FACTOR MARKET ADJUSTMENT TO INTER -INDUSTRY AND INTRA-INDUSTRY TRADE IN A DIVISION OF LABOR MODEL

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Adjustment of national factor markets, especially labour markets, to changes in the international economic environment has become a matter of widespread concern among the public, its political representatives, and, thus, among the members of the Economics profession. Because the central fact motivating much of the academic research is a deterioration in the returns to unskilled labour (both absolutely and relative to skilled labour), virtually all of this research has been framed in terms of the 2-good × 2-factor, neoclassical model (the Heckscher-Ohlin-Samuelson, or HOS, model).[1] One well-known property of the HOS model is that trade between countries is strictly inter-industry in nature. That is, since trade is caused by endowment differences between countries, trade must generate changes in production structure to take advantage of the gains from trade. Furthermore, loosely speaking, the larger the adjustment induced by trade, the larger are the aggregate gains from trade. Finally, still loosely speaking, the larger the adjustment induced by trade, the larger must be the adjustment in relative factor-prices necessary to accommodate the change in relative commodity-prices.[2] Thus, in the HOS model, we associate large adjustment costs with large aggregate gains.

A prominent fact that has emerged from the recent spate of research on the link

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[1]The key results for this research are the Stolper-Samuelson and factor-price equalization theorems that relate relative commodity-prices to relative factor-prices. See Gaston and Nelson (forthcoming) for a survey of the main contributions.

[2]This follows from the well-known 1-to-1 relationship between relative commodity prices and relative factor prices in the HOS model.

between international trade and relative wages is that, while the volume of international trade has increased quite considerably, it has proven exceptionally difficult to establish a strong connection between this trade growth and the changes in relative wages that provoked much of the present research. This paper proceeds from one of the central facts that led to a reassessment of the HOS model, a large share of intra-industry trade (IIT) in total trade, to a standard model that permits both inter-industry and intra-industry specialization and trade, Ethier's (1982) division of labor model. We use Ethier's model to frame a discussion of the primarily empirical literature that seeks to link IIT with low adjustment costs. Specifically, in the next section we review the literature on IIT and adjustment. Section II develops our theoretical framework, section III presents the measures of IIT and net trade (NT) in terms of the model's framework, and section IV presents our key comparative static results. A final section concludes.

I. Adjustment Costs under Inter-Industry *versus* Intra-Industry Trade

Analysis of IIT has developed in close relationship with both the analysis of trade liberalization and the analysis of adjustment to international trade. In their now classic analyses of the trade effects of early European efforts at economic integration, Verdoorn (1960), Drèze (1960, 1961), and Balassa (1966), all emphasized the empirical importance of IIT. Balassa's work, in particular, laid the foundation for what has become an enormous empirical literature on the measurement of IIT.[3] It was also Balassa (1966) who suggested that adjustment to IIT might be expected to involve lower costs than inter-industry trade:

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[3]Grubel and Lloyd (1975) is an essential landmark. See Greenaway and Milner (1986) for an extremely useful survey of the state of the art on all aspects of research on IIT. Greenaway and Torstensson (1997) provides an update.

> It would appear that the difficulties of adjustment to freer trade have been generally overestimated. It is apparent that the increased exchange of consumer goods is compatible with unchanged production in every country while changes in product composition can be accomplished relatively easily in the case of machine building, precision instruments and various intermediate products. These considerations may explain why the fears expressed in various member countries about the demise of particular industries have not been realized. (pg. 472)

This theme, which has figured prominently in the literature on IIT, is also central to this paper. Thus, we first review the literature on IIT and industrial adjustment, which proceeds under the assumption that intra-industry adjustment is less costly than interindustrial adjustment, and then we review some recent research in labour economics that provides evidence of this assumption.

We need to consider two key causal connections: the link between liberalization and IIT; and the relative adjustment costs of intra- *versus* inter-industry trade.[4] Following early studies that appeared to show that IIT grew rapidly relative to total intra-EEC trade and relative to IIT outside the EEC, the question of whether there was an association between liberalization, and especially preferential liberalization, and growth in IIT was addressed in a large proportion of the research on IIT.[5] There seems to be fairly widespread acceptance of the existence of such an empirical relationship, even though empirical research has provided only mixed support.[6] The difficulty with this result is that there is no particular reason for

[4]Our review of this early literature will be brief. For more detail with a particular focus on the adjustment implications of IIT in the EC context, see: White (1984); Greenaway and Milner (1986, chapter 11); Greenaway and Tharakan (1986); Greenaway (1987); and Greenaway and Hine (1991).

