ON THE ECONOMIC RELATIONSHIP BETWEEN MARGINAL INTRA-INDUSTRY TRADE AND LABOUR ADJUSTMENT IN A DIVISION OF LABOUR MODEL

Mary E. Lovely

Department of Economics
Syracuse University

Douglas R. Nelson

Murphy Institute of Political Economy
Tulane University

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Abstract:

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In the context of Ethier's (1982) division of labour model, this paper accomplishes three tasks. First, we complement existing literature on the algebraic properties of marginal intra-industry trade (MIIT) measures by embedding one of these measures in a general equilibrium model. Consistent with the existing literature, we find that change in the Grubel-Lloyd index provides systematically different economic information from change in the MIIT index. Second, we examine the connection between intra-industry trade and intra-industry adjustment. Here we find that the informal assumption that intra-industry trade generates only intra-industry cannot be sustained. That is, intra-industry trade will generally induce inter-industry adjustment. Finally, we find that, because intra-industry trade generates inter-industry adjustment, increased intra-industry trade will generally induce long-run changes in relative factor-prices. This suggests, given the prominence of intra-industry trade in the trade of OECD countries, that there may be some problems with inference on the link between trade and wages undertaken in a strict Heckscher-Ohlin framework.

Mary E. Lovely
Department of Economics
Syracuse University
Syracuse, New York 13244-1090

melovely@maxwell.syr.edu

Douglas R.Nelson
Murphy Institute of Political Economy
108 Tilton Hall
Tulane University
New Orleans, LA 70118-5698

dnelson@mailhost.tcs.tulane.edu

ON THE ECONOMIC RELATIONSHIP BETWEEN MARGINAL INTRA-INDUSTRY TRADE AND LABOUR ADJUSTMENT IN A DIVISION OF LABOUR MODEL

In recent years there has been a boom in research measuring intra-industry trade (*IIT*) with the goal of studying the relationship between that trade and labour-market adjustment (Brülhart, 1998). This research proceeds from the widely held presumption that IIT is associated with lower adjustment cost in factor markets than inter-industry, or "net", trade (*NT*). This revival of interest follows an important paper in which Hamilton and Kneist (1991) argue that using simple change in the Grubel-Lloyd index of IIT to identify low adjustment cost trade can lead to potentially serious measurement error. In addition to a number of empirical applications, an interesting body of papers has developed examining the algebraic properties of various measures of *marginal intra-industry trade* (*MIIT*) to determine their relative suitability as measures of the low adjustment cost component of increased trade (Azhar, Elliott, and Milner 1998). Because this work focuses on measures of IIT for a given sector, without incorporating adjustments of the overall equilibrium, the algebraic analysis of these measures is equivalent to a partial equilibrium analysis. The purpose of this paper is to extend the analysis of MIIT to an explicitly general equilibrium environment.

The next section provides a very brief review of research on the relationship between IIT and adjustment to put the current paper in context. The following section develops a general equilibrium framework based on Ethier's (1982) well-known division of labour model. The third section derives measures of change in IIT in the context of this model. Section IV is the core of the paper, developing our analysis of MIIT and its economic consequences. The final section concludes.

I. Related Literature

At least since the classic work of Verdoorn (1960), Drèze (1960), Kojima (1964), Balassa (1966), and Grubel (1967), it has been clear that IIT is in some fundamental way associated with trade liberalization, at least among industrial countries. Balassa in particular has argued that the empirically prominent role of IIT, along with a presumption that IIT is associated with lower adjustment cost than NT, helps to account for the unexpected sustainability of trade liberalization among industrial countries. In fact, Hufbauer and Chilas (1972), Lipson (1982), and Marvel and Ray (1987) invert Balassa's logic as the basis of a political economic account of both intra-European and multilateral liberalization.[1] Specifically, this line of research argues that, taking it as axiomatic that IIT is associated with lower adjustment cost than NT, not only will liberalization (either preferential or multilateral) be easier between countries whose trade can be expected to be characterized by a large share of IIT in total trade, but the inter-sectoral pattern of liberalization will be skewed toward sectors characterized by IIT. A survey of related research by Brülhart, Murphy, and Strobl (1998) strongly suggests widespread acceptance of the hypothesis that IIT induces lower adjustment cost than NT.[2]

If we accept that IIT really is intra-*industry* (i.e. not the result of problems with

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[1]In Lovely and Nelson (1999) contains a more detailed survey of these contributions.

[2]For obvious reasons, Brülhart, Murphy, and Strobl (1998) refer to this as the "smooth adjustment hypothesis". Thus, we note here that we will use the term "smooth adjustment" to refer to non-discontinuous adjustment along a transformation function.

categorical aggregation) and, as we shall see, more importantly, that adjustment to IIT is intra-industry, we can take advantage of substantial direct evidence from research by labour economists on the question of the relative costs of inter- versus intra-industry adjustment. Specifically, a substantial body of research uniformly finds that the cost of being unemployed in terms of lower wages is substantially higher under inter-industry adjustment (Jacobson, 1998). The modal explanation is quite clear: workers accumulate human capital which is portable between firms in the same sector, but is not portable between sectors; when a sector contracts (as the importable sector does under liberalization in the HOS model), labour is forced to move to the expanding (exportable producing) sector (e.g. Topel, 1990; Neal, 1995; Kletzer, 1996). Because human capital is sector-specific, workers lose the value of their investment and, because accumulation is related to time in an industry, they may never fully recover from the move. Intra-industry adjustment is thought to be different: firms may go out of business, but liberalization does not generate (high cost) inter-industry adjustment. As with the other trade literature on this subject, we take these empirical findings as given. That is, it will be an *assumption* of our analysis that inter-sectoral adjustment entails higher adjustment costs than intra-sectoral adjustment. On the other hand, we do not assume an identity between intra-industry trade and intra-industry adjustment. It is on the relationship between these two magnitudes that our analysis in section IV will focus.

