No 232 March 1985

A METHODOLOGY FOR
ANALYZING TRANSFER AND TARIFF POLICIES

Kathleen Segerson*

Abstract: This paper presents a general equilibrium modelling approach for analyzing the effects of transfer or tariff policies that allows for endogenous price and income determination yet can be used empirically with short run data that reflect trade surpluses or deficits. The model incorporates the Almost Ideal Demand System into an Armington-type trade model to describe both aggregate group and within group (product) demands. The policy variables that are included allow the general equilibrium effects of both the levels of and the means of financing or spending the revenue associated with different tariff or transfer policies to be examined empirically.

* Assistant Professor, Univeristy of Wisconsin-Madison

A GENERAL EQUILIBRIUM METHODOLOGY FOR ANALYZING TRANSFER AND TARIFF POLICIES

I. Introduction

Transfers and tax or tariff[1] policies are often suggested as possible policy options for solving national or international problems. For example, the domestic agricultural price and income support programs can be viewed as interregional transfers designed to improve the well-being of the agricultural sector. The recent proposal[2] to tax electricity production from fossil fuels and use the revenue generated by the tax to finance retrofit pollution control equipment for electric power plants provides another example. In addition to being a tax policy, to the extent that the tax would be paid by consumers in a region damaged by the emissions (e.g. the Northeast) and used to finance pollution abatement in a different region (e.g. the Midwest) it also represents a monetary transfer from the polluted region to the polluting region to pay for a reduction in emission levels. In an international context, the suggestion (Reeb) that Canada should consider selling hydroelectric power to the U.S. at reduced rates in exchange for a guaranteed reduction in U.S. sulfur dioxide emissions to alleviate acid rain problems is tantamount to suggesting an export subsidy with an associated transfer from Canada to the U.S.

In general, the effects of transfers and tariffs will depend upon the economic interdependence of the country or region instituting the policy and its trading partners. These effects have received considerable attention in the theoretical literature on international trade (e.g., Bhagwati, Brecher and Hatta; Caves and Jones; Kemp). Although this work is useful in indicating what the effects of these policies would be if the economy were in long-run equilibrium at full employment, the balance of trade restriction included in most of these models limits their empirical usefulness since the data that would be used in the analysis do not satisfy this restriction. On the other hand, for practical reasons empirical trade models are typically constructed from the perspective of a single country (or region) and do not allow for full endogeneity of all prices and income levels. Thus, the full extent of the interactions between that country or region and its trading partners is not captured.

The purpose of this paper is to present an approach to modelling economic interdependence that is both general equilibrium in nature and potentially useful for empirical work. It allows the effects of transfer and tariff[3] or differential tax policies to be investigated empirically in a general equilibrium framework with endogenous prices and income levels. Although the model is discussed in the context of international trade, it is equally applicable to analyzing interstate or inter-regional trade.

The paper is organized as follows. The next section summarizes the effects of transfers and tariffs in two theoretical trade models, a long run, full-employment neoclassical model and a shorter run Keynesian model. The results discussed there highlight the need for using a multi-country, multi-commodity general equilibrium model in empirical analyses. Section III provides an overview of a suggested empirical modelling approach. The fourth section gives a detailed model specification. A final section includes some concluding remarks regarding possible application of the model.

II. The Theoretical Models

1. The Neoclassical Model

Consider a two-country world in which there are two goods that are produced, traded and consumed at the price ratio $p=p_2/p_1$ (where p_i is the price of good i)[4]. In the absence of transfers and tariffs, long run equilibrium for the "home" (eventual transfer-paying or tariff-imposing) country requires that

$$X_1 + pX_2 = D_1 + pD_2, \tag{1}$$

where X_i is the quantity of good i produced by the home country and D_i is its compensated demand for good i. Equation (1) implies that the value of output must equal the value of consumption, or, equivalently, that the value of imports must equal the value of exports. Thus, trade surpluses or deficits are not allowed. In addition, all resources are required to be fully utilized, i.e. the economy is assumed to be always producing on its production possibility frontier (PPF).

If the home country transfers to the other country an amount equal to T (measured in terms of the first good), then the condition for long-run equilibrium becomes

$$X_1 + pX_2 - T = D_1 + pD_2 \tag{2}$$

If we let $W = U(D_1, D_2)$ measure aggregate welfare in the home country, then totally differentiating (2), recognizing that in equilibrium[5] $U_2/U_1 = p$ and $dX_1 + pdX_2 = 0$ (by utility and profit maximization along the PPF), implies that

$$(dW/U_1)/dT = -1 - M(dp/dT) \tag{3}$$

where $M = D_2 - X_2 > 0$ is the quantity of the home country's imports (assuming good 2 is the imported good).

If we call $dW/U_1 = dD_1 + pdD_2$ the change in "real income", dy, (Caves and Jones), then (3) says that the total effect of the transfer on the real income of the home country will be the sum of two effects: (1) a direct "revenue" effect due to the loss of income through the transfer, and (2) an indirect "price" effect, due to the fact that the transfer might change world demand patterns sufficiently to induce a change in relative prices that would affect the income of the transferring country. The fact that the transfer can change equilibrium prices, which in turn creates a welfare effect, highlights the need to use a model with endogenous prices when analyzing the impact of a transfer empirically.

