A Global Model of
North-South Trade and Growth

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1. Introduction

The economic events of the past few years have tended to shift the emphasis in discussions of development strategy on the strong international economic linkages that make it meaningful to refer to a "world economy." The purpose of this paper is to describe the structure of a global model of trade, growth and interaction between the world’s economies that we propose to use for an in-depth analysis of the interaction between alternative trade and growth strategies adopted by the industrial "North" and the developing "South," each of these two macro-regions being divided into a few component sub-regions. We shall concentrate on the structure of the model and the nature of the policy analysis we propose to undertake. Problems of data gathering, data reconciliation and estimation are reserved for a separate paper.

Often the analysis of development strategies has been carried out within the framework of single country models, with the "rest-of-the-world" specified exogenously. This approach is subject to a fundamental fallacy of composition: the results of a strategy for a country considered alone may well be very different from the results of the same strategy when applied to a large number of developing countries because of interactions which are neglected when considering a single country in isolation. These interactions or general equilibrium effects, working through the operation of world markets for commodities and capital, represent an area of increasing concern to both economists and policy makers. It is precisely these mechanisms of interaction and interdependence that are the major focus of the model set out below.
The model will be a long-run, structural equilibrium model abstracting from short-run fluctuations or purely financial disturbances. It will be a multi-country, multi-sector growth model. It builds on the interesting work that has already begun in this area. But we shall attempt to reconcile and extend some of the divergent approaches by elaborating a general, policy-oriented, and flexible new framework for global modelling of trade and growth.

The approach taken is based on recent work on economy-wide computable general equilibrium (CGE) models. Such models incorporate a highly non-linear specification that is very flexible in terms of the range of behavioral assumptions that can be incorporated. The model simulates the behavior of factor and product markets, solves endogenously for all product prices and factor payments, and can incorporate the behavioral implications of factors such as tariffs, subsidies, and taxes. The framework is thus well suited for exploring the implications of trade strategies and protection policies for the international terms of trade and the pattern of world growth. The model will particularly emphasize the analysis of policies that center on the manufacturing sectors and explore the prospects for a geographical redistribution of industrial activity.

\[1\] Previous work done in the field of international modelling notably includes Armington's demand theory for traded goods (1969), the Link Project (1973), the Simlink model built by N. Hicks at the World Bank (1976), the CEM NT model developed by V. Ginsburgh and J. Waelbroeck (1976), the international input-output model built for the U.N. (1975), the work by Deardorff, Stern and Baum calculating the impact effect of trade liberalization within the developed industrial countries (1976) and the Multilateral Model of Japanese-American Trade built by Petri (1976).
Section II below discusses the main issues of debate in international fora towards which our model is directed and its relevance to policy-makers. Section III explains our modelling strategy and how we propose to reduce the number of markets inherently involved in a global model to manageable dimensions without losing global linkages and general equilibrium interaction. Section IV presents a simplified "core" model of international trade and growth. Section V discusses how the core model will be extended to include government behavior, policy variables, exchange rates and non-traded goods. Section VI will turn to a discussion of the policy experiments to be conducted with our model emphasizing the need for analyzing the interaction of national strategies and for evaluating these strategies not only from a national or regional point-of-view but also in terms of their role in the functioning of the international economy. Section VII relates our model to past and ongoing work in the field of international modelling.
II. Policy Focus

The program of Action on the Establishment of a New International Economic Order calls for a wide range of changes in economic policies to reduce the vastly unequal relationship between the rich North and the poor South. It is argued that the South cannot get an equitable deal from the present international economic structures. There is a very unequal distribution of the value-added in the products traded between developed and developing nations as well as in the distribution of international reserves. Moreover it is argued that the protective wall erected by developed countries prevents developing nations from receiving their share of global wealth. Finally it is argued that the relationship between multinational corporations and the developing countries has resulted in a fairly unequitable sharing of benefits. Therefore, the resulting annual loss of income to the South from these market failures may well exceed the net bilateral transfers from the North.