II. A Two-Country Model with Intra-Industry Trade

Our analysis, because we are interested in inter-sectoral adjustment, requires a model with at least two sectors; and, because we are interested in the effects of intra-industry trade, requires that at least one of those sectors be characterized by IIT. While there are several models that meet these requirements, in this paper we will be working with Ethier's (1982) model of trade in differentiated intermediate goods.[3] That is, we will be working with a model with: two factors of production, labour (*l*) and capital (*k*); and two final consumption goods, wheat (*w*) and manufactures (*m*). Wheat is taken to be produced from under a standard neoclassical technology represented by a production function $f\,(k_w,l_w)$ which is twice differentiable, linear homogeneous, and strictly concave. Both factors are costlessly mobile between sectors and the markets for *k*, *l*, *w* and *m* are perfectly competitive. Demand is taken to be generated by a representative agent with Mill-Graham preferences such that a share γ of income is spent on the manufactured final good. We will be considering a two-country world in which both countries are large, share the same technology sets, tastes, and endowments of capital and labor.[4] Importantly, we assume that countries share the same trade policies (i.e. we will assume that they levy same tariff on imports of intermediate goods, $t = T$).[5] Finally, because we are interested in smooth adjustment, we will focus only on international equilibria in which both countries produce both wheat and manufactures.[6]

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[3]See Francois and Nelson (1998a) for an expository development of the Ethier model and a variety of its applications.

[4]Following Dixit and Norman (1980), we will denote home country magnitudes with lower case letters and foreign country magnitudes with upper case letters.

[5]As in Markusen's (1990) analysis of derationalizing tariffs, we assume that each country levies the same tariffs on imports of finished manufactures.

[6]There are tricky stability issues in the Ethier model that have a direct bearing on adjustment to trade. We ignore these issues here. Francois and Nelson (1998b) address some of the implications of stability for adjustment.

The Ethier model diverges from standard trade models in the technology of *m* production: *m* is produced by costless assembly of components (*x*) which are, themselves, produced with internal increasing returns. Following the development in Ethier (1982), we suppose that in the relevant equilibrium there are *n* home firms and *N* foreign firms producing intermediates. Finished manufactures are costlessly assembled from intermediate components according to

$$m = \left[\sum_{j=1}^{n} x_j^{\beta} + \sum_{i=1}^{N} X_i^{\beta} \right]^{\frac{1}{\beta}}, \quad M = \left[\sum_{j=1}^{n} x_j^{\beta} + \sum_{i=1}^{N} X_i^{\beta} \right]^{\frac{1}{\beta}}, \qquad \textbf{(1)}$$

where x_j is the input of intermediate component *j*, which is produced by the home country, and X_i is the input of intermediate component *i*, which is produced by the foreign country. Finished manufactures are produced in a similar way in the foreign country. Two features of this production technology are important. The first is the imperfect substitutability of differentiated components. The elasticity of substitution between any pair of component is $\frac{1}{(1-\beta)}$ $(0<\beta<1)$. The second feature to note is that output is increasing in *n* and *N*, the number of distinct home and foreign varieties. The elasticity of output with respect to *n* or *N* is $\frac{1}{\beta}$, indicating increasing returns to variety.

To produce x_j units of intermediate variety *j*, a firm must purchase $b_j = ax_j + A$ bundles of *K* and *L*. The internal increasing returns to scale implies that a finite number of intermediates are produced, and each variety is produced by a different firm. These firms engage in large group monopolistic competition. Note that both the fixed (*A*) and marginal (*a*) costs are paid in bundles and are constant across firms in the component producing sector. We assume all components have identical cost functions, which coupled with the symmetric form of (1) implies that all x_j and

X_i are produced in the same quantity. If we let $b = \sum b_j$, and $x_j = x \; \forall \; j \in n$, and similarly for foreign producers of intermediates, then

$$b = n[ax + A]; \quad B = N[aX + A]. \qquad \textbf{(2)}$$

With positive production of intermediates in both countries, producers of final manufactures will use all varieties of intermediates, so positive quantities of home intermediates will be consumed by both home (x_h, X_h) and foreign (x_f, X_f) firms, so:

$$x = x_h + x_f; \quad X = X_h + X_f. \qquad \textbf{(3)}$$

With a fixed endowment of factors of production, $(\bar{k}, \bar{l})$ and $(\bar{K}, \bar{L})$, we can summarize the resource constraint of the economy in terms of a transformation function between bundles and wheat:

$$w = s(b); \quad W = S(B). \qquad \textbf{(4)}$$

For this purpose, we assume that bundles used in the production of components are produced according to a standard neoclassical production function, $b = g(k_b, l_b)$, which is linear homogeneous, twice differentiable, and strictly concave. Along with the equivalent assumptions on the production of wheat, and no factor-intensity reversal, we know that the function $w = s(b)$ is the strictly concave transformation function of the HOS model. In particular, we know that $s'(b) < 0$ and $s''(b) \leq 0$.