Although the indirect price effect can be either positive or negative, in the two country model where price effects are stable the net effect will always be non-positive, i.e. $dy/dT \leq 0$ (e.g., Brecher and Bhagwati). However, this result does not necessarily hold when more than two countries exist, i.e. when it cannot be assumed that the rest of the world has homogeneous tastes and therefore can be aggregated into a single "other country." Yano has shown that any pattern of gains and losses (with the exception of all countries gaining or all countries losing) can result from the transfer, depending on the distribution of the transfer among the non-paying countries, the elasticities of substitution in production and consumption, and each country's marginal propensity to consume the good imported by the transferring country[6]. Thus, the results obtained from the two-country model do not necessarily provide an accurate indication of the pattern of real income gains and losses for any particular transfer scheme; a multi-country model with at least three countries is needed.

Consider next the imposition of an ad valorem tariff at rate t on imports of good 2 into the home country. Let p represent the domestic (tariff-inclusive) price ratio and let $p^* = p/(1+t)$ be the world price ratio. Long-run equilibrium now requires that

$$X_1 + p^* X_2 = D_1 + p^* D_2. \tag{4}$$

The change in the home country's real income that results from a marginal change in the tariff rate is then given by

$$dy/dt = tp^*(dM/dt) - M(dp^*/dt) \tag{5}$$

Again, the total effect of the policy is the sum of two effects, a revenue effect and a price effect, and the existence of the price effect again highlights the need for use of a price-endogenous empirical model.

In general, the signs of both dM/dt and dp^*/dt are expected to be negative, so that the revenue and price effects are offsetting and the sign of the net effect is indeterminate. Although certain conditions can be identified under which this sign is unambiguous[7], in general both the direction and magnitude of the long-run change in real income must be determined empirically. They will depend upon the import demand elasticities and the marginal propensities to consume imports in the home country and in each country related to the home country through trade.

2. A Keynesian Model

Although the above results from the neoclassical model are well-known, relatively little attention has been given to a theoretical analysis of transfers and tariffs in an economy with under-utilized resources and a trade surplus or deficit. Vanek has extended the standard Keynesian income equation to include transfers and tariffs, but the analysis ignores the effects of the relative price changes that could result from these policies. An extension that allows for relative price changes is presented here.

In a Keynesian model in which savings can occur, (1) is replaced by

$$p_1X_1 + p_2X_2 = p_1D_1 + p_2D_2 + S \tag{6}$$

where S is the value of savings in the home country[8]. Note that the absolute price levels enter this equation instead of simply the relative price as in the neoclassical model. This formulation implicitly assumes that some price (e.g. the wage rate) is inflexible in the short run so that some resource is underutilized, i.e. the economy is not on its PPF. Equation (6) implies that

$$p_1(X_1 - D_1) = p_2(D_2 - X_2) + S,$$

i.e. the value of exports must equal the value of imports plus savings. Thus, a balance of trade is not required.

Consider now a transfer (T) from the home country to the rest of the world. Equation (6) becomes

$$p_1D_1 + p_2D_2 + S = p_1X_1 + p_2X_2 - T \tag{7}$$

Totally differentiating (7) and defining the change in real income, dy, to be $p_1dD_1 + p_2dD_2 + dS$[9] implies that

$$\frac{dy}{dT} = -1 + \quad E\frac{dp_1}{dT} - M\frac{dp_2}{dT} \quad + \quad p_1\frac{dX_1}{dT} + p_2\frac{dX_2}{dT} \tag{8}$$

where E is the quantity of exports from the home country. The first two terms in this equation are analogous to the two terms in (3). The first is the direct revenue effect that results from the initial decrease in income due to the transfer (before any Keynesian multiplier effects have occurred). The second term is the price effect that reflects the change in the value of trade (at the original level of exports and imports). The last term, which did not exist in the neoclassical model, can be called the output effect. Because resources are not necessarily fully utilized, the value of output can respond to the changes in demand that result from the transfer. These changes are due partly to substitution effects and partly to income effects. The income-induced component reflects the total multiplier effect of the transfer, i.e. the sum of the contractionary response to the decrease in the home country's own income (operating through the demand for domestically produced goods) and the expansionary response to the increase in income in the receiving country (operating through the export function).

Since $dX_i = (dX_i/dp_i)\, dp_i$, if prices do not change as a result of the transfer[10], then the price and output effects would be zero and real income would change only by the amount of the transfer. However, in general, under the short-run Keynesian formulation the direction of the transfer-induced change in real income cannot be determined qualitatively even in the two-region case.