[5]In addition to the papers by Verdoorn, Drèze, and Balassa that we have already mentioned, important early papers by Kojima (1964) and Grubel (1967) also showed an apparently strong connnection between liberalization and IIT. Similar results are recorded by Menon (1994) for the case of the Australia-New Zealand Closer Economic Relations Pact (CER).

[6]Key papers supporting the presence of a link between IIT and preferential liberalization are: Loertscher and Wolter (1980); Havrylyshyn and Civan (1983); Balassa and

there to be such a relationship based on economic fundamentals. Even in a world characterized by IIT, there is no particular reason for general liberalization, whether preferential or multilateral, to generate more IIT than would be present in the general evolution of trading patterns.[7]

The peculiarity of the apparent connection between liberalization and IIT has led a number of investigators to conjecture that the causation actually runs from IIT (or, rather, potential for IIT) to liberalization. The argument proceeds from the claim, already present in the quotation above from Balassa (1966), that adjustment to IIT is less costly than adjustment to inter-industry trade, to the claim that countries negotiating liberalization will be predisposed to agree to liberalize sectors characterized by significant IIT, via a straightforward political economy argument. This suggestion was first studied in detail by Hufbauer and Chilas (1974), in the context of an analysis of trade among industrial countries, arguing:[8]

Bauwens (1987); and Globerman and Dean (1990). Pagoulatos and Sorenson (1975) and Caves (1981) consider measures of tariff level and tariff similarity between countries to test the hypothesis that multilateral liberalization induced IIT–i.e. tariff levels should be negatively associated and tariff similarity positively associated with IIT. Pagoulatos and Sorenson interpret their findings as supportive of this relationship. Caves, for whom levels had the wrong sign, found the relationship unconvincing on *a priori* grounds and took his results as insufficiently strong to change his priors. More recent research on protection levels or openness measures continues to generate mixed results, with Balassa and Bauwens (1987, 1988), Lee (1989), Clark (1993), and Stone and Lee (1995) providing support for some relationship, but Toh (1982) agreeing with Caves, and Torstensson (1996) arguing that protection variables are not robust in sensitivity analyses.

[7]This is particularly true given that the relationship between liberalization and IIT seems to be present in both south-south (Balassa, 1979; Havrylyshyn and Civan, 1983, 1985) and north-south (Tharakan, 1984, 1986) trade. As Havrylyshyn and Civan (1983) make clear, while the trade of LDCs contains significant IIT, it is important to note that the volume of intra-industry trade declines as GNP per capita declines for any country, and also declines with the difference in GNP per capita between trading partners.

[8]One might note that this is also the basis of the common claim that free trade areas/customs unions are easier to create among countries between which IIT might be expected to be intense–i.e. relatively developed countries with similar factor endowments. Thus, whether preferential or multilateral, the liberalization process has been most successful

> GATT negotiations very much favor intra-industry over inter-industry specialization. ... It is easier to secure one industry's consent for lower trade barriers if that *same* industry stands to gain from reciprocal concessions. ... Thus, GATT concessions typically foster intra-industry specialization. (pg. 6)

The authors then compare inter-industry specialization within the European Community to that between states in the United States, finding substantially higher inter-industry specialization within the US. That is, in an environment where local (i.e. national in the EC context) governments are able to resist market reallocation, we observe the same pattern of IIT dominated trade that we observe under GATT liberalization.

The suggestion that political economy forces help account for the prominence of IIT is widely cited and has received additional systematic study in the U.S. case by Finger and DeRosa (1979), Marvel and Ray (1987), and Ray (1991). Finger and DeRosa estimate a cross-industry regression of nominal or effective (post-Kennedy round) tariff rates on capital, labor, and human capital inputs as well as measures of intra-industry trade, finding a highly significant positive effect of labor use, and highly significant negative effects of human capital use and IIT for the case of nominal tariffs. That is, independently of the commonly noted tendency of industrial countries to protect labor, and controlling for factors generating export success, Finger and DeRosa find evidence of an independent effect of IIT on protection. Marvel and Ray (1987) regress measures of nominal or effective tariffs on instruments for import share, export share, and an interaction of the two, finding support for the claim that "as imports rise, additional exports limit significantly the protectionist impulse that the imports