To alleviate these perceived inequities, the South has argued for a relocation of industry from the North by improving access to markets in the North through the elimination of trade barriers and a redistribution of value-added through further processing of raw materials in the South. In the monetary sphere, a reform of the international monetary system is urged to maintain and increase the real value of the South's reserves. Finally, the South calls for access to modern technology on improved terms and for some regulation of multinational corporations to promote reinvestment of profits and regulation of the repatriation of profits.
There are essentially two mechanisms whereby these proposed reforms may take place: First, through a change in policies shaping the economic relations between the two blocs; and secondly through institutional changes in the present international order.

Our proposal is directed towards providing policy-makers with an indication of the possible extent of the shift in location of industry and redistribution of wealth between the North and the South through fundamental changes in economic policies regulating international trade between the two blocs. We propose to investigate whether the changes in trade policies called for in the Program of Action would lead to substantial changes without significant alterations in institutional structures. By focusing on the implications of alternative long-term trade strategies and by abstracting from the details of international monetary institutions, the project would not be dealing with the implications of external shocks to the burden and speed of adjustment between major trading blocs. Rather it would focus on structural changes and the likely time required for such changes in a growing world.

More specifically, as discussed in section VI, our model will yield the global implications of alternative strategies pursued by major trading blocs. The main policy options we will explore relate to commercial policies which restrict the flow of commodities and factors of production between major trading blocs. We will trace out the quantitative effects of alternative trade strategies on the redistribution of value-added between
the North and the South through both changes in the international terms of trade and changes in the location of industry. Our model will yield an estimate of both the static and dynamic costs of non-optimal commercial policies, and also indicate the distribution of these costs to each of the major trading blocs. Moreover, our modelling strategy will provide some indication of the extent to which alternative policies would lead to a redistribution of income both between and within regions. Finally, we will explore both the implications of different rates of transfer of resources through foreign aid or foreign investment between the North and the South as well as the consequences of different rates of transmission of technological knowledge between the two blocs. These last estimates will be more tentative, since we do not possess satisfactory theories of the determinants of foreign investments and the transfer of technology. However, we feel that simulation of alternative scenarios will provide policymakers with an indication of the quantitative importance of policy changes in this area.

A key factor of our proposal is that we intend to portray carefully the degree and extent of market imperfections and structural rigidities in each of the major trading blocs. While our model involves the simulation of product and factor markets, our framework is nonetheless flexible enough to incorporate structural rigidities and market imperfections characteristic of the South. Distortions in commodity and factor markets will be combined with varying assumptions about the ease with which factors of
production and commodities may be substituted. The model should thus be a much more realistic portrayal of the world facing policy-makers than the purely neoclassical competitive world described by trade theorists.

By specifying that imported and domestically produced goods are imperfect substitutes, the model captures an important feature of the developing world often emphasized by policy-makers. By varying the parameters specifying the elasticity of substitution in use for different sectors and across different regions, the model incorporates assumptions ranging from complete insubstitutability (e.g. two-gap models) to perfect substitutability (e.g. neoclassical trade theory models).

Indeed some of our experiments will analyze the dynamic effects of trade strategy when the value of the elasticity of substitution between factors of production and commodities in use between domestically produced and imported goods increases smoothly over time indicating the structural evolution of the South. We would expect the varying extent of structural rigidities between different major trading blocs to have a quantitatively significant effect on the dynamic evolution of the structure of the world economy.
III. The Treatment of Product Differentiation by Region of Origin

The need to remain within manageable dimensions precludes the possibility of dealing with a market for every good distinguished both by sector of commodity classification and by region of origin. With seven or eight regions and a dozen goods we would already have to deal with almost 100 markets. On the other hand, it is not realistic to treat goods of the same category but produced in different regions as perfect substitutes, an approach taken by the theoretical trade literature. The compromise that needs to be made should allow for product differentiation by region of origin but at the same time preserve aggregate commodity categories.