A similar result holds when tariffs are introduced into the Keynesian model. In this case (6) must hold in terms of world prices (denoted by asterisks[11]), and the change in real income of the home country is given by

$$\begin{aligned} dy/dt = {} & p_2^* t \, dM/dt + [E dp_1^*/dt - M dp_2^*/dt] \\ & + [p_1^* \, dX_1/dt + p_2^*(1+t) \, dX_2/dt] \; . \end{aligned} \tag{9}$$

This equation is analogous to (5) for the neoclassical model, with the first two terms representing a revenue and a direct price effective respectively. Again, the third term represents an output effect that results from the expansion or contraction of the economy in response to the change in the tariff. Although circumstances exist in which the sign of (9) is unambiguous (e.g. when the home country is small and increases its tariff rate from zero to a marginally positive level), in general the direction of change in real income again cannot be determined qualitatively.

III. An Overview of the Suggested General Equilibrium Model

The results of the previous section indicate that in most cases, both the qualitative and the quantitative effects of transfer or tariff policies must be determined empirically, but that a general equilibrium trade model with endogenous prices and income levels should be used to capture fully the expected effects.

Rhomberg, in discussing the "ideal" trade model for linking national economies, considered two alternatives. Under the first alternative, trade within a particular commodity class is assumed to be trade of a homogeneous good. For example, manufactures produced in the U.S. are assumed to be identical to those produced in Canada, and both are assumed to be traded at the same price. If at that price a country demands more of the good than it supplies, it is an importer of the good. If its supply exceeds its demand, then it exports the good.

This approach does not, however, explain two empirical observations: (1) that, for many goods, country-specific variations in price movements do exist that cannot be explained solely by changes in transportation costs or trade barriers, and (2) that in many cases a country will be both an importer and an exporter of a particular good. These observations are instead consistent with a situation in which, for classification purposes, two goods are considered to be identical but in reality they are sufficiently qualitatively different (due, for example, either to physical characteristics, the composition of the commodity bundle, or the terms of sale) so as not to be considered by their users to be perfect substitutes. Thus, Rhomberg suggests that the ideal trade model should not assume that production in all countries results in homogeneous goods but should instead assume that the production of any good in one country is qualitatively different from that in another country. A potential limitation of this approach, however, is that it requires that the output of each good from each country be considered separately in that it has its own price and demand and supply functions. If the number of goods and/or countries is large, the number of price variables that theoretically enter each demand equation will be so large as to make the approach intractable for empirical work in the absence of some simplifying assumptions.

As suggested by Armington, this problem can be overcome by assuming that in any given market each country's production of a given good is a close but not a perfect substitute for another country's production of that good. Technically, the utility function is assumed to be weakly separable in goods, and the level of a good is defined as a composite or aggregate of the levels of the "products" that comprise that good, where each product is a good produced in a specified country (e.g. French manufactures or Canadian manufactures). This assumption implies that consumers in any given market have an overall demand for a good, which is then allocated across the potential supplies or products that comprise the good. Using this basic assumption and the further assumption that each country's market share in any given market depends only on relative prices and not on the size of the market (i.e. that the aggregation function is homogenous of degree one), Armington developed a model that is empirically tractable even in the presence of a large number of goods and countries. The first assumption (weak separability) allows the allocation of the demand for a good across products to be written solely as a function of the prices of the products that comprise that good, i.e. the allocation does not depend on the prices of other goods or their products. The second assumption (homogeneity) guarantees that "group price" indices exist and that a country's demand for a given good can be written solely as a function of those indices[12]. Thus, the Armington approach explains individual trade flows but maintains tractability by dividing the decision process into two stages, each of which depends on fewer price variables than the original problem.

The Armington model in which products are distinguished by their place of production forms the basis of the modelling approach suggested here for analyzing the effects of transfers and tariffs. To better suit that purpose, however, it is modified in two ways. First, the homogeneity assumption is replaced by a much less restrictive assumption regarding the form of the market share equations, namely that they can be characterized by the "Almost Ideal Demand System (AIDS)" of Deaton and Muellbauer (1980a, 1980b). Second, the model is expanded to capture general equilibrium effects through prices and income.

The first modification is included because the homogeneity assumption is considered to be too restrictive. As shown in Segerson, the advantages of using the homogeneity assumption can also be obtained using the far less restrictive AIDS model. Winters has suggested this approach as a means of generalizing the market share equations and allowing market size to affect those shares. He does not, however, consider its implications for reducing the number of price variables in the first stage of the decision-making process, namely the determination of a country's overall demand for a good, or for the consistent estimation of supply and input demand equations.

The second modification, expanding the model to include general equilibrium effects, is necessary to assess fully the implications of the tariff and transfer policies described in the previous section. A move toward a more general equilibrium specification of the Armington model has been made by Geraci and Prewo, who made import prices endogenous through the inclusion of supply equations. However, their specification assumes that first the demand for imports of a particular good (as opposed to the overall demand) is determined, and then this demand is allocated among foreign suppliers. (In other words, the utility function is assumed to be weakly separable in imported and domestic goods, and the aggregation function that captures the imperfect competition assumption covers only foreign supplies of the good.) This assumption was not suggested by the original Armington formulation and seems not to have any apparent justification (except perhaps adherence to a "buy American" principle)[13]. An alternative specification would assume that domestic suppliers are no different from foreign suppliers in the eyes of consumers, and that they therefore compete along with foreign suppliers for the overall demand for a good. (The aggregation function would then cover all sources, including domestic ones.) Although this specification introduces empirical complexities that do not exist under the Geraci and Prewo formulation, it appears to be more in the spirit of the Armington model and is therefore the approach adopted here. The result is that all prices, for both imported and domestic goods, are endogenous.