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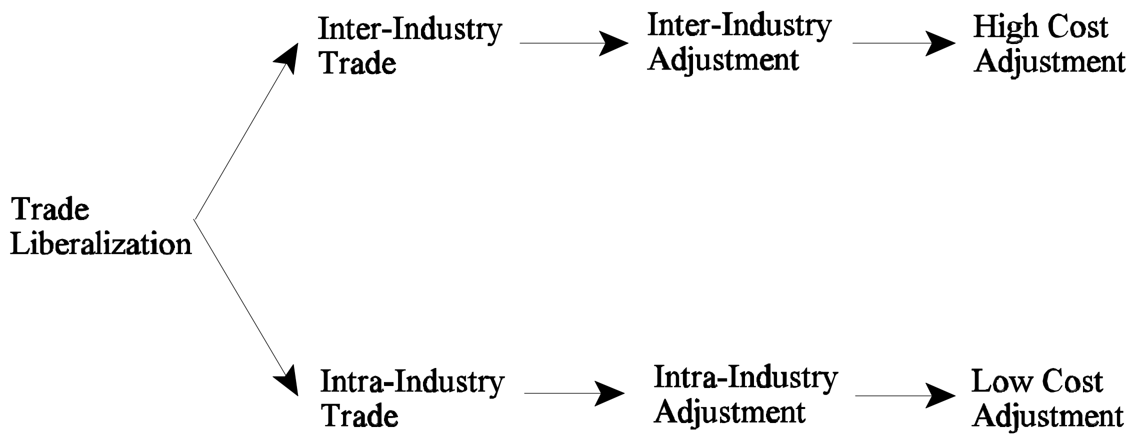
when it begins with partners and goods that are expected to involve relatively low adjustment costs and builds on that base. This would seem to be the model of the EU, NAFTA (which began not just with the US and Canada, but with autos), and the GATT/WTO. Difficulties developed in all three cases in extending the logic of liberalisation to both new products and new members. Thus, it is probably not surprising that such expansions have led to a boom in research on adjustment.

engender" (pg. 1288).[9] Lundberg and Hansson (1986) examine the relationship between protection and IIT for the case of Sweden finding only a weak and insignificant correlation (1959) or a positive and significant correlation (1972). However, when Lundberg and Hansson consider changes, they find a strong positive correlation between the initial level of IIT in 1959 and the reduction in tariffs from 1959 to 1972.[10] They take this as evidence in favor of the claim that adjustment costs are lower for IIT than inter-industry adjustment.

–Doug needs to write more here on sector and factor market adjustment–



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[9]Nelson (1990) and Ray (1991) provide discussions of the implications of this intersectoral pattern of protection on the prospects for LDC exports.

[10]This can be compared with Finger and DeRosa who find no cross-sectional relationship between their factor-input and IIT measures and changes. In the Finger-DeRosa case, because they were looking at effects generated by the Kennedy Round, which, as Jan Tumlir points out in a comment on the paper, was the first round to use a linear cut, this was to be expected. Similarly, since Lundberg and Hansson examine only correlation and not a regression, their cross-section results on levels of protection are not strictly comparable with those of Finger and DeRosa.

Research on adjustment to trade has taken two quite distinct approaches: the Stolper-Samuelson approach, reflected in the upper arm of the above diagram; and the Krugman-Ethier approach reflected in the lower arm. As we have seen, evidence of substantial IIT has led many, following Balassa, to suggest that liberalization is actually less costly than we might expect if trade were predominantly endowment-based. The research that we have reviewed to this point attempts to provide empirical support for the empirical significance of the Krugman-Ethier arm.[11] An interesting body of recent research, however, has questioned whether evidence of increases in IIT, as measured in conventional ways, provides a sufficient basis for accurate inferences about adjustment. This research accepts, as do we, the causal connection, based on findings by labour economists that intra-industry adjustment is associated with lower adjustment cost than inter-industry adjustment, but suggests alternative measures of the trade forces inducing the adjustment.

