $S_i$ that is produced will be produced in the same quantity (implying that $\sum S_i = nS_i$ where $n$ is endogenous). The first-order conditions relating to $S$ and $n$ are then given as follows.

$$\frac{\partial \pi}{\partial S_j} = (p/\beta)[n(S_j^\beta)]^{\alpha - 1} S_j^\beta - w = pn^\alpha - w = 0; \quad \alpha \equiv (1-\beta)/\beta$$

$$\frac{\partial \pi}{\partial n} = (p/\beta) [n(S_j^\beta)]^{\alpha} S_j^\beta - (wS_i + wF) = 0,$$

$$= (p/\beta)n^\alpha S_i^\beta - wS_i - wF = 0.$$  

Multiply (6) through by $S_i$. Then subtract (6) from (7).

$$((1-\beta)/\beta)pn^\alpha S_j = wF$$

But from (6) we see that $n^\alpha = (w/p)$, so that the solution values are

$$S_j = (\frac{\beta}{1-\beta})F; \quad n = (w/p)^{\beta/(1-\beta)}$$

Now consider the monopolistic-competition equilibrium. The price faced by an individual $S_i$ producer is the marginal product of $S_i$ in producing $X$. Denoting this price as $r_i$ (the same for all $S$ producers due to
symmetry), this is given from (6) as

\[(10) \quad r = (p/\beta)n(S_i)^{\beta} S_j^{\beta-1} = q S_i^{\beta-1}; \quad q = (p/\beta)n(S_j)^{\beta}a.\]

Suppose that there are many S producers, such that we can assume relatively "competitive" conjectures. Assume that S producers view p as exogenous and also view X as exogenous. Then the individual S producers view q in (10) as fixed. An S producer's programming problem is given by

\[(11) \quad \text{Max } \pi^* = (q S_i^{\beta-1}) S_i - wS_i - wF \quad \text{w.r.t. } S_i\]

The first-order condition for $S_i$ is

\[(12) \quad \frac{\partial \pi^*}{\partial S_i} = q \beta S_i^{\beta-1} - w = 0\]

The second-order condition holds since q and w are viewed as exogenous. Free entry of S producers results in zero profits, so

\[(13) \quad q S_i^{\beta} - wS_i - wF = 0\]

Substituting for q from (10), (12) and (13) are respectively

\[(14) \quad p\beta n^\alpha - w = 0; \quad (p/\beta)n^\alpha S_i - wS_i - wF = 0\]

Multiply the first equation through by $S_i$. Combining the two equations in (14), we get the values of $S_i$ and n at the monopolistic-competition equilibrium.

\[(15) \quad S_i = (\frac{\beta}{1-\beta})F; \quad n = (w/p\beta)^{\beta/(1-\beta)}\]

Compare the monopolistic-competition values in (15) to the socially optimal values in (9). $S_i$ is the same in both cases and constant. The X industry expands via increases in n and the market equilibrium produces the optimal amount of any $S_i$ that is produced. The former property implies increasing returns to scale in X since $X = n^{1/\beta} S_i$ ($\beta > 1$). The latter property implies that the market equilibrium will be on the economy's
efficient production frontier.

Comparing the values of \( n \) from (9) and (15), we see, however, that the two equilibria cannot be the same. At the optimal values of \( w \) and \( p \), \( n \) would be smaller at the market equilibrium, indicating that the market will not support the optimal allocation. This is the familiar distortion result result that at a given \( p \), the economy will under-produce \( X \) and will not be at a point of tangency between \( p \) and the marginal rate of transformation (MRT). The MRT is simply given by the ratio of the marginal product of labour in \( Y \) to its marginal product in \( S \).

\[
(16) \quad \text{MRT} = \frac{MP_y}{MP_x} = \frac{G^y}{n^\alpha}
\]

where \( MP_x \) is the "social" marginal product of labour in \( X \), given in (6). But the equilibrium price ratio involves the private marginal product of labour \( (MP_x^*) \), given in (11) and (14).

\[
(17) \quad p = \frac{MP_y}{MP_x} = \frac{G^y}{\beta n^\alpha}
\]

Combining the results in (16) and (17), we have

\[
(18) \quad p > p \beta = \text{MRT}.
\]

The results in (18) combined with the earlier result that the market equilibrium will be on the production possibility frontier is shown in Figure 1. TT' is the production possibility frontier, which may take on a number of shapes.

Differentiating \( \text{MRT} = G^y / MP_x = w / MP_x \), we have

\[
(19) \quad \frac{d(\text{MRT})}{dL_x} = \frac{MP_x w' - w MP_x'}{MP_x^2} = \frac{1}{MP_x} \left[ w' - w \frac{MP_x'}{MP_x} \right]
\]

\[
= (1/MP_x)(w - p \beta MP_x) \quad \text{since} \quad p \beta = w / MP_x.
\]
Note that the term \((w' - p\text{MPP}_x)\) is just (minus) the derivative of the first-order condition (14) at constant \(p\). At constant prices, stability and concavity (to the origin) of the production frontier are equivalent, and require \((w' - p\text{MPP}_x) > 0\). \(w'\) is positive and increasing in \(x\) (\(G\) is strictly concave) but \(MP_x'\) is also positive (we are referring to how the MP of labour changes as we change \(n\), since \(S\) is constant in general equilibrium).

(19) can also be written as

\[
\frac{d(MRT)}{dL_x} = \frac{w}{n\text{MP}_x} \left[ \frac{nw'}{w} - \frac{n\text{MP}_x'}{\text{MP}_x} \right] = \frac{w}{n\text{MP}_x} \left[ nw^* - \alpha \right]
\]

since \(\text{MP}_x' = an^{-\frac{1}{\alpha}}\), \(\text{MP}_x = n^\alpha\) and where \(w^* \equiv w'/w\). The production frontier will be locally concave if the concavity of \(G\) outweighs scale economies so that \((nw^* - \alpha) > 0\).