To complete the general equilibrium specification of the model, income is made endogenous through inclusion of a Keynesian income equation.

IV. A Model Specification

Figure 1 presents a flow diagram of the model for one country (X) for the case where there are three countries/regions (X, Y and Z) and one good (assumed to be a final good). The specification of the model in equation form is given below.

Let q_{ij}^{k} be the quantity of good k produced in country j and consumed in country i. Each q_{ij}^{k} represents consumption of a different "product". If j is not equal to i, the q_{ij}^{k} is the trade flow of good k from country j to country i. When j = i, then q_{ij}^{k}'s represent domestic consumption of domestically produced goods. Note that for non-traded goods, $q_{ij}^{k} = 0$ for all j not equal to i. The preferences of consumers in country i are represented by the utility function

$$\bar{U}_i(q_{i1}^{1},\ldots,q_{iM}^{1},q_{i1}^{2},\ldots,q_{iM}^{2},\ldots,q_{i1}^{n},\ldots,q_{iM}^{n}) \qquad (10)$$

where M is the total number of countries and n is the total number of final goods. The consumer maximizes (10) subject to the budget constraint

$$Y_i = \sum_{k=1}^{n} \sum_{j=1}^{M} p_{ij}^{k} q_{ij}^{k}$$

where p_{ij}^{k} is the price in country i of good k produced in country j and Y_i is income in country i. This utility maximization problem implicitly defines country j's demand for all final products.

The demands for intermediate products are derived demands, determined from a firm's profit maximization problem. Assume that the technology in country i reflecting the production of final products using intermediate products as inputs can be represented by a multiple-input multiple-output production function of the form:

$$\bar{F}_i(y_i^1,\ldots,y_i^n,q_{i1}^{n+1},\ldots,q_{iM}^{n+1},\ldots,q_{i1}^N,\ldots,q_{iM}^N,L_i^1,\ldots L_i^G) = 0$$

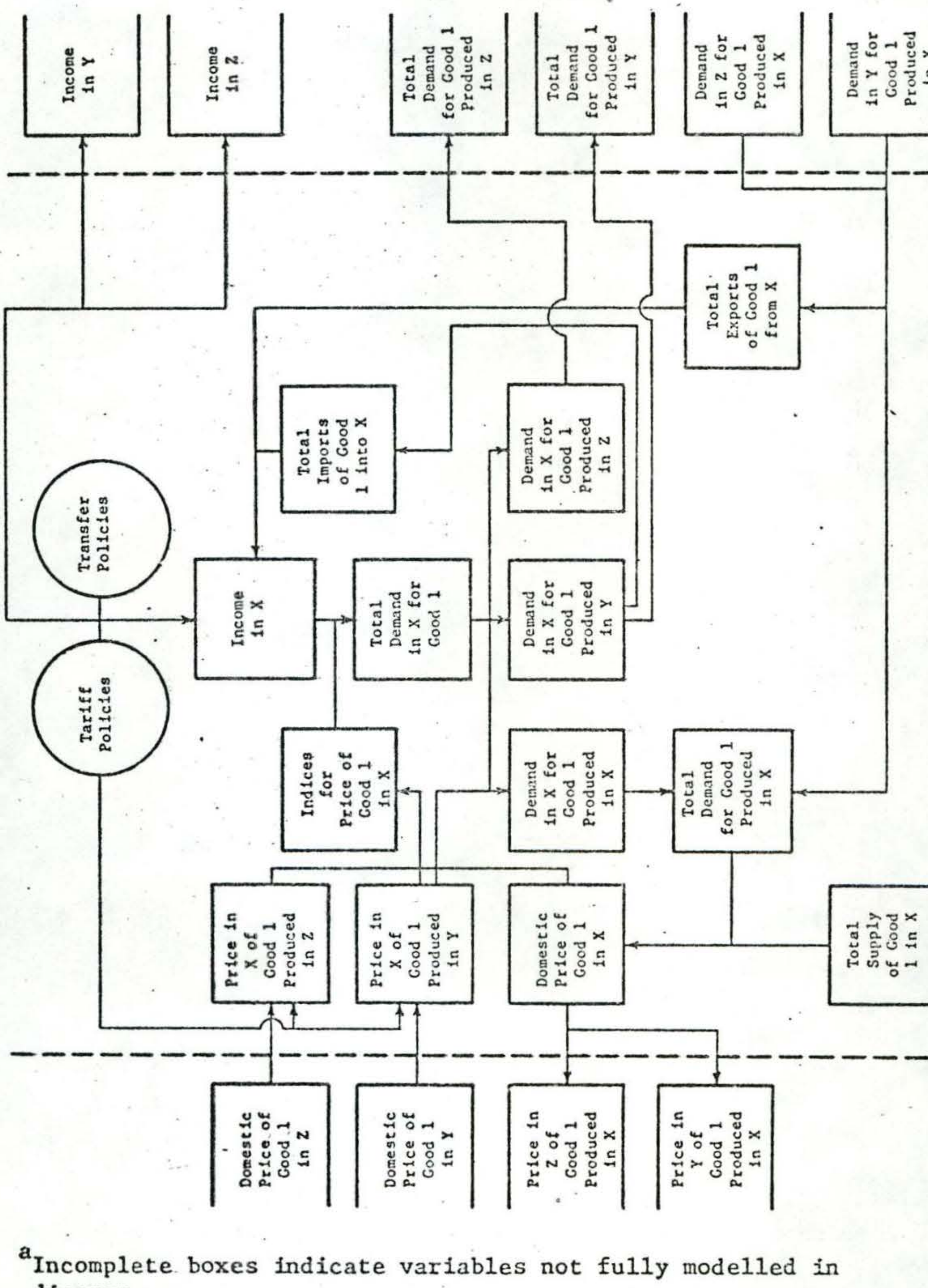
where y_i^k is the output of good k in country i, N is the total number of produced goods (N - n is the number of intermediate goods), L_i^g is the use of primary input g in country i and G is the total number of primary inputs. Thus, in its production of final products, the firm is assumed to use both domestically produced and imported intermediate products, as well as primary inputs (i.e. non-produced inputs, such as labor or land), which are assumed to be domestic. Given appropriate assumptions on $\bar{F}_i$, the domestic supply functions for final products and the derived demands for intermediate products are given by the solution to