Virtually all of the work we have considered to this point measures IIT by the Grubel-Lloyd index, or one of its variants.[12] 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:[13]

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[11]This reconstruction is temporally inaccurate: the empirical fact of IIT and the suggestion that it would be associated with low adjustment costs preceded the development of fully worked-out theoretical frameworks embodying these relations by Krugman, Ethier, and others.

[12]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).

[13]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 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].

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

G_j gives IIT as a share of total trade in commodity j and, thus, takes values between 0 (all trade is IIT) and 1 (no IIT). These indices can be studied directly or aggregated to study broad sectoral or economy-wide trends in IIT. To do the latter, it is common to use an average of the form:

$$G_J := \sum_{j \in J} w_j G_j,$$

where J is a subset of industries (often manufacturing), at some level of aggregation (commonly 3-digit SITC), and where the w_j are aggregation weights such that $\sum_{j \in J} w_j = 1.$ The research we reviewed above, 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 cost adjustment. That is, for the case of IIT in sector j, this research considers:

$$\Delta G_j := G_{j,t+1} - G_{j,t}. \quad \textbf{(2)}$$

Starting with a paper by Hamilton and Kniest (1991), however, it has been argued that equation (3) cannot provide accurate information on adjustment pressure.[14] Hamilton and Kniest argue, following Caves (1981, pg. 213), that what is relevant is not whether the amount of IIT has increased, but whether the share of IIT in *new* trade has increased. That is, if one is interested in the effect of changed trading conditions on adjustment, it is necessary to identify

[14]See Azhar, Elliott, and Milner (1998) for a very useful geometric comparison of the empirical properties of the various marginal IIT indices, and Brülhart (1998a) for a detailed review of measures and empirical results, with particular reference to adjustment issues.

the contributions of change in IIT and change in net trade (NT) to change in total trade. Thus, they propose a measure of *marginal* IIT (MIIT). Following a critical evaluation by Greenaway, Hine, Milner, and Elliott (1994) which identified some serious shortcomings in Hamilton and Kniest's indices, the great bulk of empirical research on IIT and adjustment has focused on two, closely related, sets of measures of MIIT–one set due to Jayant Menon and Peter Dixon, the other due to Marius Brülhart. Because Menon is fundamentally concerned with measurement of MIIT and its contribution at the margin to change in total trade, where Brülhart is ultimately interested in issues of adjustment, we will start with Menon's analysis and then take up Brülhart's.

In a very useful series of papers, Menon and Dixon develop the theory of MIIT measurement in considerable detail.[15] Menon and Dixon's basic measure of the contribution of the change in IIT to the percent change in total trade is:

$$C_j := \frac{\Delta IIT_j}{TT_j} = I\hat{I}T_j \, G_j , \tag{3}$$

where the hat denotes a proportional change and G_j is the Grubel-Lloyd index for commodity j. 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 (1996a, pp. 7-8) show analytically, it is possible for $\Delta G_j > 0$ to be associated with a smaller C_j than the marginal increase in net trade. Perhaps more importantly, they develop extensive empirical evidence of precisely such an implication. Dixon and Menon (1997) uses

[15]Dixon and Menon (1997) lays out the basic theory, Menon and Dixon (1996a) develops the application to regional trade arrangements, and Menon and Dixon (1996b) develops a framework within which the contributions of exports and imports of a commodity are separately considered.

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. Specifically, 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 increases in G_j but larger contributions of marginal net trade than marginal IIT. In Menon and Dixon (1996a) and Menon (1996) this methodology is applied to the issue of IIT in preferential trade arrangements. The first of these is a study of the effects of the Australia-New Zealand Closer Economic Relations Trading Agreement (ANZCERTA) on IIT between the countries and with the rest of the world.

Dixon and Menon (1997) point out that C_j may itself lead to faulty inference if the goal of the analysis is to identify that share of trade growth characterized by low adjustment costs. As an alternative, they propose:

$$D_j := \frac{2\min\left[\Delta X_j, \Delta M_j\right]}{TT}. \quad \textbf{(4)}$$

Since $2\min\left[\Delta X_j, \Delta M_j\right] \neq \Delta IIT,$ it is clear that the indices in (4) and (5) are distinct.[16] D_j is a measure of the part of trade change accounted for by matched changes in imports and exports, which is precisely a measure of the share of trade change that creates low adjustment costs. Specifically, Dixon and Menon (1997, at equations 17-20) show that C_j will overestimate the contribution of MIIT to the non-disruptive part of change in trade (i.e. $C_j \geq$

[16]It is straightforward to show that $\Delta IIT = \Delta X_j + \Delta M_j - |X_j - M_j| + |X_j + \Delta X_j - M_j - \Delta M_j|$ and that $2\min[\Delta X_j, \Delta M_j] = \Delta X_j + \Delta M_j - |\Delta X_j - \Delta M_j|$.