If \(Y\) is Cobb-Douglas, for example, \(Y = L^\gamma K^{1-\gamma}\) and

\[
w^* = -\frac{G_y}{G_L} = (1-\gamma)/L_y.
\]

(20) will be negative (\(TT'\) convex to the origin) in the neighbourhood of \(X = 0\) (\(n = 0\)) but will quickly become positive (\(TT'\) concave to the origin) as \(X\) increases (\(n(1-\gamma)/L_y\) increases) if \(\gamma\) and \(\alpha\) are small (recall \(\alpha = 1/\beta - 1\) approaches zero as \(\beta\) approaches 1). The production frontier will have the shape shown in Figure 1. For the remainder of the paper, we assume that \(\alpha\) is sufficiently small, \(G\) is sufficiently concave, and demand for \(X\) is sufficiently high such that equilibrium occurs on the concave portion of the production frontier in Figure 1.

3. Gains from Trade

Consider first a situation in which there is free trade in goods only. Let subscripts \(g\) and \(a\) denote quantities evaluated at the free goods-trade and
autarky equilibria respectively. \( C_y \) and \( C_x \) will denote consumption of goods \( Y \) and \( X \) respectively. By the usual revealed preference criterion, a country gains from trade if

\[
(21) \quad C_y + p_x C_x \geq C_y + p_x C_x.
\]

In autarky, we have market clearing, while in free trade we have balance-of-payments equilibrium.

\[
(22) \quad C_y + p_x C_x = Y_a, \quad C_x = X_a;
\]
\[
C_y + p_x C_x = Y_g + p_x X_g.
\]

Substituting (22) into (21), we have

\[
(23) \quad Y_g + p_x X_g \geq Y_a + p_x X_a.
\]

Now subtract the value of the factor endowment at free-trade prices from both sides of (23), and let \( k \) denote the return to \( Y \)-sector capital.

\[
(24) \quad (Y_a - w L_a - k K) + (p_x X_a - w L_a) \geq (Y_a - w L_a - k K) + (p_x X_a - w L_a)
\]

The left-hand side of (24) is zero since both industries make zero profits in equilibrium. The first term on the right-hand side of (24) is non-positive: the autarky factor proportion \( (K/L_a) \) is not the most efficient way to produce \( Y_a \) at free-trade factor prices, hence profits would be negative from doing so. The sufficient condition for gains from trade thus becomes

\[
(25) \quad (p_x X_a - w L_a) = (p_x X_a / X_a) \leq 0 \quad \text{iff} \quad (L_a / X_a) \geq (L_a / X_a) \quad \text{iff} \quad X_g > X_a.
\]

which follows from \( (p_x - w (L_a / X_a)) = 0 \) (zero profits). Since \( X \) uses only labour and since \( X = \frac{1}{B} S \), \( L_a / X_a \) falls with increases in \( X \) and (25) holds if and only if \( X_g > X_a \). The latter is a sufficient condition for gains from trade.

The "product expansion condition" \( X_g > X_a \) for gains from trade is by now familiar to most international trade economists. Intuitively, with the price of \( X \) (private marginal cost) greater than true social marginal cost,
there is a "Harberger triangle" associated with changes in $X$ output, $(p-MC)\Delta X$, which is positive if $\Delta X > 0$. In our case, $MC = w/MP_X = pB$, so $(p-MC) = p(1-B) > 0$.

It is also reasonably well known that this condition may not hold in practice. Figure 2 shows a situation where the small home country (superscript h) is at a cost disadvantage relative to the large foreign country (superscript f). Relative to autarky equilibria at $A^h$ and $A^f$, country $h$ could lose at the free trade equilibrium $C^h$, $C^f$ (consumption) $Q^h$, $Q^f$ (production) due to the distortion between $p$ and the MRT as shown in Figure 2 and as demonstrated by Markusen and Melvin (1981, 1984a).

Now we consider free trade in specialized inputs versus autarky. Note with respect to (10)-(14) that free trade in $S$ equalizes the $r_i$ across countries. The fact that the same number of inputs $n = n^h + n^f$ is available in each country at the same prices implies that they are used in the identical relative amounts in each country. The marginal products of additional inputs are equal across countries and hence, from (10) and (14), the product price ratio $p_i = r/n^a$ must be equal. Factor prices are equalized (equal $r$ imply equal $w$ imply equal $k$) and gains from trade are exhausted regardless of whether or not the final good $X$ is also traded.

The free-input trade (subscript s) is revealed preferred to the autarky bundle if

$$C^h_{ys} + p_s C^h_{xs} \geq C^h_{ya} + p_s C^h_{xa}$$

The balance-of-payments and market-clearing conditions are given by

$$C^h_{ys} + p_s C^h_{xs} = Y^h_{s} + r_s n^h_{s}; \quad C^h_{ya} = Y^h_{a}; \quad C^h_{xa} = X^h_{a}$$

where $r_s$ is the free-trade price of a representative service and $S$ is the
constant $8P/(1-8)$. Substituting (27) into (26), we have

$$\begin{align*}
(28) \quad y^h_s + r_n^h n^h_s & \geq c^h_a + p_s x^h_a
\end{align*}$$

Subtracting the value of the factor endowment at free input-trade prices from both sides of (28), the left-hand side will equal zero since profits in both industries are zero. We are left with the condition for gains from trade as

$$\begin{align*}
(29) \quad 0 & \geq \left( y^h_a - w_s^h L^h_s y^h - k^h_s k^h_s \right) + \left( p_s - w_s^h \left( L^h_s x^h_a / x^h_a \right) \right)
\end{align*}$$

The first term in (29) is negative as before. Since inputs are freely traded at equal prices, the average cost $(L_i^x / X_i)$ depends only on the number of inputs available. We can demonstrate using Figure 3 and results derived in the appendix that $n^h_s = n^h_s + n^f_s > n^i_a (i = h, f)$. Hence

$$L^h_{xa} / x^h_a > L^h_{xs} / x^h_s = p_s / w_s$$

and both countries are assured of gains from free trade relative to autarky.