Notation

We distinguish between the "North" and "South" as well as sub-regions within each of these blocs.

N, S: Superscripts for "North" and "South"

j, k: Subscripts referring to sub-regions in the North (j) and South (k)

i: Subscript referring to the "type" of commodity

There are n northern regions (j=1,...,n), s southern regions (k=n+1,...,n+s) and m commodities (i=1,...,m).

\( X_i \): Quantity index of worldwide demand for commodity i

\( X_{iN} \): Quantity index of worldwide demand for commodity i originating in the North.
$X^S_i$: Quantity index of worldwide demand for commodity $i$ originating in the South

$X^N_{ij}$: Worldwide demands for commodity $i$ originating in Northern region $j$ and Southern region $k$

$X^S_{ik}$: Product originating in the South

$P_i$: World-price index for commodity $i$

$P^N_i$: Price index for commodity $i$ originating in the North

$P^S_i$: Price index for commodity $i$ originating in the South

$P_{ij}$: Prices of commodity $i$ originating in northern region $j$ and southern region $k$.

The quantity index for each aggregate commodity is a function of its components by region of origin.

\[ X_i = f_i(X_{1i}, \ldots, X_{ni}, X_{i,n+1}, \ldots, X_{i,n+s}) \]  \hspace{1cm} (1)

We shall decompose the aggregation into two stages by first distinguishing a "Northern" and a "Southern" product each being a CES quantity index of its regional components:

\[ X^N_i = (\beta_{11}X_{1i}^{-\rho_1} + \beta_{12}X_{i,n+1}^{-\rho_1} + \ldots + \beta_{in}X_{in}^{-\rho_1})^{-1/\rho_1} \]  \hspace{1cm} (2)

\[ X^S_i = (\beta_{i,n+1}X_{i,n+1}^{-\nu_1} + \beta_{i,n+2}X_{i,n+2}^{-\nu_1} + \ldots + \beta_{i,n+s}X_{i,n+s}^{-\nu_1})^{-1/\nu_1} \]  \hspace{1cm} (3)
where \[ \sum_{j=1}^{n} \beta_{ij} = 1 \quad \text{and} \quad \sum_{k=n+1}^{n+s} \beta_{ik} = 1. \]

Define,

\[ \sigma_{1}^{N} = \frac{1}{1+\sigma_{1}} : \quad \text{The elasticity of substitution between northern products of category } i. \]
\[ \sigma_{1}^{S} = \frac{1}{1+\sigma_{1}} : \quad \text{The elasticity of substitution between southern products of category } i. \]

If prices \( P_{1}^{N}, P_{1}^{S}, P_{1j}^{i}, \) and \( P_{1k}^{i} \) are given and if total demands for the northern and the southern good, \( X_{1}^{N} \) and \( X_{1}^{S} \), are also given, the assumption of cost minimization leads to the following demand functions for commodities differentiated by region of origin:

\[ X_{1j} = \beta_{1j}^{i} X_{1}^{N} \left( \frac{P_{1j}^{i}}{P_{1}^{N}} \right)^{-\sigma_{1}^{N}} \quad \text{(North)} \]  
\[ X_{1k} = \beta_{1k}^{i} X_{1}^{S} \left( \frac{P_{1k}^{i}}{P_{1}^{S}} \right)^{-\sigma_{1}^{S}} \quad \text{(South)} \]

The aggregate northern and southern goods must now themselves be aggregated into a composite world good \( X_{1} \). Assume for the moment that the aggregation is of the Cobb-Douglas form:

\[ X_{1} = (X_{1}^{N})^{\eta_{i}} (X_{1}^{S})^{1-\eta_{i}} \]

This leads to the following simple demand functions for the aggregate northern and southern goods given a world price \( P_{1} \) and total demand for the composite good \( X_{1} \).
\[ x_i^N = \eta_i \frac{p_i}{p_i^N} x_i \]  \hspace{1cm} (6)

\[ x_i^S = (1-\eta_i) \frac{p_i}{p_i^S} x_i \]  \hspace{1cm} (7)