D_j).[17] As they argue, since D_j is a direct measure of matched changes in imports and exports, relative to total trade, it is precisely a measure of the non-disruptive trade. With reference to the same Australian data used to evaluate the inferential implications of ΔG_j relative to C_j, Dixon and Menon find that the strict inequality applies in 21% and 34% of the 133 industries. Perhaps more damaging from this perspective, in many of the cases, the signs are even different, with D_j taking negative signs.

Brülhart is particularly interested in generating a measure with properties like those of the Grubel-Lloyd index. Specifically, Brülhart proposes an index of MIIT:

$$A_j := 1 - \frac{\left|\Delta X_j - \Delta M_j\right|}{\left|\Delta X_j\right| + \left|\Delta M_j\right|}. \qquad \textbf{(5)}$$

Like G_j, A_j takes values in [0,1], with a value of 0 denoting that the entire change in trade is inter-industry in nature, while a value of 1 denotes the entire change is intra-industry in nature. Also, like G_j, A_j can be aggregated to give a measure of broad sectoral or economywide MIIT.[18] On the other hand, A_j seems to lack a clear derivation of the sort Dixon and Menon give for D_j.[19]

Finally, it is worth noting, with Menon and Dixon (1997), that if we are really

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[17]Specifically, $C_j > D_j$ if $\text{sgn}[X_j - M_j] \neq \text{sgn}[\Delta X_j - \Delta M_j]$.

[18]We note, however, that Oliveras and Terra (1997) show that Brülhart's *A* index does not fully share the aggregation properties of B_j. They argue that where B_j can be consistently aggregated across time, and has systematic (and thus known) aggregation bias across sectors, A_j does not have these properties. Rather, A_j is sensitive to both the temporal and sectoral levels of aggregation, but not in generally predictable directions.

[19]The problem is that, since $\left|\Delta X_j\right| + \left|\Delta M_j\right| \geq \Delta X_j + \Delta M_j$, with strict inequality if ΔX_j or ΔM_j or both are negative, the A_j index does not follow from an obvious operation on the identity $\Delta TT_j = \Delta IIT + \Delta NT$ or $\Delta TT = 2\min[\Delta X_j, \Delta M_j] + |\Delta X_j - \Delta M_j|$.

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:

$$F_j = \frac{\Delta NT_j}{TT_j} = N\hat{T}_j \left(1 - G_j\right). \tag{6}$$

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:

$$T\hat{T}_j = C_j + F_j = I\hat{I}T_j G_j + N\hat{T}_j \left(1 - G_j\right). \tag{7}$$

The second equality follows from the definition of the Grubel-Lloyd index, $B := \frac{IIT}{TT}$, and simple manipulation.

However, just as Dixon and Menon prefer their D index as a measure of low adjustment cost trade, they propose a measure of unmatched change in international trade:

$$UMCIT_j := \left|\Delta X_j - \Delta M_j\right|. \tag{8}$$

If we again normalize by TT, we have an index directly parallel to D_j. If we denote this index U_j,

$$U_j := \frac{\left|\Delta X_j - \Delta M_j\right|}{TT_j}, \tag{9}$$

then, we find that the relationships between U_j, D_j, and TT_j are given by:[20]

$$\hat{TT}_j = D_j + U_j. \tag{10}$$

The literature we have just reviewed makes it quite clear that MIIT is empirically significant, and carries strong implications for inference on the link between trade and adjustment. However, Brülhart, Murphy and Strobl (1998) note that, while the Grubel-Lloyd index has been systematically incorporated in theoretical frameworks which generate IIT, there has been no similar development with respect to MIIT.[21] Given the importance of MIIT measures for inference on the link between trade and adjustment, Brülhart *et al*. argue that this is a serious shortcoming in the theoretical literature. We now turn to a first attempt to fill this gap.