The appendix to the paper establishes the existence of reaction curves which are useful in establishing the result in (29). These are shown in Figure 3. $n^h_a$ and $n^f_a$ are the autarky values of $n$ in countries $h$ and $f$ respectively. $n^h_m (n^f_m)$ is the $n$ that country $h$ ($f$) would produce if country $f$ ($h$) were constrained from producing any $n$ in the free-trade situation. Positive demand from the other country dictates that $n^h_m > n^h_a (n^f_m > n^f_a)$.

The reaction curves, which give the optimal $n^i$ for one country given the exogenous $n^j$ for the other country, are either both downward sloping or both upward sloping. The reaction curves $n^h_m n^h_s$ for the home country and $n^f_m n^f_s$ for the foreign country illustrate the former case. The
appendix demonstrate that \( n_{m}^{h} n_{s}^{h} \) has a slope between 0 and -1 in this case and \( n_{m}^{f} n_{s}^{f} \) has a slope less than -1. Subject to the economies being "similar", the reaction curves cross and produce a stable equilibrium at A in Figure 3.

If inputs are "strong" complements (defined more precisely later on), the reaction curves both slope upward as illustrated by \( n_{m}^{h} n_{s}^{h'} \) and \( n_{m}^{f} n_{s}^{f'} \) in Figure 3. An equilibrium occurs at a point like B, where one or even both countries could be specialized (\( n_{m}^{h} n_{s}^{h'} \) becomes flat, or \( n_{m}^{f} n_{s}^{f'} \) becomes vertical). Combinations of these cases may occur, but the important point for our purposes is that the slope of h's reaction curve must be greater than minus one, and the slope of f's must be less than -1 or greater than +1 (see appendix).

These slope restrictions along with \( n_{m}^{h} > n_{a}^{h} \) and \( n_{m}^{f} > n_{a}^{f} \) imply that the equilibrium in Figure 3 must involve
\[
\frac{h}{s} = \frac{n_{s}^{h}}{n_{s}^{f}} > \frac{n_{a}^{h}}{n_{a}^{f}}. 
\]
More inputs are available with free input trade than in either country in autarky. Since the average cost of labour in X declines with n, and since \( p_{s} \) and \( w_{s} \) are the free-trade values in both countries, the inequality in (29) must hold. Both countries are assured of gains from trade.

Now consider the comparison of goods trade only with free trade in specialized inputs. Input trade is revealed preferred to goods trade if
\[
(30) \quad c_{y_{s}}^{h} + p_{s} c_{x_{s}}^{h} \geq c_{y_{s}}^{h} + p_{s} c_{x_{s}}^{h}
\]
By adding and subtracting the same terms, the goods-trade balance-of-payments constraint can be written as
\[
(31) \quad c_{y_{s}}^{h} + p_{s} c_{x_{s}}^{h} + \left( p_{s} c_{x_{s}}^{h} - p_{s} c_{x_{s}}^{h} \right) = y_{g}^{h} + p_{s} X_{s}^{h} + \left( p_{s} X_{s}^{h} - p_{s} X_{s}^{h} \right)
\]
Substituting this into (30) and replacing the left-hand side of (30) with the input-trade balance-of-payments constraint in (27), (30) becomes

\[(32) \quad \frac{y}{s} + r_n s - \frac{y}{g} + p_x s - (p_g - p_s)(x_h - c_h)\]

Subtract the value of the factor endowment at input-trade prices from both sides of (32) and the left-hand side will be zero as before. The condition for superiority of goods trade becomes

\[(33) \quad 0 \geq (\frac{y}{g} - w_s l - r_x) + (p_s - w_s l (\frac{x_h}{x_g}) x_h + (p_g - p_s)(x_h - c_h)\]

The first term is negative as before: using goods-trade factor proportions is not the most efficient way to produce \(Y\) at input-trade factor prices and hence profits in \(Y\) are negative.

The third term in (33) is a terms-of-trade affect. It states, for example, that if \(h\) exported \(X\) at the goods-trade equilibrium \((x_g > c_x)\) and the price of \(X\) is higher at the input-trade equilibrium, then the term is negative and produces the desired direction of inequality in (33). But note that a favorable terms-of-trade effect for one country must be exactly matched by a negative terms-of-trade effect in the other country. Since the larger (as in Figure 2) and/or more labour abundant country is likely the exporter of \(X\) in goods-trade equilibrium, and since the price of \(X\) in input-trade is likely less than in goods-trade (discussed below), the larger/labour abundant country likely loses from the effect. Bilateral improvement at the input-trade equilibrium is not guaranteed unless the volume of trade at the goods-trade equilibrium is small.

The second term in (33) is once again our product expansion condition. Again, since the average product of labour depends only on the number of \(n\) available, this term will be negative for both countries if
\[ n_s = n^h_s + n^f_s > (n^h_g, n^f_g). \]

The argument that \( n_s > (n^h_g, n^f_g) \) is made with respect to Figure 4. Since both countries face the same producer prices (and MRT's) in goods-trade equilibrium, we can aggregate their production frontiers together to arrive at the aggregate frontier \( TT_g \) in Figure 4. Assume also that countries have identical, homothetic utility functions so that we can aggregate their tastes. Given these results, the goods-trade equilibrium at the common price ratio \( p_g \) will occur at a point like \( G \) in Figure 4, where \( p_g \delta = MRT \) along \( TT_g \) as in the case for each country individually.