Furthermore, given perfect competition in wheat and bundles, and taking wheat as the numeraire, the relative price of factor bundles for component production is $p_b = -s'(b)$. Since component producers purchase bundles under competitive conditions, total cost for a representative component producing firm is $-s'(b)[ax_j + A]$ and total revenue is $q_j x_j$, so the condition that marginal revenue equals marginal cost can be rearranged to get an expression for q_j, the common price of intermediates:

$$q = \frac{-s'(b)\,a}{\beta}; \quad Q = \frac{-S'(B)\,a}{\beta}. \qquad \textbf{(5)}$$

The profit of each component producing firm is $\pi_j = q_j x_j + s'(b)[a x_j + A]$ which will be driven to zero by free entry and exit (abstracting from integer problems). Thus, setting $\pi_j = 0$ and substituting for q_j from equation (5), we get:

$$x = \frac{A\beta}{a(1-\beta)}; \quad X = \frac{A\beta}{a(1-\beta)}. \qquad \textbf{(6)}$$

Since this is made up entirely of parameters that are constant across component producing firms, equations (6) underwrite our treatment of x as identical across firms.[7] Note also that these parameters are globally common, so all intermediate firms, regardless of location, produce the same quantity of the intermediate good.

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[7]Thus, from the fact that $b = n(ax + A)$, we can solve for the number of firms as a function of aggregate output of bundles:

$$n = \frac{(1-\beta)}{A} b.$$

Note the implication that b and n are linearly related.

It is important to note that, as shown in equation (6), while a representative home producer of intermediates produces exactly the same quantity as a representative foreign producer, it will not generally be the case that $x_h = X_h$ or $x_f = X_f$. In particular, the presence of tariffs creates a distortion in the intermediate good choice of final manufacturers between home and foreign produced varieties. Since this fact is essential to our analysis, we note that:

$$\frac{x_h}{X_h} = \left[\frac{Q(1+t)}{q}\right]^{1/(1-\beta)}; \quad \frac{X_f}{x_f} = \left[\frac{q(1+T)}{Q}\right]^{1/(1-\beta)}. \qquad \textbf{(7)}$$

Ceteris paribus, a tariff shifts the input mix toward domesitically produced intermediates. The elasticity of substitution between home and foreign inputs is $1/(1-\beta)$.

We complete our model with two key behavioral relations. Because the market for final manufactures is perfectly competitive, equilibrium is characterized by zero profits:

$$pm = qnx_h + Q(1+t)\,NX_h; \quad PM = QNX_f + q\,(1+T)\,nx_f. \qquad \textbf{(8)}$$

Finally, our assumption of Mill-Graham demands ensures that a constant share, γ, of national income will be spent on manufactured goods. Thus,

$$pm = g\left(w + qnx + QtNX_h\right); \quad PM = g\left(W + QNX + qTnx_f\right). \qquad \textbf{(9)}$$

Equations (1) through (9) describe the two-country economy we seek to analyze.

III. MIIT in a Two-Country Ethier Model

As we note above, there is a widely held presumption that the existence of IIT implies lower adjustment cost to increased international trade due to the association of IIT with intra-industry adjustment. This has led to a number of studies that use measures of change in IIT more-or-less explicitly as a proxy for low adjustment cost trade. Most of this work measures IIT by the Grubel-Lloyd index, or one of its variants.[8] If we let X_j and M_j denote exports and imports of commodity *j*, the Grubel-Lloyd index of IIT in sector *j* is given by:[9]

$$G_j := \frac{IIT_j}{TT_j} = \frac{X_j + M_j - \left|X_j - M_j\right|}{X_j + M_j} \equiv 1 - \frac{\left|X_j - M_j\right|}{X_j + M_j}. \qquad \textbf{(10)}$$

G_j gives IIT as a share of total trade in commodity *j* and, thus, takes values between 0 (no IIT, all trade is NT) and 1 (all IIT). These indices can be studied directly or aggregated to study broad sectoral or economy-wide trends in IIT. The earlier research on the liberalization-IIT-adjustment links, implicitly or explicitly, takes change in the (sectoral or aggregate) Grubel-Lloyd index to indicate the magnitude of that part of trade that does not generate high adjustment cost. That is, for the case of IIT in sector *j*, this research considers:

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[8]See Grubel and Lloyd (1975) for the original presentation of this index. The variants attempt to correct for problems related to categorical aggregation or unbalanced trade, neither of which will concern us in our theoretical development, so we will focus on the Grubel-Lloyd index. For details on other measures, see Chapter 5 of Greenaway and Milner (1986).

[9]The Grubel-Lloyd index follows straightforwardly from the fact that $IIT_j := 2\min[X_j, M_j] = X_j + M_j - |X_j - M_j|$, and normalization by total trade (TT). It is also quite natural to interpret G_j by noting that since $NT_j := |X_j - M_j|$, we can rearrange the identity $TT \equiv IIT + NT$, and divide by *TT* to get an index that takes values in [0,1].

$$\Delta G_j := G_{j,t+1} - G_{j,t}. \tag{11}$$

To derive an expression for the Grubel-Lloyd index in terms of the framework developed in section II, suppose the home country is (weakly) a net exporter of components. Then we can write exports of components, XC_h, and imports of components, MC_h, as

$$XC_h = nx_f, \quad MC_h = NX_h, \text{ and } nx_f \geq NX_h. \tag{12}$$

In the context of the division-of-labour model IIT is:

$$IIT = 2\min\left[nx_f, NX_h\right] = 2\, NX_h. \tag{13}$$

Thus, the Grubel-Lloyd index, G, is expressed as

$$G = \frac{2NX_h}{nx_f + NX_h}. \tag{14}$$

Using hats to denote proportional changes, i.e. $\hat{x} = \dfrac{dx}{x}$, we can get change in the Grubel-Lloyd index as:

$$\hat{G} = \frac{nx_f}{nx_f + NX_h}\left[\hat{N} + \hat{X}_h - \hat{n} - \hat{x}_f\right]. \tag{15}$$

By this measure, intraindustry trade increases when the number of foreign varieties or the quantity of each foreign variety used by home producers expands. In contrast, intraindustry trade seems lower when the number of home varieties or the quantity of each home variety used by foreign producers expands. Note that the weight on the expansion of varieties in either country is the same -- home exports as a share of total components trade.