$$\text{maximize:} \sum_{k=1}^{n} p_{ii}^k y_i^k - \sum_{k=n+1}^{N} \sum_{j=1}^{M} p_{ij}^k q_{ij}^k - \sum_{g=1}^{G} w_i^g L_i^g$$

subject to the given technology $\bar{F}_i(\ ) = 0$, where w_i^g is the price in country i of primary input g.[14]

Note that, for both the utility maximization problem determining the demand for final products and the profit maximization problem determining the demand for intermediate products, the number of price variables that enters the problem will be very large if the number of countries and/or goods is large. However, this number can be reduced, at least for purposes of determining market shares once total demand for a good has been determined, by imposing the assumption of weak separability on the utility and the production functions. Thus, we assume

FIGURE 1: FLOW DIAGRAM FOR ONE-GOOD MODEL[a]



[a]Incomplete boxes indicate variables not fully modelled in diagram..

that there exist functions U_i, F_i and q_i^k for all $i = 1,\ldots,M$ and $k = 1,\ldots,N$ such that

$$\bar{U}_i(q_{i1}^1,\ldots,q_{iM}^1,\ldots,q_{i1}^n,\ldots q_{iM}^n) = U_i(q_i^1,q_i^2,\ldots,q_i^n)$$

$$\bar{F}_i(y_i^1,\ldots,y_i^n,q_{i1}^{n+1},\ldots q_{iM}^{n+1},\ldots q_{i1}^N,\ldots q_{iM}^N,L_i^1,\ldots,L_i^G)$$

$$= F(y_i^1, \ldots ,y_i^n,q_i^{n+1}, \ldots ,q_i^N,L_i^1, \ldots ,L_i^G) \tag{11}$$

where $q_i^k = q_i^k(q_{i1}^k,\ldots,q_{iM}^k)$.

Under this assumption, minimizing the cost of "producing" q_i^k yields product demand equations of the form

$$q_{ij}^k = q_{ij}^k(x_i^k,p_{i1}^k, \ldots ,p_{iM}^k) \tag{12}$$

where x_i^k is total expenditure in country i on good k, i.e.

$$x_i^k = \sum_{j=1}^{M} p_{jj}^k\, q_{ij}^k$$

when the q_{ij}^k's are at their optimal levels.[15] Thus, market share demand equations in value terms are given by:

$$s_{ij}^k = (p_{jj}^k q_{ij}^k)/x_i^k = s_{ij}^k(x_i^k,p_{i1}^k,\ldots,p_{iM}^k). \tag{13}$$

Note that only within-group prices enter the right hand side.

To estimate group demands in a tractable and consistent manner, we assume, in accordance with the results of Segerson, that the aggregation functions in (11) yield group cost functions that can be represented by the AIDS model, i.e.