We can also aggregate the free-input trade production frontiers to arrive at the world production frontier \( TT_s \) by virtue of the fact that commodity and factor prices are equalized in input trade. Indeed \( TT_s \) in Figure 4 is the world Pareto optimum frontier. To see that \( TT_s \) lies everywhere outside of \( TT_g \) except at \( T \), simply note that, holding \( n^h_g \) and \( n^f_g (Y^h_g \text{ and } Y^f_g) \) constant, each country could exchange a portion \((1-\delta)\) of each of its \( n_i \)'s for a portion \( \delta \) of each of the other countries \( n_i \)'s, where \( \delta^h = n^h_g / (n^h_g + n^f_g) = n^h_g / n_s \). Trade balances under such a scheme. The output of \( X \) in \( h \) becomes

\[ X^h = (n^h_g)^{1/\delta}(\delta S) = (n^h_g / \delta)^{1/\delta}(\delta S) > X^h_g = (n^h_g)^{1/\delta}S \]

and similarly for country \( f \). In general further adjustments are optimal.

World income increases with service/input trade over goods-only trade due to commodity and factor price equalization and the increasing returns to \( n \). Because consumers are identical and face the same prices, the aggregate preference map in Figure 4 is the same as with goods trade. Third, the distortion ratio \( p \delta = MRT \) holds along \( TT_g \) as in the case of \( TT_s \) and the individual country production frontiers. Finally, the slope of \( TT_s \) must be
less at S than the slope of the point on TT_g directly below, G. The marginal product of labour in Y must be less at the former (Y_s > Y_g) and the marginal product of labour in X greater (X_s = X_g, but with less labour in X at X_s, it follows that n_s > n_g and hence MP_{xs} > MP_{xg}). The equilibrium along TT_s must then be at a point like S' where X_s ≥ X_g if X is non-inferior in consumption.

This last result implies that the total number of inputs produced in the input-trade equilibrium must exceed the total produced in either country in the goods-trade equilibrium. This follows from a simple argument by contradiction. If, for example, n^h_g > n_s = n^h_s + n^f_s, then X^h_g > X_s (even ignoring output from f) which contradicts the result that X_g = X^h_g + X^f_g ≤ X_s. Thus n_s ≥ (n^h_g, n^f_g).

The proof that n_s ≥ (n^h_g, n^f_g) is in turn all that we need to prove that the second term in (33) is non-positive. Except for the terms-of-trade effect (the third term in (33)), both countries are assured of gains at the input-trade equilibrium relative to the goods trade equilibrium, and one must prefer the former. Note also if we add the inequality in (33) to the corresponding one for f (identical homothetic utility makes this meaningful), the terms-of-trade effects cancel. The world consumption bundle at the service-trade equilibrium is preferred to that in goods-trade equilibrium.

4. Protection That Fails to Protect

In this section, we consider the effects of a small tariff on imported specialized inputs in the neighborhood of a free input-trade equilibrium. The model of section 2 implies that the home economy's aggregate transformation
function can be written as

\[ T(Y, X, n, n^f, n^s, n^h, n^f, e_s^h) = T(Y, X, n^h, n^f, m_s^h, e_s^h) = 0 \]

where \( S_{ij}^i \) is the amount of service produced in \( i \) and used in \( j \), \( e_s^h \) is the export of services by \( h \) and \( m_s^h \) is the import of services by \( h \). For constant \( n^h \) and \( n^f \) (no externality), we have the standard properties that

\[ \frac{\partial Y}{\partial X} = p^h, \quad \frac{\partial Y}{\partial m_s^h} = r_f^h, \quad -\frac{\partial Y}{\partial e_s^h} = r_h^h \]

Define the following

\[ \frac{\partial Y}{\partial n^h} \equiv s^h > 0, \quad \frac{\partial Y}{\partial n^f} \equiv s^f > 0. \]

Increasing \( n^h \) or \( n^f \) holding \( X, m, \) and \( e \) constant implies that we are reducing the \( S_{ij}^i \) as we increase \( i \). Our earlier results imply that this lowers the labour needed to produce the fixed level of \( X \) (recall \( X = n^{1/\beta} S \)).

Consider the problem in the neighborhood of a free trade equilibrium where \( S_{ij}^i = S_{ij}^j \). If we increase \( n \) and reduce all the \( S \) together such that \( dX = 0 \), we have

\[ dx = \frac{dx}{dn} dn + \frac{dx}{dS} dS = 0 = \frac{1}{\beta} n^\alpha S dn + n^{1/\beta} dS. \]

Labor requirements in \( X \) are

\[ L_X = nS, \quad dL_X = nS + Sdn \]

Combining (38) and (39),

\[ dL_X = -(1/\beta-1)Sdn, \quad dL_y = (1/\beta-1)Sdn \]

\[ dY = wdl_y = w(1/\beta-1)Sdn \]

Equation (41), gives us \( s^h = s^f = s \) in the neighborhood of free trade.
\[(42) \quad \frac{\partial Y}{\partial n^h} = \frac{\partial Y}{\partial n^f} = w(1/\beta - 1)S = s\]

As expected, \(s\) approaches zero as \(\beta\) approaches one (scale economies disappear).