As we noted in the introduction, Hamilton and Kniest (1991) argue, following Caves (1981, pg. 213), that what is relevant to the analysis of factor market adjustment is not whether the amount of IIT has increased, but whether the share of IIT in trade has increased. That is, if one is interested in the effect of changed trading conditions on adjustment, it is necessary to identify the contributions of change in IIT and change in net trade (NT) to change in total trade. In this paper we will focus on a set of indexes due to Dixon and Menon (1997) which, like the Grubel-Lloyd index (see footnote 10), have the attractive property that they can be derived from an identity with an intuitive relationship to both the theory and the data. Specifically, Dixon and Menon's (1997) basic measure of the contribution of the change in IIT to the percent change in total trade is:

$$C_j := \frac{\Delta IIT_j}{TT_j} = \hat{IIT}_j \, G_j . \qquad \textbf{(16)}$$

The second equality follows from the definition of the Grubel-Lloyd index, $G := \frac{IIT}{TT}$, and simple manipulation. Menon and Dixon prefer C_j to ΔG_j because the latter can lead to quite misleading inferences about the significance of MIIT in changing trade. Specifically, an increase in G_j is generally taken to imply an increase in the significance of IIT relative to NT. However, as Menon and Dixon (1996, pp. 7-8) show analytically, it is possible for $\Delta G_j > 0$ to be associated with a smaller increase in marginal IIT than the marginal increase in net trade.[10]

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[10]Perhaps more importantly, they develop extensive empirical evidence of precisely such an implication. For example, Dixon and Menon (1997) use Australian data at the 3-digit SITC level to illustrate the empirical significance of the measure one chooses to use in analyzing the effect of IIT in changing aggregate trade. They find that, of the 133 manufacturing industries that make up their data set, about 14% in 1981-1986, and 31% in 1986-1991, were characterized by

In terms of the Ethier model developed above, we can write the C index as:

$$C = \frac{2\, NX_h}{nx_f + NX_h} \left[\hat{N} + \hat{X}_h \right]. \qquad \textbf{(17)}$$

This measure involves only expansion of foreign varieties and home usage of foreign varieties. Provided the home country remains the net exporter of components, changes in the number of home varieties and foreign usage of each home variety do not contribute to the measured change in intraindustry trade. Another distinction between this MIIT measure and the change in the Grubel-Lloyd index is that the weight used here is twice foreign intermediate exports as a share of total intermediates trade. If foreign production of components is small, changes in foreign exports of components lead to a small measured change in MIIT.

Finally, it is worth noting, with Menon and Dixon (1997), that if we are really interested in adjustment cost, rather than the indirect measures of the sort we have been considering to this point, which are, after all, measures of low-adjustment-cost trade, what we should really use is a measure of the amount of trade that generates high adjustment costs. One alternative would be to use a measure of change in NT as a share of TT:

$$F_j = \frac{\Delta NT_j}{TT_j} = N\hat{T}_j \left(1 - G_j\right). \qquad \textbf{(18)}$$

It is straightforward to show the relationship between C_j, F_j, and TT_j if we begin with the identity $\Delta TT_j = \Delta IIT + \Delta NT$, and evaluate the changes relative to TT_j to get:

$$T\hat{T}_j = C_j + F_j = I\hat{I}T_j\, G_j + N\hat{T}_j \left(1 - G_j\right). \qquad \textbf{(19)}$$

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increases in G_j but larger contributions of marginal net trade than marginal IIT.

To adapt this measure for use in our analytical framework, we denote net trade as:

$$NT = nx_f - NX_h. \qquad \textbf{(20)}$$

Then we have:

$$F = \frac{nx_f}{nx_f + NX_h}\left[\hat{n} + \hat{x}_f\right] - \frac{NX_h}{nx_f + NX_h}\left[\hat{N} + \hat{X}_h\right]. \qquad \textbf{(21)}$$

In this measure, changes in home exports of components and home imports of components have different weights when contributing to the change in net trade. As in the marginal Grubel-Lloyd measure, increases in the number of foreign varieties or the quantity of each foreign variety used by home producers reduces net trade while increases in the number of home varieties or the quantity of each home variety used by foreign producers expands net trade. However, unlike the Grubel-Lloyd measure, the market share of each country matters when measuring the marginal change in net trade. If the foreign country is a small producer of components, changes in its exports of components to the home country will contribute only a small amount to the measured change in net trade. In the Grubel-Lloyd measure, changes in home exports or foreign exports have equal weight.

Thus, a first useful result from this analysis is that we confirm, in the context of a standard general equilibrium model, a result well-known from the algebraic analysis of the Grubel-Lloyd index and the Menon-Dixon indices: these are measures of economically different things.

IV. MIIT and Adjustment in a Two-Country Ethier Model

We now apply the analysis from sections II and III to our central question: what is the relationship between IIT and intra-industry adjustment? We proceed by totally differentiating the system given in equations (1) to (9). Following Ethier (1979), we can express the international equilibrium in terms of national allocation curves. The home-country equilibrium requires that the market for finished manufactures clear. Because we assume the same import tariff that is levied on components is also levied on imports of finished manufactures, there is no trade in finished manufactures. Consequently, domestic equilibrium requires that the domestic demand price of finished manufactures equals the domestic supply price. This condition implies that the value of consumption of finished manufactures (given by equation (9)) equals the total cost of inputs to domestic manufactures (given by equation (8)).