$$\log x_i^k(q_i^k,p_{i1}^k,\ldots,p_{iM}^k) = a_i^k(p_{i1}^k,\ldots,p_{iM}^k)+q_i^k b_i^k(p_{i1}^k,\ldots,p_{iM}^k), \tag{14}$$

where a_i^k and b_i^k are two indices that are functions of within group prices. Then optimal group expenditures on intermediate goods will satisfy

$$x_i^k = - \delta S_i^F/\delta a_i^k =$$

$$x_i^k(p_{ii}^1,\ldots,p_{ii}^n,\exp(a_1^{n+1}),b_i^{n+1},\ldots,\exp(a_i^N),b_i^N,w_i^1,\ldots,w_i^G) \tag{15}$$

for $k = n+1, \ldots, N$, where S_i^F is the pseudo-profit function for the production of final goods in country i defined by

$$S_i^F = \sum_{k=1}^{n} p_{ii}^k \, y_i^k - \sum_{k=n+1}^{N} \exp(a_i^k + q_i^k b_i^k) - \sum_{g=1}^{G} w_i^g \, L_i^g$$

when y_i^k, q_i^k and L_i^g are at their optimal levels, and exp() denotes the exponential function. (See Segerson, or Segerson and Mount, for a detailed discussion). Analogously, group expenditures on final goods will satisfy

$$x_i^k = x_i^k(Y_i, \exp(a_i^1), b_i^1, \ldots, \exp(a_i^n), b_i^n) \tag{16}$$

for $k = 1, \ldots, n$. Thus, (15) and (16) determine total demand in country i for good k (in value terms) as a function of the group indices a_i^k and b_i^k; (13) then allocates that demand across potential suppliers and thereby determines trade flows in value terms. These equations completely specify the demand side of the model.

If we assume that producers do not discriminate among buyers, i.e. that they sell to all buyers at the same price, then, for all traded goods, p_{ij}^k can be written as

$$p_{ij}^k = p_{jj}^k(1+t_{ij}^k)(1+c_{ij}^k) \tag{17}$$

where p_{jj}^k is the domestic price in country j of good k, t_{ij}^k is the ad valorem tariff in country i on imports of good k from country j (assuming tariffs are on prices inclusive of transportation costs), and c_{ij}^k is the cost of transporting one dollar's worth of good k from country j to country i. Both transportation costs and tariff levels are assumed to be exogenous.

The supply side of the model is given by a set of industry supply functions. For final goods, under the assumption of the AIDS model, these are given by[16]

$$y_j^k = \delta S_j^F / \delta p_{jj}^k \tag{18}$$

$$= y_j^k(p_{jj}^1, \ldots, p_{jj}^n, \exp(a_j^{n+1}), b_j^{n+1}, \ldots, \exp(a_j^N), b_j^N, w_j^1, \ldots, w_j^G)$$

for $k = 1, \ldots, n$. A similar equation is assumed to exist for each intermediate good, i.e.

$$y_j^k = \delta S_j^I / \delta p_{jj}^k = y_j^k(p_{jj}^{n+1}, \ldots, p_{jj}^N, w_j^1, \ldots, w_j^G) \tag{19}$$

for $k = n+1, \ldots, N$ where S_j^I is the psuedo-profit function for production of intermediate goods in country j. Note that no group indices enter the right hand side of (19), since only primary inputs are assumed to be used in this production process, and these are assumed to be non-traded.

Given the demand and the supply equations, producer prices are determined by an assumption that all markets must clear, i.e.

$$\sum_{i=1}^{M} x_{ij}^k = p_{jj}^k \, y_j^k \quad \text{for } k=1,\ldots,N \text{ and } j=1,\ldots,M, \tag{20}$$

where $x_{ij}^k = p_{jj}^k \cdot q_{ij}^k$.

Finally, we follow Adams et al. in specifying national income in country i (Y_i) by a Keynesian income equation. Assume for the moment that no tariffs or transfers exist. Then nominal income is given by

$$Y_i = C_i + I_i + VE_i - VM_i \tag{21}$$

where C_i is aggregate consumption in country i, I_i is the level of autonomous expenditure, VE_i is the total value of exports from country i given by

$$VE_i = \sum_{k=1}^{N} \sum_{j=1, j\neq i}^{M} x_{ji}^k (1 + c_{ji}^k) \tag{22}$$

and VM_i is the total value of imports into country i given by[17]

$$VM_i = \sum_{k=1}^{N} \sum_{j=1, j\neq i}^{M} x_{ij}^k (1 + c_{ij}^k). \tag{23}$$

In the presence of many goods, consumption plus autonomous expenditure is equal to total domestic expenditure on <u>final</u> goods. (Expenditure on intermediate goods is not included since those expenditures are included in the value of domestically produced goods.) Since expenditures are measured exclusive of transportation costs, not only the expenditures for the goods themselves but also the expenditures for the transportation costs associated with the consumption of imported final goods must be included. (Transportation costs on imports of intermediate goods are included in the value of domestically produced final goods.) Thus, consumption plus autonomous expenditure can be written as:

$$C_i + I_i = \sum_{k=1}^{n} x_i^k + \sum_{k=1}^{n} \sum_{j=1, j \neq i}^{M} x_{ij}^k c_{ij}^k \tag{24}$$

Note that, if total expenditure on good k is equal to output minus exports plus imports of that good, i.e.

$$x_i^k = p_{ii}^k y_i^k - \sum_{j=1, j \neq i}^{M} x_{ji}^k + \sum_{j=1, j \neq i}^{M} x_{ij}^k ,$$

then substituting (22) through (24) into (21) gives the result that income is equal to (the value of output of final goods) + (exports of intermediate goods) + (transportation services provided for exports of all (both intermediate and final) goods) - (imports of intermediate goods, including transportation costs), which is the value-added in the economy.