Using (36) and (37), the total differential of (32) gives us

\[(43) \quad dY + p^h dX - s^h d\gamma - s^f d\rho + p^h d\gamma - r^h d\gamma_s - r^f d\gamma_s = 0\]

The economy’s welfare level can be summarized as

\[(44) \quad \bar{w}^h = \bar{w}(\bar{c}_y, \bar{c}_x), \quad \frac{d\bar{w}}{\bar{w}_y} = \frac{d\bar{c}_y}{\bar{w}_y} + \frac{d\bar{c}_x}{\bar{w}_y} dC_x = dC_y + p^h dC_x\]

where \(\bar{c}_y\) and \(\bar{c}_x\) are the consumption levels of \(Y\) and \(X\) respectively. The balance-of-payments constraint is \(e^h_y \equiv (Y - C_y)\) given by

\[(45) \quad e^h_y + r^h_y h_s - r^f_s = 0; \quad de^h_y + e^h_s d\gamma_s - m^h_s r^f_s + r^h_s d\gamma_s - r^f_s = 0.\]

Use the definition of \(e^h_y\) and the fact that domestic production and consumption of \(X\) are equal to rewrite (44) as

\[(46) \quad \frac{d\bar{w}}{\bar{w}_y} = dY - d\gamma_y + p^h dX.\]

Substituting for \(dY\) from (43) and for \(d\gamma_y\) from (45), equation (46) becomes

\[(47) \quad \frac{d\bar{w}}{\bar{w}_y} = (p^h - p^f) dX + s^h d\gamma + s^f d\rho + e^h_s d\gamma_s - m^h_s r^f_s + (r^h_h - r^f_h) d\gamma_h + (r^f_h - r^h_f) d\gamma_f\]

In the neighborhood of a zero tariff, \(r^h_h = r^f_f\), and \(s^h = s^f \equiv s\).

(47) then reduces to

\[(48) \quad \frac{d\bar{w}}{\bar{w}_y} = s(d\gamma^h + d\gamma^f) + e^h_s d\gamma_s - m^h_s r^f_s.\]

The second and third terms in (48) are the standard terms-of-trade effects of a tariff, which normally contribute to improving welfare. The
first term in (48) is the externality effect that weakens and perhaps outweighs the terms-of-trade effect.

The appendix to the paper presents an analysis of (48) for two identical economies. The first result of the appendix is that the tariff does not affect the equilibrium quantity of any output that is produced:

\[ S = \frac{8F}{(1-\beta)}. \]

Thus we can continue to write \( w^h = w^h(n^h) \) or the inverse relationship \( n^h = n^h(w^h) \) since labour demand \( (L_x) \) is proportional to \( n^h \). \( rS = w \) then implies \( (dn/dr) = \beta(dn/dw) = \beta n^h \). The fact that the two economies are identical implies that they trade only specialized inputs, and thus \( e^h_s = m^h_s \) for balance-of-payments equilibrium. Similar comments apply to the foreign country, so \( n^f = n^f(r^h) \). Each country exports half of any output it produces so

\[
(49) \quad e = n^h_S f = m = n^h_S f = n^h S/2 = nS/2
\]

where \( n = n^h = n^f \). Now form the expression using (49) and (42)

\[
(50) \quad \frac{sBn'}{e} = \frac{w(1/\beta-1)SBn'}{nS/2} = 2(1/\beta-1)\beta wn'/n = 2(1-\beta)(wn'/n) \equiv \varphi > 0
\]

The welfare differential in (48) becomes

\[
(51) \quad \frac{dw^h}{W} = e \left[ (\varphi+1)dr^h + (\varphi-1)dr^f \right]
\]

Sufficient conditions for the country to be made worse off by its own tariff are that \( dr^h < 0 \) and \( \varphi > 1 \) (the appendix shows that \( dr^f \) must be negative).

Consider first \( \varphi > 1 \), and let \( \sigma \equiv nw'/w = (wn'/n)^{-1} \). From (50), we have

\[
(52) \quad \varphi > 1 \quad \text{iff} \quad 2(1-\beta) > \sigma
\]

Note from the definition of \( \sigma \) that the convexity condition in (20) above
required \((1/\beta-1) < \sigma\) or \((1/\beta)(1-\beta) < \sigma\). This is compatible with (52) if 
\(\beta > 1/2\), which is a reasonable assumption since \(\beta < 1/2\) implies that \(X\) is
homogeneous of degree \(\geq 2\). Note also from the Cobb-Douglas example following
(20) that \(\sigma\) must run from zero to infinity along the production frontier,
hence it is guaranteed that there exists a stable region in which (52) holds
subject only to \(\beta > 1/2\).

Now consider the condition \(dr^h < 0\). The appendix demonstrates in an
unfortunately long and tedious proof that

\[(53) \quad dr^h/dT < 0 \quad \text{iff} \quad (1-\beta) > 1/\eta\]

where \(\eta\) is the price elasticity of final demand for \(X\) and \(T\) is the home
country's import tariff. This condition is easily satisfied under the
restriction \(\beta > 1/2\) \((1-\beta < 1/2)\) by picking a final demand function with a
sufficiently high demand elasticity, a choice that is quite independent of
other requires and constraints of the model. Our result is

\[(54) \quad dw^h/dT < 0 \quad \text{if} \quad 2(1-\beta) > \sigma, \quad (1-\beta) > 1/\eta\]

subject to \((1/\beta)(1-\beta) < \sigma\). I suggest that it is very easy to find
functional forms and parameter values that satisfy these sufficient conditions.

Briefly, the intuition behind these results is as follows. First, the
result in (52). The tariff forces down the price of foreign inputs \((dr_f < 0)\), creating negative profits in that country. Labor must exit from the \(X\)
industry until the wage \(w^f\) is forced down enough to restore zero profits.
This exit will be larger, and the fall in \(n^f\) larger, when the elasticity of
the wage with respect to \(L_X/(\sigma)\) is small. \(1-\beta\) reflects the externality
effect on \(h\) of the loss in \(n^f\).

The result in (53) arises because the loss of some inputs from \(f\) lowers
the marginal product of inputs in h in proportion to (1-β). But the loss of
n^f and decreased X production also bids up the price of X, thereby
encouraging more production of inputs in h. The latter effect is small and
dominated by the former if the inverse price elasticity of demand for X is
small (a large fall in X generates a small increase in p).