–Figure 1 about here--

As shown in the Appendix, the system reduces to two simultaneous equations that may be depicted as allocation curves. Letting $\tau = (1 + t)$ and $\mathrm{T} = (1 + T)$, these equations take the form:

$$\begin{aligned} \phi_n \hat{n} + \phi_N \hat{N} + \phi_t \hat{\tau} + \phi_T \hat{\mathrm{T}} &= 0, \\ \Gamma_n \hat{n} + \Gamma_N \hat{N} + \Gamma_t \hat{\tau} + \Gamma_T \hat{\mathrm{T}} &= 0. \end{aligned} \tag{22}$$

The home allocation curve is depicted in Figure 1 as the curve HH′ and the foreign allocation curve is depicted as FF′. We have assumed that the international equilibrium is stable and occurs at point A in the presence of identical tariffs on intermediates imports in each country. To understand the effect of liberalization, we note that a tariff reduction by the home country alone shifts both allocation curves. The horizontal shift in HH′ is given by

$$\left.\frac{\hat{n}}{\hat{\tau}}\right|_{HH'} = -\frac{\phi_t}{\phi_n}. \qquad \textbf{(23)}$$

Domestic stability requires that ϕ_n be negative. ϕ_t may take either sign and we assume that $\phi_t > 0$. Thus, an increase in the home tariff shifts HH′ to the right. The foreign allocation curve also shifts, however, and its horizontal shift is given by

$$\left.\frac{\hat{n}}{\hat{\tau}}\right|_{FF'} = -\frac{\Gamma_t}{\Gamma_n}. \qquad \textbf{(24)}$$

As discussed in the appendix, Γ_t is negative and Γ_n is negative. The sign of this derivative is therefore negative. Because HH′ shifts right and FF′ shifts left, the number of home input varieties rises while the number of foreign varieties falls when the home country levies a tariff. The new equilibrium occurs at point B in figure 1. Because the home and foreign countries are identical, a tariff levied by the foreign country has similar effects, with the equilibrium number of foreign varieties rising and the number of home varieties falling.

When both the home and foreign countries liberalize, with the same percentage reduction in their tariffs, both countries influence the position of the two allocation curves. The net effect on the number of varieties depends on whether the effect of a tariff cut on one's own allocation curve induces a shift of the same, larger, or smaller magnitude (in absolute value) on the allocation curve of one's partner. Clearly, since the two countries cut tariffs by the same proportion, the net effect of the two policy changes will be the same for each country's total number of varieties. Whether the total number of varieties in each country rises or falls, these changes will be identical.

We can solve for the change in home varieties (the change in foreign varieties will be the same) as

$$\hat{n} = \frac{1}{D}\left[\left(\phi_N - \phi_n\right)\left(\phi_t + \phi_T\right)\right]\hat{\tau}, \qquad \textbf{(25)}$$

where we have used the symmetry assumptions, as shown in the Appendix. Because the equilibrium is stable, the determinant, *D,* is positive. As in Ethier (1979), we also assume that an increase in either country's finished manufactures output reduces the demand price both absolutely and relative to that country's supply price and lowers the supply price of the other country. These assumptions imply that both ϕ_N and ϕ_n are negative but that $\phi_N > \phi_n$. Therefore, the sign of (25) depends on the sign of $\phi_t + \phi_T$. This sign will be positive if the rightward shift in the home allocation curve induced by an increase in the home tariff exceeds the leftward shift induced by an increase in the foreign tariff. If we assume this to be the case, the number of home varieties must fall when the home and foreign tariffs are reduced. Because the identical responses occur in the foreign country, liberalization reduces the total number of intermediates varieties.[11]

Now we turn to the measures of marginal intraindustry trade used in the empirical trade literature. These measures require measurement of changes in the amount of each variety that enters trade as well as their number. Using equations (3) and (7), we can derive expressions for

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[11]Markusen (1990) derives conditions under which a tariff makes the number of domestic and foreign input varieties fall. He shows that a necessary condition for tariffs to be "derationalizing" is that the price elasticity of demand for finished manufactures exceeds the elasticity of substitution between home and foreign intermediate inputs. In the present model, this condition does not hold. Following Ethier (1982), we assume that the price elasticity of demand is unity, while the elasticity of substitution exceeds unity. Thus, in the present case, a liberalization may be derationalizing, in the precise sense that the liberalization reduces the total number of input varieties. Most treatments of trade policy with differentiated consumer or producer goods use models that produce the result that a tariff raises the number of domestic varieties, as is the case here. See Markusen for references and further detail.

the changes in the volume of each imported intermediate. The change in home imports of each foreign variety is

$$\hat{X}_h = \frac{1}{1-\beta}\frac{X_f}{\Lambda}\left[x\,\varepsilon_h\left(\hat{n} - \hat{N}\right) + \left(x_f - x_h\right)\hat{\tau}\right], \tag{26}$$

where Λ is a measure of the home bias in input choices induced by the tariff and is positive and ε_h is the elasticity of the supply price of factor bundles. We have also used symmetry of the two economies and of the policy changes. Similarly, the change in foreign imports of each home variety is

$$\hat{x}_f = -\frac{1}{1-\beta}\frac{x_h}{\Lambda}\left[X\,\varepsilon_h\left(\hat{n} - \hat{N}\right) + \left(X_f - X_h\right)\hat{\tau}\right], \tag{27}$$

Because $\hat{n} = \hat{N}$, and $X_f > X_h$ while $x_f < x_h$ (home bias in input usage), it can be seen by inspection that the tariff reductions must increase both X_h and x_f.