Substituting (6) and (7) into (4) and (5) leads to the following system of demand equations for the products of each region:

\[ x_{1j} = \beta_{1j} \sigma_i \eta_i \frac{p_i^N}{p_i} \left( \frac{p_i^N}{p_i} \right) \frac{p_i^N}{p_i^N} \]  \hspace{1cm} (8)

\[ x_{1k} = \beta_{1k} \sigma_i (1-\eta_i) \frac{p_i^N}{p_i^S} \left( \frac{p_i^S}{p_i} \right) \frac{p_i^S}{p_i^S} \]  \hspace{1cm} (9)

It is by no means necessary to restrict to unity the elasticity of substitution between the northern aggregate good and the southern aggregate good. If the elasticity of substitution in the north-south aggregation function is denoted by \( \sigma^* \), the demand functions for the products of each region will have the slightly more complex form given below:

\[ x_{1j} = \beta_{1j} \sigma_i \frac{p_i^N}{p_i} \left( \frac{p_i^N}{p_i} \right) \frac{p_i^N}{p_i^N} \]  \hspace{1cm} (10)

\[ x_{1k} = \beta_{1k} \sigma_i (1-\eta_i) \frac{p_i^N}{p_i^S} \left( \frac{p_i^S}{p_i} \right) \frac{p_i^S}{p_i^S} \]  \hspace{1cm} (11)

It is worth considering the simple case where all substitution elasticities are equal to unity. Setting \( \sigma_i^N = \sigma_i^S = \sigma_i^* = 1 \) we get:
\[ X_{ij} = \beta_{ij} \eta_i X_i \frac{P_i}{P_{ij}} \]

\[ X_{ik} = \beta_{ik} (1-\eta_i) X_i \frac{P_i}{P_{ik}} \]

and therefore, denoting by \( \theta_{ij} \) and \( \theta_{ik} \) the value shares of individual regions in total demand,

\[ \theta_{ij} = P_{ij} X_{ij} \frac{1}{P_i} \frac{X_i}{X_i} = \beta_{ij} \eta_i \]

\[ \theta_{ik} = P_{ik} X_{ik} \frac{1}{P_i} \frac{X_i}{X_i} = \beta_{ik} (1-\eta_i) \]

Each country would thus have a constant value share in total world demand that is equal to its share in total demand for the northern (southern) good multiplied by the share of the northern (southern) good in total world demand.

In our case with \( \sigma_i^N \), \( \sigma_i^S \), \( \sigma_i^* \) in general differing from unity, it is easily shown from (10) and (11) above that the shares are no longer constant and obey the following equations:

\[ \theta_{ij} = \beta_{ij} \sigma_i^N \eta_i \sigma_i^* \left( \frac{P_i^N}{P_{ij}} \right) \left( \frac{1}{N-1} \right) \]

\[ \theta_{ik} = \beta_{ik} \sigma_i^S(1-\eta_i) \sigma_i^* \left( \frac{P_i^S}{P_{ik}} \right) \left( \frac{1}{S} \right) \]

Note that these shares are not shares in world trade but shares in total demand including domestic demand for domestic goods. Note also
that we have not distinguished between consumption demand, intermediate

demand and investment demand.

The price indices \( p_i^N, p_i^S, \) and \( p_i \) will be defined so as to
satisfy the following equations:

\[
\begin{align*}
p_i^N x_i^N &= \sum_{j=1}^n p_{ij} x_{ij} \\
p_i^S x_i^S &= \sum_{k=n+1}^{n+s} p_{ik} x_{ik} \\
p_i x_i &= p_i^N x_i^N + p_i^S x_i^S
\end{align*}
\]

and therefore:

\[
\sum_{j=1}^n \theta_{ij} + \sum_{k=n}^{n+s} \theta_{ik} = 1.
\]

This view of imperfect substitutability between goods of
different geographical origin may reflect differences in product quality
as well as regional biases in tastes. It very naturally allows two-way
trade in the sense that it is perfectly conceivable that a region will
import machinery of a certain "type" and at the same time export domesti-
cally produced machinery of a different "type." Our treatment closely
follows Armington's formulation\(^1\) but rather than treating all regions
symetrically, we introduce a North-South sub-aggregation that will
focus the model on the issue of global development.