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

Our analysis, because we are interested in adjustment, requires a model with at least two sectors; and, because we are interested in the effects of intra- versus inter-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)

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[20]The indices in equations (4) and (9) still have an interpretation in terms of proportional change in total trade. Since $2\min[\Delta X_j, \Delta M_j] = \Delta X_j + \Delta M_j - |\Delta X_j - \Delta M_j|$, if we let $|\Delta X_j - \Delta M_j|$ be our measure of change in NT, it is easy to see that $\Delta TT = 2\min[\Delta X_j, \Delta M_j] + |\Delta X_j - \Delta M_j|$. We can divide through by TT and manipulate to get $\hat{TT}$ as a weighted average like the one in equation (7), but since the first and second expressions on the RHS are not ΔIIT and ΔNT, we would need different labels.

[21]For derivation of the Grubel-Lloyd index in well-specified general equilibrium models, see Helpman (1981, at eqs. 42 and 43) and Helpman and Krugman (1985, Chapter 8) for the case of trade in differentiated final goods, or Ethier (1982, at eq. 24) for the case of trade in differentiated intermediate goods.

model of trade in differentiated intermediate goods.[22] That is, we will be working with a model with: two factors of production, labor (*L*) and capital (*K*); and two final consumption goods, wheat (*w*) and manufactures (*m*). Wheat is taken to be produced from *K* and *L* 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 and tastes, and may differ in endowments of *K* and *L*.[23] Finally, because we are interested in smooth adjustment, we will focus only on international equilibria in which both countries produce both wheat and manufactures.[24]

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 under large-group monopolistic competition. Following the development in Ethier (1982), we suppose that in the relevant equilibrium there are *n* home firms and *N* foreign firms producing intermediates under a common technology such that to produce x_j units of intermediate variety *j*, a firm must purchase $b_j = ax_j + A$

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

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

[24]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.

bundles of K and L. The 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. If we let $b = \sum b_j$, and $x_j = x \; \forall \; j \in n$, and similarly for foreign producers of intermediates, then

$$b = n[ax + A]; \quad B = N[aX + A]. \tag{11}$$

As a result of decreasing costs, no two firms will produce the same type of component. 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:

$$x = x_h + x_f; \quad X = X_h + X_f. \tag{12}$$

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

$$w = s(b); \quad W = S(B). \tag{13}$$

For this purpose, we assume that bundles used in the production of components are produced according to a standard neoclassical production function, $m = g(K_m, L_m)$, 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 (i.e. in m), and taking wheat as the numeraire, the relative cost 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 just $q_j x_j$, so the condition that marginal revenue equals marginal cost can be rearranged to get an expression for q_j:

$$q = \frac{-s'(b)\,a}{\beta}; \quad Q = \frac{-S'(B)\,a}{\beta}. \tag{14}$$

In deriving (13) we substitute $\frac{d\,x_j}{d\,q_j} = \frac{1}{1-\beta}\frac{x_j}{q_j}$, which can be derived from the demand curve for component j (See Ethier, 1982, equation (4)). 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 p_j from equation (4), we get:

$$x = \frac{A\beta}{a(1-\beta)}; \quad X = \frac{A\beta}{a(1-\beta)}. \tag{15}$$

Since this is made up entirely of parameters that are constant across component producing firms, equation (14) underwrites our treatment of x as identical across firms.[25] Note also that

[25]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.

these parameters are globally common, so all intermediate firms, regardless of location, produce the same quantity of the intermediate good.

To this point, with the exception of equations (11), nothing in the development has reflected the presence of international trade in intermediate goods. Under the CES function that aggregates intermediates into final manufactures, since all home goods enter the aggregator symmetrically and all foreign goods enter symmetrically, we follow Ethier and others in representing production of manufactures (via costless assembly of intermediate goods) as:

$$m = \left[nx_h^{\beta} + NX_h^{\beta}\right]^{1/\beta}; \quad M = \left[nx_f^{\beta} + NX_f^{\beta}\right]^{1/\beta}. \qquad \textbf{(16)}$$

Here n types of domestic, and N types of foreign, components are costlessly assembled into final manufactures and β is an indicator of the degree of substitutability between varieties of inputs (x_i).[26] Note that in our formulation of this model we take all manufactures to be produced for final consumption in the country where they are consumed–i.e. there is no trade in final manufactures.[27]