Because symmetry ensures that $X_f = x_h$ and $X_h = x_f$, it can easily be confirmed that the change in the Grubel-Lloyd index, G, and in net trade, F, is zero. These results follow from the symmetry assumption: all trade is intraindustry. The liberalization by both countries does alter trade, however, in that fewer varieties are traded but each variety is now traded in larger quantities — the home bias in input use is reduced by the tariff reductions.

The measure that captures the intraindustry trade induced by the mutual liberalization is the Menon-Dixon C index. For the present model, this expression is

$$C = \frac{2NX_h}{nx_f + NX_h}\left[\hat{N} + \hat{X}_h\right]. \qquad \textbf{(28)}$$

The number of varieties falls while the amount of each variety traded rises, but the net effect on intraindustry trade in indeterminate.

Although the change in the volume of trade is indeterminate, the direction of adjustment is determinate. Because the number of varieties falls in each country, the total amount of domestic resources devoted to the manufacturing sector must fall. Trade generated or reduced is intraindustry, but the adjustment is interindustry. This observation leads us to the following propositions.

Proposition 1: For identical countries under smooth adjustment and interior equilibria before and after liberalization, mutual reductions in tariffs on imported intermediates can reduce the amount of resources employed in the manufacturing sector.

Proof: If $\hat{n} < 0,$ then $\hat{b} < 0.$ This follows from the positive (linear) relationship between n and b (see footnote 6). Resources are reallocated from the manufacturing sector to the wheat sector. In the symmetric case discussed above, all marginal trade is intraindustry but all adjustment is interindustry.

This proposition suggests that the MIIT measures are poor guides to the share of adjustment that is low-cost adjustment. It also suggests that observations about changes in trade patterns do not map directly into changes in industry resource allocations.

Proposition 2: For identical countries under smooth adjustment and interior equilibria before and after liberalization, mutual reductions in tariffs on imported intermediates alter the distribution of income. Assuming that the manufacturing sector is capital intensive, liberalization reduces the return to capital and raises the wage.

Proof: Because *n* and *N* fall with liberalization, *q* and *Q* fall with liberalization. As shown by Ethier (1982, Proposition 4), a fall in the price of intermediates reduces the return to the factor used intensively in manufacturing and raises the return to the other factor.

V. Conclusions

The two main results of this paper have interesting implications for research on trade and labour market adjustment. With respect to research on measuring MIIT with the goal of linking MIIT to factor-market adjustment costs, we conclude that the algebraic/partial equilibrium approach characterizing the earlier literature may be misleading. Even in the symmetric case, in which all existing indexes yield the same result, these indexes imply that, because there is only MIIT, there must be only low cost adjustment. *Ex post*, it is probably clear that, in a general equilibrium environment, it is not the case that net trade is a necessary condition for high cost (i.e. inter-sectoral) factor market adjustment. In fact, intersectoral adjustment is generically associated with trade liberalization. It is an open question whether an increase in MIIT is associated in general with lower intersectoral adjustment than an increase in marginal net trade. In any event, one implication of proposition 1 would appear to be that, if we are interested in the link between trade and intersectoral adjustment, we will need measures of both intersectoral movement and trade.[12]

The second proposition takes us from the focus on short-run costs of adjustment to the long-run consequences of trade liberalization which has been the focus of so much recent

[12] See Brülhart, Murphy, and Strobl (1998) for a first attempt in this direction.

empirical research (Gaston and Nelson, forthcoming). Specifically, the implication of proposition 2 is that, not only is IIT generally associated with high-cost intersectoral adjustment, but as a result, will also be associated with long-run changes in relative factor-returns. This suggests that worries about north-south trade, exemplified by rhetoric about a "giant sucking sound", as a culprit in the deterioration of the wages of unskilled workers may be missing the point in a way very different from the current stress on technological change. The culprit could conceivably be trade with other industrial nations.[13] It follows from the analysis leading to Ethier's (1982) proposition 5 that, even with pure intra-industry trade, the inter-sectoral adjustment will induce a change in relative price of manufactures. This change in P_m/P_w can take either sign for a given change in P_b/P_w, though the change in the relative price of manufactures will be smaller than the change in the relative price of bundles. Given the prominence of IIT among OECD economies, this suggests the possibility that both informal and econometric inference on the relationship between the relative prices of final goods and factors based on the HOS model may be faulty. At the very least, by using a model that incorporates IIT, which is such a prominent feature of trade data, we are alerted to aspects of the relationship between trade and wages that have been ignored in the focus on the Heckscher-Ohlin model.

[13]It is important to note, along with this theoretical possibility, that this is not a Stolper-Samuelson result. We have not shown that any factor experiences a *real* decline. As Ethier (1982, proposition 6) makes clear, to make such a statement requires explicit attention to the interaction between inter-sectoral effects, of the usual Stolper-Samuelson sort, and scale effects.