\(^1\)See Armington (1969) as well as Robinson and de Melo (1976).
IV. The Specification of the Core Model

Supply and Demand for Goods in the World Market

In section II we discussed the definition of the composite goods, $X_1$. Given a complete set of world prices, the demand functions can be used to decompose a given demand for the composite good into the demand for individual commodities by country of origin ($X_{1j}$ and $X_{1k}$).

A metaphorical way of viewing the world market is that it is a large department store called the "World Market" which sells only "house brands." The store takes in goods from all over the world ($X_{1j}$ and $X_{1k}$) and combines them together according to the aggregation functions to make up "world goods," $X_1$. It is these world goods which are put on display and are demanded by all users. The only behavioral assumption we make is that the world department store seeks to minimize costs when it makes up world goods and thus follows equations (10) and (11).

The goods $X_{1j}$ and $X_{1k}$ have units of physical quantities of production in each country. The goods $X_1^N$ and $X_1^S$ have composite units of the North and South (the first level of aggregation). But in our metaphor, no one ever demands $X_1^N$ and $X_1^S$ directly. They represent only an intermediate step in the making of world goods $X_1$ ($X_1^N$ and $X_1^S$ only appear in the back room of the department store). Note that for the moment we have assumed that all prices are in world currency (dollars). There are no exchange rates and all transactions are made in dollars. Each region can be viewed as selling all its output to the world market, receiving dollars, and then purchasing world goods from the world market to satisfy all domestic demands.
From this basic starting point the model can be extended in several directions. First, we shall include non-traded goods which are produced and sold domestically and hence do not pass through the world market. Second, we shall introduce national currencies and exchange rates. Third, we shall introduce price distortions such as trade quotas and taxes in the form of tariffs and subsidies. These extensions will be discussed below after we have presented the simpler model.

Equations (10) and (11) can be thought of as describing how the world market department store works. Given a set of demands for world goods $X_{ij}$ and a set of prices $P_{ij}$ and $P_{ik}$, the store will generate a set of demands for country goods $X_{ij}$ and $X_{ik}$. It serves a pure intermediary function. We must now describe the supply and demand equilibrium for all country goods. Each country demands world goods which the store translates into demands for country goods, $X_{ij}$ and $X_{ik}$. Given prices, each country will produce and hence supply country goods, $S_{ij}$ and $S_{ik}$. The clearing of all world markets requires that we find a set of prices $P_{ij}$ and $P_{ik}$ such that $X_{ij} = S_{ij}$ and $X_{ik} = S_{ik}$ for all goods and countries. It now remains to describe how these supplies and demands are determined.

Regional Models

Each region will be modelled as if it represented a single integrated economy. Each such economy will be represented by a computable general equilibrium (CGE) model.\footnote{Of the recent CGE models that have been developed, one that probably best represents the approach that we will take is Robinson and de Melo (1976) because it includes the specification of an elasticity of substitution in use between imported and domestically produced goods.} Single country CGE models have been
used to solve for a set of product prices and factor rentals (wages and capital rentals) which clear domestic factor and product markets. In our overall model, we seek a set of world prices that clear all product markets yielding \( P_{ij} \), \( P_{ik} \), and \( X_{ij} \) and \( X_{ik} \). Given world product prices, each regional CGE model must yield regional product supplies, employment, incomes, and the demand for world goods. The CGE models will work by specifying firm behavior and simulating the operation of factor markets. They will all take as a starting point the basic equation structure described below.

The model is static and represents the basic within-period specification. The full model will be dynamic and will include a set of submodels which will provide all the necessary intertemporal linkages.