5. **Summary**

The purpose of this paper is to develop and analyze a model of trade in
which trade occurs in differentiated or specialized intermediate products
produced with increasing returns. I suggest that increasing returns
characterize both capital-intensive intermediate manufactures and
knowledge-intensive producer services. Many of these inputs are
differentiated and complementary to domestic inputs.

As in the case of Ethier (1982), the model adapts the Dixit-Stiglitz
categorization of differentiated goods to differentiated inputs. These
inputs are produced with increasing returns and so differentiation is limited
by the extent of the market, and increases with international trade in
specialized inputs or services.

Two results are highlighted. First, permitting trade only in final
goods is an imperfect and inferior substitute for permitting trade in
specialized services in two well-defined senses. (A) Free trade in
inputs/services is Pareto superior to autarky while free trade in goods only
may not be. (B) Free trade in inputs/services is superior to free trade in
goods from the point of view of the world as a whole. Second, even though a
country has monopoly power in trade, a small import tariff can lower welfare.
Since foreign and domestic specialized inputs/services are complementary, the
loss of foreign inputs through exit caused by the tariff has a negative effect on the productivity of domestic inputs. Parameter values are presented such that this derationalization effect outweighs a favorable terms-of-trade effect so that the tariff-imposing country is worse off.

These results have special relevance to current discussions about the liberalization of trade in services, particularly trade in producer services. I suggest that these services are very likely to have the complementarity property found in the model. Because of the need to move people and/or establish a foreign presence, trade in producer services tends to fall under restrictions imposed by immigration and foreign investment laws. In most countries, these laws tend to be significantly more restrictive than barriers to trade in goods. Combining this generalization with the welfare results of the previous section suggests the possibility of significant gains from liberalized trade in producer services.
REFERENCES


APPENDIX

The first purpose of this section is to establish the result needed in section 4 that a tariff does not affect the output level of any \( S_i \) in either country. Since there is no price discrimination by assumption, firms must divide incremental outputs between the home and foreign markets such that price relationships are preserved. These are

\[
(A1) \quad r_h^h = r_f^f; \quad r_h = r_f^f(1 + T)
\]

where \( r_i^j \) is the price of any of country \( i \)'s inputs in country \( j \) and \( T \) is country \( h \)'s import tariff. Let \( \delta \) and \( \sigma \) be the shares of incremental output of \( S_h \) and \( S_f \) respectively that must go to the home market to preserve (A1) and \((1-\delta), (1-\sigma)\) the corresponding shares to the foreign market.

A representative home firm's profits are given by

\[
(A2) \quad \pi^h = (q_h^h S_h^h(\beta-1))S_h^h + (q_f^h S_f^h(\beta-1))S_f^h - w^h(S_h^h + S_f^h) - w^h_F
\]

where \( S_j^i \) is the supply of a country \( i \) service in country \( j \). The terms in brackets in (A2) are \( r_h^h \) and \( r_f^h \) and are equal by (A1). \( q_j^i \) is viewed as constant by the firm as before.

Marginal revenue equal marginal cost for a producer in \( h \) is given by

\[
(A3) \quad \delta q_h^h S_h^h(\beta-1) + (1-\delta)(q_f^h S_f^h(\beta-1)) - w^h = 0
\]

But the terms in brackets are \( \beta r_h^h = \beta r_f^h \) so (A3) can be written as

\[
(A4) \quad \beta r_h^h - w^f = 0; \quad r_h^h = r_h = r_f^h
\]
The profit equation (A2) can be written as

\[(A5)\quad r^h S^h - w^h S^h - w^f F = 0\]

which equals zero by virtue of free entry. Multiplying (A4) through by \(S^h\) and substituting for \(r^h S^h\) from (A5) gives us

\[(A6)\quad S^h = \frac{BF}{(1-\beta)}\]

which is the same value as that given in the body of the paper.

For the foreign country, the profit equation of a representative firm is

\[(A7)\quad \pi^f = ((1+\tau)^{-1} q^f \theta_S^h S^h)^f + (q^f \theta_S^f)^f - w(S^h + S^f) - w^f\]

where the terms in brackets in the first two additive terms are the prices received by the \(S^f\) producers in \(h\) and \(f\) respectively and are therefore equal.

Marginal revenue equals marginal cost for a producer in \(h\) is given by

\[(A8)\quad \sigma((1+\tau)^{-1} q^f \theta S^h S^h) + (1-%(1-\sigma)(q^f \theta S^f S^f) = w = 0\]

which due to (A1) simplifies in the same manner as (A3).

\[(A9)\quad \beta r^f - w^f = 0\quad r^f = r^f = (1+\tau)^{-1} r^h\]

As in the case of (A5), the profit equation (A7) can be written

\[(A10)\quad r^f S^f - w^f S^f - w^f F = 0\]

Following the same procedure as before, we get \(S^f = BF/(1-\beta)\) so that outputs per firm in both \(h\) and \(f\) are independent of the tariff.

The second purpose of this appendix is to establish the conditions under which a tariff on imported services in country \(h\) derationalizes production, leading to a fall in \(n^h\) and a fall in \(r^h\). For simplicity, we will assume the absence of income effects so that the price of \(X\) depends only on the world
output of X. This can be generated by a utility function of the form
\[ U(X, Y) = U(X) + Y, \quad U'' < 0. \]
Also assume that h and f are identical so that \( p^h = p^f, \quad r^h = r^f, \) and \( n^h = n^f \) in free service-trade equilibrium.

General equilibrium can be examined in several ways. One alternative is to consider the programming problem of the X industry in the home country.

\[
\text{(A11) \quad } \max_{S^h, S^f} p^n(r^h)(S^h_{r^h})^{\beta} + n^f(r^f)(S^f_{r^f})^{1/\beta} - r^h n^h(r^h) S^h_{r^h} - r^f n^f(r^f) S^f_{r^f}
\]

The simple general-equilibrium relationships \( n^h = n^h(r^h) \) and \( n^f = n^f(r^f) \) follow from our earlier results that (1) S is the same and constant across countries, (2) labour to produce n is drawn from the Y sector at increasing marginal cost of \( G^y = w, \) and (3) \( r^\beta = w \) (equations (1) and (12)).