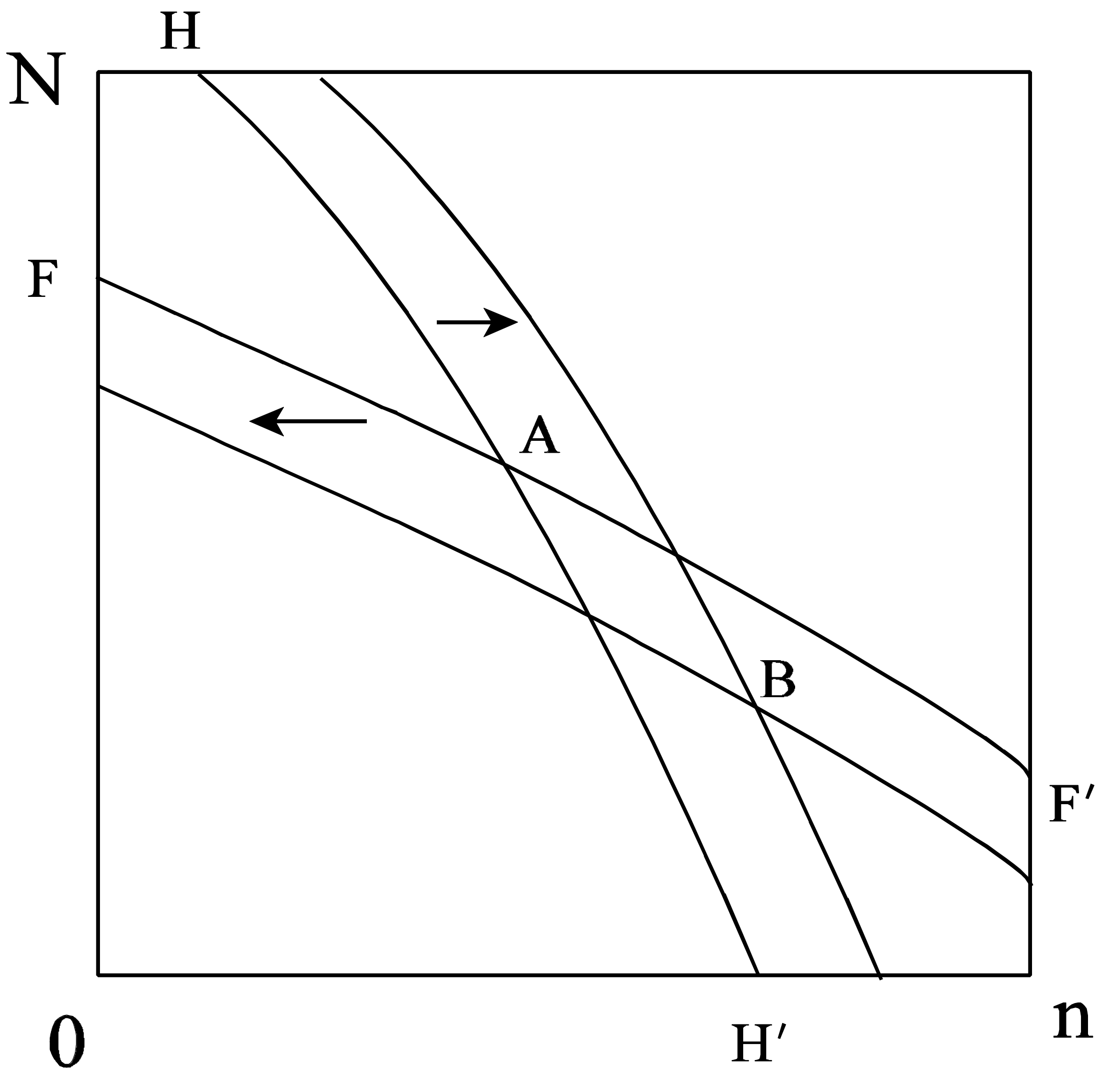

Figure 1: National Allocation Curves–Effect of an Increase in the Home Tariff

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Appendix

1. Derivation of Equations (22).

Equations (22) are the home and foreign allocation curves, respectively. They are reduced forms derived from by fully differentiating system (1) to (9). For the home country, this system is:

$$\hat{b} = \hat{n} + \frac{ax}{ax + A}\hat{x}. \tag{A.1}$$

$$\hat{x} = \frac{x_h}{x}\hat{x}_h + \frac{x_f}{x}\hat{x}_f. \tag{A.2}$$

$$\hat{w} = -v\hat{b}, \text{ where } v \equiv -s'(b)\frac{b}{s(b)} > 0. \tag{A.3}$$

$$\hat{q} = e_h\hat{b}, \text{ where } e_h = \frac{s''(b)}{s'(b)}b > 0. \tag{A.4}$$

$$\hat{x} = 0. \tag{A.5}$$

$$\hat{x}_h - \hat{X}_h = \frac{1}{1-\beta}\left[\hat{Q} + \hat{\tau} - \hat{q}\right]. \tag{A.6}$$

$$\hat{p} + \hat{m} = c_h\left(\hat{q} + \hat{n} + \hat{x}_h\right) + c_f\left(\hat{Q} + \hat{\tau} + \hat{N} + \hat{X}_h\right)$$
$$\text{where } c_h = \frac{qnx_h}{pm} \text{ and } c_f = \frac{QNX_h\tau}{PM}. \tag{A.7}$$

$$\hat{p} + \hat{m} = g_w \hat{w} + g_h\left(\hat{q} + \hat{n} + \hat{x}\right) + g_f\left(\hat{Q} + \hat{N} + \hat{X}_h\right) + g_t \hat{\tau} \qquad \textbf{(A.8)}$$