It is important to note that, as shown in equation (15), while a representative home

[26]It is straightforward to show that for $0 < \beta < 1$ (as we assume it to be) there are increasing returns to the variety of inputs, i.e.: $\frac{\partial m}{\partial n} = \frac{1}{\beta} n^{\frac{1-\beta}{\beta}} x > 1.$ Since, as we shall see, x is constant in equilibrium, it is easy to see that the production of M is homogeneous of degree $\frac{1}{\beta} > 1.$

[27]We could simply assume that the technology of final manufactures is such that final assembly always takes place in the contry of consumption or, alternatively, we could follow Markusen's (1990) analysis of derationalizing tariffs and assume that the same tariff rate (i.e. t or T) applies to both intermediates and final goods.

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:

$$\frac{x_h}{X_h} = \left[\frac{Q(1+t)n}{qN}\right]^{1/b}; \quad \frac{X_f}{x_f} = \left[\frac{q(1+T)M}{Qn}\right]^{1/b}. \qquad \textbf{(17)}$$

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

$$pm = qnx_h + Q(1+t)NX_h; \quad PM = QNX_h + q(1+T)nx_f. \qquad \textbf{(18)}$$

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

$$pm = g\left(w + qnx + QtNX_h\right); \quad PM = g\left(W + QNX + qTnx_f\right). \qquad \textbf{(19)}$$

Equations (11) through (19) describe the two-country economy we seek to analyze.

III. Marginal Trade Measures in a Two-Country Ethier Model

Following the development in section I, in this section we derive expressions for various measures of MIIT in the context of the model developed in section II. Suppose the home country is a net exporter of components. Then we can write exports of components, XC_h, and imports of components, MC_h, as

$$XC_h = nx_f, \quad MC_h = NX_h, \text{ and } nx_f \geq NX_h. \qquad \textbf{(20)}$$

In the context of the division-of-labor model, and recalling our that the home country is a net exporter of intermediates, IIT is:

$$IIT = 2\min\left[nx_f, NX_h\right] = 2\,NX_h. \tag{21}$$

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

$$G = \frac{2\,NX_h}{nx_f + NX_h}. \tag{22}$$

The marginal change in the Grubel-Lloyd index is

$$\hat{G} = \frac{nx_f}{nx_f + NX_h}\left[\hat{N} + \hat{X}_h - \hat{n} - \hat{x}_f\right]. \tag{23}$$

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 of 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 -- the home share of total components production.

Marginal trade measures present quite different calculations. Dixon and Menon's (1997) *C* index is

$$C = \frac{2\,NX_h}{nx_f + NX_h}\left[\hat{N} + \hat{X}_h\right]. \tag{24}$$

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 the foreign share of total component production. If foreign production of components is small, changes in foreign exports of components lead to a small measured change in intraindustry change.

As we are concerned with adjustment, we may want to measure the change in net trade directly. Defining net trade as

$$NT = nx_f - NX_h. \tag{25}$$

Dixon and Menon's first measure of marginal net trade is

$$F = \frac{nx_f}{nx_f + NX_h}\left[\hat{n} + \hat{x}_f\right] - \frac{NX_h}{nx_f + NX_h}\left[\hat{N} + \hat{X}_h\right]. \tag{26}$$

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 various MIIT indices: these are measures of economically different things.

IV. IIT, MIIT, and Adjustment

In this section we turn to the relationship between liberalization and, ultimately, adjustment. However, following our development of the literature on IIT and adjustment, we begin with the relationship between liberalization and MIIT. In particular, we begin with the identical countries case.

Thus we find that, in a general equilibrium model of the Ethier sort, even when there is only IIT before and after a liberalization, so that all measures agree that there is only IIT, it turns out that there will be adjustment of the usual sort. Specifically, both countries will experience an increase in output of intermediates. Since this implies movement along the transformation function between wheat and factor-bundles, this implies inter-sectoral adjustment and changes in factor-returns. Note two interesting facts about this adjustment: 1) as in the HOS case, even with pure IIT (i.e. no trade in wheat), increased IIT induces intersectoral adjustment; but 2) unlike the HOS case, both countries experience the same adjustment (with SS effects moving in the same direction, rather than inverse directions).

V. Some Implications for Research on Trade and Labour Markets

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