Finally, a measure of real income can be obtained by dividing nominal income by an appropriate price deflator. In general, the choice of a price deflator depends upon the measure of real income that is desired. For example, if a measure of the quantity of output of the economy is desired, then a price deflator that reflects changes in the prices of domestically produced goods (regardless of whether those goods are exported or consumed domestically) should be used. However, if a measure of real purchasing power is desired, then a price deflator that reflects changes in the price of final goods (regardless of whether they are produced domestically or imported) should be used. The use of the change in real purchasing power appears to be preferable to the use of the change in the quantity of domestic output as a proxy for a welfare change in an open economy, since it reflects the welfare effects of changes in the terms of trade that were discussed in Section II. An aggregate price deflator based on the prices of final goods is therefore used to convert nominal income into real income. In particular, the "aggregate price index" for region i (API_i) is defined to be a geometric weighted average of the prices of final goods, i.e.

$$\log(API_i) = \sum_{k=1}^{n} [x_i^k / (\sum_{k=1}^{n} x_i^k)] \log(P_i^k) \tag{25}$$

where $\log(P_i^k) = \sum_{j=1}^{M} s_{ij}^k \log(p_{ij}^k)$. Real income in region i (W_i) is then given by:

$$W_i = Y_i / API_i. \tag{26}$$

Consider now the possibility of transfers or tariffs. The first implication of allowing tariffs is that (23) must be modified so that import prices include the tariffs, i.e. it must be written as:

$$VM_i = \sum_{k=1}^{N} \sum_{j=1, j\neq i}^{M} x_{ij}^k (1 + c_{ij}^k)(1 + t_{ij}^k). \tag{27}$$

In addition, the income determination equation must be modified to reflect the transfer or the tariff revenue that is generated. If tariffs are based on prices inclusive of transportation costs, then for country i total tariff revenue will be given by:

$$R_i = \sum_{k=1}^{N} \sum_{j=1, j\neq i}^{M} x_{ij}^k (1 + c_{ij}^k)\, t_{ij}^k. \tag{28}$$

In general, as shown by Vanek,[18] the contribution of tariff revenues to national income depends on the manner in which that revenue is distributed.

Similarly, the effect of a transfer will depend on how the transfer money is raised in the paying region and distributed in the receiving region. In general, the revenue effects of both transfers and tariffs can be incorporated into the income equation by re-writing (21) as:

$$Y_i = C_i + I_i + VE_i - VM_i + \sum_{j=1}^{M} \rho_{ij} R_{ij} + \sum_{j=1}^{M} \tau_{ij} T_{ij} - \sum_{j=1}^{M} \omega_{ji} T_{ji} \tag{29}$$

where ρ_{ij} is the fraction of the tariff revenue raised in region j that is spent in region i, T_{ij} is the gross lump-sum transfer from region j to region i, τ_{ij} is the fraction of the transfer from j to i that is spent domestically (in i), and ω_{ji} is the fraction of the transfer from i to j that is raised domestically (in i). In general, these fractions are policy variables that reflect the particular financing or spending components of a given tariff or transfer policy.

Equations (13)-(29) completely specify the model. All prices (except those for primary inputs) and quantities are endogenous. The only exogenous variables are autonomous expenditure, tariff levels and transportation costs.

V. Concluding Remarks

The above model is suggested as a starting point for analyzing the effects of transfer and tariff policies. In order to estimate the model, functional forms must be chosen for the a_i^k and b_i^k indices and for S_i^F and S_i^I. If the a_i^k are assumed to be log-quadratic and the b_i^k take a Cobb-Douglas form as suggested by Deaton and Muellbauer (1980a, 1980b), then the share equations in (13) are nearly linear. Likewise, if S_i^F and S_i^I are normalized by an output price and the normalized functions are assumed to be quadratic (see Segerson), then the associated supply and input demand equations will be linear and can be estimated as s system with the necessary cross-equation constraints using standard linear regression techniques.

Because of data and size limitations, it is likely that any application of the model could include only a relatively small number of countries and goods. For example, a model analyzing transfer effects might include only three regions, the transfer-paying country, the transfer-receiving country, and the "rest of the world". Likewise, the model might include only three goods, an aggregate manufacturing good, an aggregate agricultural good and an aggregate mining good, using the International Standard Industrial Classification (ISIC) to define the categories.[19] The manufacturing good could be treated as a final good, while the other two goods could be treated as intermediate goods. Although these aggregate definitions do not allow detailed analyses of industry-specific effects, they do allow an assessment of the impact of a transfer or tariff policy on the overall agricultural, mining or manufacturing sectors. In addition, through changes in the parameters ρ_{ij}, τ_{ij} and/or ω_{ji}, the effects of alternative means of raising the money to finance a transfer or spending the revenue resulting from an increased tariff could be analyzed.

Footnotes

1/ The term "tax" is usually used in a domestic context, while "tariff" is used in an international context. Since the model presented in this paper is applicable to either, we use the two terms interchangeably.