$$\text{For equation } (A.8)\text{:}$$

$$\text{Let } NI = w + qnx + QNX_h\tau - QNX_h,$$

$$g_w = \frac{w}{NI} \qquad g_h = \frac{qnx}{NI}$$

$$g_f = \frac{QNX_h}{NI} \qquad g_t = \frac{QNX_h\tau}{NI}$$

Combining (A.2), (A.5), and (A.6), and similar expressions for foreign output production and usage, yields the expressions for $\hat{X}_h$ and $\hat{x}_f$ given by equations (26) and (27) as well as the expressions for usage of domestic inputs:

$$\hat{x}_h = \frac{1}{1-\beta}\frac{x_f}{\Lambda}\left\{X\,\varepsilon_h\left(\hat{n} - \hat{N}\right) + \left(X_f - X_h\right)\hat{\tau}\right\} \qquad \textbf{(A.9)}$$

$$\hat{X}_f = -\frac{1}{1-\beta}\frac{X_h}{\Lambda}\left\{x\,\varepsilon_h\left(\hat{n} - \hat{N}\right) + \left(x_f - x_h\right)\hat{\tau}\right\} \qquad \textbf{(A.10)}$$

where we have used the symmetry assumption $\varepsilon_h = \varepsilon_f$ and $\hat{\tau} = \hat{\mathrm{T}}$, and where

$$\Lambda = X_f x_h - X_h x_f = X_f x_f\left[\frac{x_h}{x_f} - \frac{X_h}{X_f}\right] > 0$$

is a measure of initial input bias.

Market clearance requires equality of the domestic demand and supply prices: $\hat{P}_D - \hat{P}_S = 0.$ Using (A.7), (A.8), and (A.5),

$$\hat{P}_D - \hat{P}_S = g_w \hat{w} + (g_h - c_h)(\hat{q} + \hat{n}) + (g_t - c_f)(\hat{Q} + \hat{N} + \hat{X}_h) - c_h \hat{x}_h + (g_f - c_f)\hat{\tau}. \tag{A.11}$$

From equation (A.1) and (A.5), $\hat{b} = \hat{n}$. Therefore, using (A.3), $\hat{w} = -v\hat{n}$ and using (A.4), $\hat{q} = \varepsilon_h \hat{n}$.

With these substitutions,

$$\hat{P}_D - \hat{P}_S = -g_w v\hat{n} + (g_h - c_h)(\varepsilon_h + 1)\hat{n} + (g_t - c_f)(\varepsilon_h + 1)\hat{N} + (g_t - c_f)\hat{X}_h - c_h \hat{x}_h + (g_f - c_f)\hat{\tau}. \tag{A.12}$$

It is possible to show that $(g_t - c_f) < 0$, $(g_f - c_f) < 0$ and the sign of $(g_h - c_h)$ is indeterminate. Substituting in the expression for $\hat{X}_h$ given by (26) and $\hat{x}_h$ given by (A.9) and rearranging yields the allocation curves:

$$\begin{aligned} \phi_n \hat{n} + \phi_N \hat{N} + \phi_t \hat{\tau} + \phi_T \hat{T} &= 0, \\ \Gamma_n \hat{n} + \Gamma_N \hat{N} + \Gamma_t \hat{\tau} + \Gamma_T \hat{T} &= 0. \end{aligned} \tag{22}$$

where

$$\phi_n = (g_h - c_h)(\varepsilon_h + 1) - g_w v - \frac{1}{1-\beta}\frac{\varepsilon_h}{\Lambda}\left(c_h x_f X - (g_t - c_f) X_f x\right)$$

$$\phi_N = (g_t - c_f)(\varepsilon_f + 1) + \frac{1}{1-\beta}\frac{\varepsilon_f}{\Lambda}\left(c_h x_f X - (g_t - c_f) X_f x\right)$$

$$\phi_t = (g_f - c_f) + \frac{1}{1-\beta}\frac{1}{\Lambda}\left(c_h x_f x_h - (g_t - c_f) X_f x_h\right)$$

$$\phi_T = -\frac{1}{1-\beta}\frac{1}{\Lambda}\left(c_h x_f X_f - (g_t - c_f) X_f x_f\right)$$

The foreign allocation curve and its parameters can be derived in a similar manner.

The signs of ϕ_n and ϕ_N are generally indeterminate. However, these parameters are restricted by our assumption that the allocation curves are negatively sloped in [n, N]-space. The slope of the home allocation curve is given in the text as $-\dfrac{\phi_n}{\phi_N}$. Restricting this to be negative implies that ϕ_n and ϕ_N take the same sign. Domestic stability requires the demand curve for manufactures to be more steeply sloped than the domestic supply curve (see Ethier, 1979), which implies that $\phi_n < 0$. Therefore, $\phi_n < 0$ and $\phi_N < 0$. The sign of ϕ_t is indeterminate, while $\phi_T < 0$. Similarly, $\Gamma_n < 0$ and $\Gamma_N < 0$, while the sign of Γ_T is indeterminate and $\Gamma_t < 0$.

2. Solutions for $\hat{n}$ and $\hat{N}$.

Using the system (22),

$$\hat{n} = \frac{1}{D}\left[\left(\phi_N\Gamma_t - \Gamma_N\phi_t\right)\hat{\tau} + \left(\phi_N\Gamma_T - \Gamma_n\phi_T\right)\hat{\mathrm{T}}\right], \qquad \textbf{(A.13)}$$

where $D = \theta_n\Gamma_N - \phi_N\Gamma_N > 0$ because we assume the international equilibrium is stable. With symmetry, $\phi_N = \Gamma_n$, $\phi_n = \Gamma_N$, $\phi_t = \Gamma_T$, and $\phi_T = \Gamma_t$. Consequently, equation (A.13) reduces to equation (25) in the text.