Combining the solution to (A11) with the corresponding one for the foreign country gives us general-equilibrium supply functions of the form

\[
\text{(A12) \quad } S^h_{r^h} = S^h_{r^h}(r^f, r^f + T, n^h(r^h), n^f(r^f))
\]

where T is a specific import tariff in country h (\( r^f \) is the price of foreign services in the foreign country).

Consider (A12) and corresponding functions for \( S^f_{r^f}, S^h_{r^h}, \) and \( S^f_{r^f} \) in the neighborhood of free trade. Note from (A11) that \( n^h \) and \( n^f \) have an identical effect on all the \( S^i_{r^h}, \) given free trade and the symmetry assumptions that imply \( n^h = n^f, \quad p^h = p^f, \) and \( r^h = r^f. \)

\[
\frac{\partial S^i_{r^h}}{\partial n^h} = \frac{\partial S^i_{r^f}}{\partial n^f} \equiv S_i > 0.
\]

Let \( S^i_{r^h} \equiv S^i_{r^h}/r_{r^h} \). Symmetry assumptions also imply that

\[
\text{(A14) \quad } S^i_{r^h} = S^i_{r^f}, \quad S^i_{r^h} = S^i_{r^f}, \quad S^i_{r^h} = S^i_{r^f}, \quad S^i_{r^h} = S^j_{r^h} = S^j_{r^f}.
\]

that is, the effect of an increase in the price \( r^i \) on \( S^j \) is the same.
regardless of the country in which $S^j$ is being used. Equilibrium requires

(A15) $S^h_n + S^f_n - \bar{S} = 0$. $S^h_f + S^f_f - \bar{S} = 0$.

Assume free trade except for an import tariff $T$ in the home country and consider the system in the neighborhood of $T = 0$. Making use of the symmetry assumptions in (A13) and (A14), differentiation of (A15) yields

(A16) $\begin{bmatrix} 2S^i_{1i} + 2S^i_{nn'} \\ 2S^i_{jj} + 2S^i_{nn'} \end{bmatrix} \begin{bmatrix} 2S^i_{jj} + 2S^i_{nn'} \\ 2S^i_{ii} + 2S^i_{nn'} \end{bmatrix} \begin{bmatrix} dr^h \\ dr^f \end{bmatrix} = \begin{bmatrix} -S^i_{jj}dT \\ -S^i_{ii}dT \end{bmatrix}$

Stability requires that the determinant $\Delta$ of (A16) is positive and the symmetric form of the X production function implies that $|S^i_{ii}| > |S^i_{jj}|$.

Solutions are given by

(A17) $\frac{dr^h}{dT} = \frac{-2S^i_{jj}S^i_{nn'} + 2S^i_{ii}S^i_{nn'}}{\Delta} < 0 \text{ iff } S^i_n > 0$

(A18) $\frac{dr^f}{dT} = \frac{-2S^i_{ii}S^i_{nn'} + 2S^i_{jj}S^i_{nn'}}{\Delta} + \frac{-S^i_{ii}S^i_{nn'} + 2S^i_{jj}S^i_{nn'}}{\Delta}$

(A19) $\Delta = (4S^i_{ii}S^i_{ii} - 4S^i_{jj}S^i_{jj}) + (8S^i_{ii}S^i_{nn'} - 8S^i_{jj}S^i_{nn'})$.

Let $a \equiv 2S^i_{ii}S^i_{ii} - 2S^i_{jj}S^i_{jj}, b \equiv 4S^i_{ii}S^i_{nn'} - 4S^i_{jj}S^i_{nn'}$

where symmetry and the restriction that $\Delta > 0$ imply $a > 0, a+b > 0$.

Results are

(A20) $\frac{dr^h}{dT} = \frac{b/2}{2(a+b)}, \quad \frac{dr^f}{dT} = \frac{-(a+b/2)}{2(a+b)} < 0 \quad \frac{dr^h}{dT} + \frac{dr^f}{dT} = \frac{-a}{2(a+b)} < 0$

$dr^h/dT < 0$ iff $b < 0$ iff $S^i_n > 0$. Note that when $b < 0$, the restriction that $a+b > 0$ implies that

(A21) $(dr^f/dT) < (dr^h/dT)$

so that regardless of whether $b > 0$, $r^f$ decreases more with the home-country tariff than $r^h$, which can either rise or fall.

Now turn to the determinants of whether $S^i_n$ is greater than or less
than zero. The value of the marginal product of labour in producing $X$ in the home country at the free-trade equilibrium is given by

$$\text{VMP}_x = p(X)n_h h + n f(S_f h)^{\alpha} (S_h)^{\beta-1} = r = p(X)n^\alpha = c_h$$

where the second equality follows from the free-trade and symmetry assumptions. From (A22) the change in $S_j^i$ with respect to a change in either $n^h$ or $n^f$ at constant $r$ is given by

$$p(X)\frac{\partial\text{MP}}{\partial n} + MP_x p'(X)\frac{\partial X}{\partial n} + n MP_x \frac{\partial\text{MP}}{\partial s} + MP_x p'(X)\frac{\partial X}{\partial s} = 0.$$  

The sign of the second bracketed term is negative so we have

$$\text{sign} (\frac{\partial}{\partial n}) = \text{sign} (\frac{\partial\text{VMP}_x}{\partial n})$$

the first bracketed term of (A23) can be rewritten as

$$\frac{\partial\text{VMP}_x}{\partial n} = \frac{p(X)\text{MP}_x}{n} \frac{n\partial\text{MP}_x}{n} + n\frac{\partial X}{\partial n} \frac{p'(X)X}{p(X)}$$

$$\frac{\partial \text{VMP}_x}{\partial n} = \frac{p(X)\text{MP}_x}{n} [\frac{\partial}{\partial n} + \frac{e\text{X/\partial n}}{e\text{X/\partial p}}]$$

where the notation $e\text{X/\partial Y}$ denotes the elasticity of $X$ with respect to $Y$.