2/ This is sometimes referred to as the Glenn tax.

3/ The model can be easily modified to allow for export or import subsidies.

4/ This model is described in many sources. The formulation and notation used here follow most closely Caves and Jones, and Brecher and Bhagwati.

5/ Here $U_i = dU/dD_i$.

6/ See also Bhagwati, Brecher and Hatta.

7/ For example, if the original tax rate is equal to zero, then dy/dt will be non-negative. Alternatively, if the home country is so small that $dp^*/dt = 0$, then dy/dt will be non-positive as long as the imported good is a normal good.

8/ I am indebted to Makoto Yano for suggesting this representation of the Keynesian model.

9/ This assumes that $W=U(D_1, D_2, S)$, which implies that $dW = U_1\ dD_1 + U_2\ dD_2 + U_3 dS$. dy is then defined to be dW/U_3, with $U_i/U_3 = p_i$.

10/ Prices would remain constant if either (1) tastes in the two regions are identical so that the marginal propensities to consume each good in the rest of the world are equal to those in the home country, or (2) the home country is "small".

11/ Of course, $p_1=p_1^*$ since good 1 is assumed not to be subject to a tariff.

12/ The work of Gorman shows that the more general assumption of homotheticity guarantees this result.

13/ This point is also made by Winters. Using tests on British imports of manufactures, he concludes that domestic prices influence foreign market shares, i.e. domestic sales and imports are not separable.

14/ Prices of primary inputs are assumed to be exogenous.

15/ This formulation using x_i^k to represent market size is preferable to using q_i^k since many types of trade data are only available in value terms.

16/ Note that this formulation depends on the absence of price discrimination by producers of final goods.

17/ This formulation assumes that transportation services are provided by the exporting country and that trade flows are measured exclusive of the cost of those services (e.g. f.o.b.).

18/ See also the discussion in Segerson.

19/ The advantage of using the ISIC (or SIC in a strictly domestic model) is that production data are reported using this classification and these data are necessary to determine domestic consumption of domestically produced goods. A drawback, however, is that trade data are not reported using this classification and must therefore be transformed to it to ensure comparability.

REFERENCES

Adams, F.G., H. Eguchi and F. Meyer-Zu-Schlerchtern (1969) An Econometric Analysis of International Trade: An Interrelated Explanation of Imports and Exports of OECD Countries, Paris: Organization for Economic Cooperation and Development.

Armington, P.S. (1969) "A Theory of Demand for Products Distinguished by Place of Production," International Monetary Fund Staff Papers, Vol. 16, pp. 159-77.

Bhagwati, J.N., R.A. Brecher and T. Hatta (1983) "The Generalized Theory of Transfers and Welfare: Bilateral Transfers in a Multilateral World," American Economic Review, Vol. 83, No. 4, pp. 606-618.

Brecher, R.A. and J.N. Bhagwati (1981) "Foreign Ownership and the Theory of Trade and Welfare," Journal of Political Economy, Vol. 89, pp. 497-511.

Caves, R.E. and R.W. Jones (1977) World Trade and Payments: An Introduction, Boston: Little, Brown, and Co.

Deaton, A.S. and J. Muellbauer (1980a) "An Almost Ideal Demand System," American Economic Review, Vol. 70, No. 3, pp. 312-326.

______________ (1980b) Economics and Consumer Behavior, Cambridge, England: Cambridge University Press.

Geraci, V.J. and W. Prewo (1982) "An Empirical Demand and Supply Model of Multilateral Trade," The Review of Economics and Statistics, Vol. 64, No. 3, pp. 432-441.

Gorman, W.M. (1959) "Separable Utility and Aggregation," Econometrica, Vol. 27, No. 3, pp. 469-81.

Kemp, M.C. (1964) The Pure Theory of International Trade, Englewood Cliffs, N.J.: Prentice-Hall, Inc.

Reeb, D.J. (Study Director) (1983) Economic Impact Study of Acid Precipitation: A Study Undertaken for the New York State Dept. of Environmental Conservation, Rockefeller College of Public Affairs and Policy, State University of New York at Albany.

Rhomberg, R.R. (1973) "Towards a General Trade Model," In R.J. Ball, ed., The International Linkage of National Economic Models, Amsterdam: North-Holland Publishing, Co.

Segerson, K. (1984) "Unilateral Transfrontier Pollution and Economic Interdependence: A Methodological Study," unpublished Ph.D. dissertation, Cornell University.

Segerson, K. and T.D. Mount (1984) "A Non-homothetic Two-Stage Decision Model Using AIDS," Department of Agricultural Economics, University of Wisconsin-Madison.

Vanek, J. (1962) International Trade: Theory and Economic Policy, Homewood, Illinois: Richard D. Irwin, Inc.

Winters, L.A. (1982) "Separability and the Specification of Foreign Trade Functions," Discussion Paper No. 82/126, Dept. of Economics, University of Bristol, Bristol, England.

Yano, M. (1983) "Welfare Aspects of the Transfer Problem," Journal of International Economics.