Considering $e\text{MP}_x/\partial n$, we have

$$\frac{\partial\text{MP}_x}{\partial n} = p(x)(1/\beta - 1)n^{-1/\beta - 2}$$

For $e\text{X/\partial n}$, we have

$$\frac{\partial\text{MP}_x}{\partial n} = \frac{1}{\beta} S$$

Denote (minus) the elasticity of demand as $\eta = -(p(X)/(\partial X/\partial p))$. Combining (A25), (A26), and (A27), we have

$$\text{sign} S = \text{sign} \frac{\partial\text{VMP}_x}{\partial n} = \text{sign} \left( \frac{1}{\beta} - 1 - \frac{1}{\beta n} \right) = \text{sign} (\eta - \frac{1}{1-\beta})$$

Relating this to the comparative statics of the tariff, we have
\( \frac{\partial r^h}{\partial T} < 0 \iff s_n > 0 \iff \eta > \frac{1}{1-B}. \)

The intuition is as follows. The home tariff lowers \( n^f \) which has two opposing effects on the VMP of labour in \( X \) in country \( h \). First, the physical marginal product of services in \( h \) falls but second, the price of \( X \) rises as \( n^f \) falls. If demand is elastic (\( n \) large), the latter effect is weak, the former dominates, and the VMP\( _x \) falls. Optimal inputs are reduced at constant \( r^h \) (\( s_n > 0 \)) and in general-equilibrium \( r^h \) falls.

The third purpose of this appendix is to establish the properties of the reaction curves shown in Figures 3. These properties do not require the symmetry assumptions of identical economies.

In the presence of service trade, prices of the specialized inputs will be equalized by trade, each country will use all of the inputs, and each country will use each input in the same relative amount. The only thing that must be determined is how the total \( S \) of each input must be split between countries. But this last consideration is not relevant for our purpose since there are constant returns to the input levels. Equilibrium in the domestic \( X \) industry is given by

\[
(A30) \quad p(X)M_P^X - r(n^h) = 0, \quad X = X^h + X^f
\]

\[
(A31) \quad p'(X)(M_P^X)\frac{\partial X}{\partial n}(dn^f + dn^h) + p(X)\frac{\partial M_P^X}{\partial n}(dn^f + dn^X) - r'dn = 0
\]

Note that \( n^h \) and \( n^f \) enter \( X \) symmetrically so that superscripts on \( n \) in \( (\partial X/\partial n) \) and \( (\partial M_P^X/\partial n) \) can be dropped. The slope of country \( h \)'s reaction curve is then given by

\[
(32) \quad \left[ \frac{\partial n^h}{\partial n} \right] = -\frac{-p'(X)(M_P^X)(\partial X/\partial n) - p(X)(\partial M_P^X/\partial n)}{-p'(X)(M_P^X)(\partial X/\partial n) - p(X)(\partial M_P^X/\partial n) + r'}
\]

Factor out \( p(X)(M_P^X)/n \) from both the numerator and denominator of \( (A32) \) and
cancel. This leaves

\[
\begin{align*}
\left( \frac{dn^h}{dn^f} \right)^h &= \frac{p'(X)X n_\delta X}{p(X) X \delta n} - \frac{n_{MP}'}{X} \\
&= \frac{p'(X)X n_\delta X}{p(X) X \delta n} - \frac{n_{MP}'}{X} \\
\left( \frac{dn^h}{dn^f} \right)^f &= \frac{1/(\beta \eta) - (1/\beta - 1)}{1/(\beta \eta) - (1/\beta - 1) + nr^h} \\
\end{align*}
\]

Recall that restricting ourselves to the concave portion of the production frontier implies \(nr^h > (1/\beta - 1)\). Since \(n = (n^h + n^f)\) never approaches zero along the reaction curve, \(nr^h > (1/\beta - 1)\) may hold globally over the reaction curve, which is the situation we assume here.

Consider first the case where \(1/(\beta \eta) > (1/\beta - 1)\) or \(\eta < 1/(1-\beta)\). Note that this is a case where \(S_n < 0\) (equation A(29)). The numerator of (A34) is positive, so (A34) is negative but everywhere greater than -1 (assuming \(nr^h > (1/\beta - 1)\)). If \(\eta > 1/(1-\beta)\) (\(S_n > 0\)), then the numerator is negative and (A34) is positive. A sufficient condition for (A34) to be less than -1 in this case is that \(\eta < 2/(1-\beta)\) and is less stringent as \(nr^h\) is large relative to \((1/\beta - 1)\). Summarizing we have

\[
\begin{align*}
(A35) & \quad -1 < \left( \frac{dn^h}{dn^f} \right)^h < 0 \quad \text{iff } \eta < 1/(1-\beta) \\
& \quad 0 \leq \left( \frac{dn^h}{dn^f} \right)^h < 1 \quad \text{if } 1/(1-\beta) \leq \eta < 2/(1-\beta)
\end{align*}
\]

The reaction curve for country \(f\) is simply the inverse of (A34). Thus

\[
\begin{align*}
(A36) & \quad \left( \frac{dn^h}{dn^f} \right)^f < -1 \quad \text{iff } \eta < 1/(1-\beta) \\
& \quad 1 < \left( \frac{dn^h}{dn^f} \right)^f \leq \infty \quad \text{if } 1/(1-\beta) \leq \eta < 2/(1-\beta)
\end{align*}
\]
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