In this section, we will drop the separate \( j \) and \( k \) subscripts. The subscript \( j \) is assumed to refer to all regions, both North and South (\( n + s \) in all). As before, there are \( m \) goods and the variable \( P_{ij} \) now refers to the domestic price (in dollars) of good \( i \) in country \( j \). The variable \( P_{i} \) still refers to the price of the world composite good. The separate North and South composite goods are not needed in this section dealing with the individual region models.

**Production functions**

\[
S_{ij} = g_{ij} (L_{ij}, K_{ij}) \quad \quad m \cdot (n+s) \text{ equations} \quad (12)
\]

We shall assume neo-classical production functions with smooth capital-labor substitution for most of the goods produced in the various
sub-regions. Labor and capital in each sector may also be treated as composite factors. For some sectors such as agriculture and minerals it will be necessary to alter the specification of production functions to include more meaningful natural resource constraints.

**Intermediate goods**

The demand for intermediate goods will be linked by fixed input-output coefficients to sectoral production levels. It is important to note however that the intermediate goods demanded will be composite "world goods" whose components by region of origin will be derived from the cost minimizing demand equations of section II above.

**Factor supplies**

As a first approximation, total primary factor supplies will be assumed to be exogenous in each region:

\[ \sum_{i=1}^{m} L_{ij} = \tilde{L}_j \quad (n+s) \text{ equations} \quad (13) \]

\[ \sum_{i=1}^{m} K_{ij} = \tilde{K}_j \quad (n+s) \text{ equations} \quad (14) \]

**Factor demands**

Assuming that all producers seek to maximize profits, the demands for factors will depend on standard neo-classical marginal productivity
relations. If \( P^*_{ij} \) refers to the net price or per unit value-added in sector \( i \) derived by subtracting the value of intermediate goods from the output price \( P_{ij} \), the demand equations may be written as:

\[
L_{ij} = h^L_{ij} (s_{ij}, P^*_{ij}, w_j, q_j) \quad m \cdot (n+s) \text{ equations (15)}
\]

\[
K_{ij} = h^K_{ij} (s_{ij}, P^*_{ij}, w_j, q_j) \quad m \cdot (n+s) \text{ equations (16)}
\]

where \( w_j \) and \( q_j \) are wages and capital rentals in each region.

The formulation may assume perfect competition in both factor and product markets. However, in many cases it will be desirable to assume imperfectly competitive factor markets and limited factor mobility.

Given goods prices, equations (12) to (16) contain \((3m+2) \cdot (n+s)\) endogenous variables: \( S_{ij}, L_{ij}, K_{ij}, w_i \) and \( q_i \). There are also exactly \((3m+2) \cdot (n+s)\) equations. These equations can be solved by essentially simulating the working of the factor markets to find market clearing wages and rental rates. They thus yield factor prices, employment and product supplies.\(^1\)

**Factor incomes**

Given the solution of the factor market equations for each region, one can derive factor incomes and consumption demands.

Factor incomes in each region are given by:

\(^1\)See Adelman and Robinson (1977) for a survey of techniques for solving such CGE models.
\[ y^L_j = \sum_i w^L_{ij} L^i_j \]  
\[ (n+s) \text{ equations} \]  
\[ (17) \]

\[ y^K_j = \sum_i q^K_{ij} K^i_j \]  
\[ (n+s) \text{ equations} \]  
\[ (18) \]

Linear homogeneity of the production functions guarantees that the payments to all factors will exactly equal total value-added for each sector in each region and hence for all sectors together in each region.

\[ P^*_i j s^*_i j = w^L_{ij} L^i_j + q^K_{ij} K^i_j \]

Thus:

\[ \sum_i P^*_i j s^*_i j = y^L_j + y^K_j \]

Each type of income recipient (laborers and capitalists) is assumed to save one part of his income and spend the rest on world goods. Expenditure functions are given by:

\[ c^L_{ij} = b^L_{ij} (Y^*_j, p^L_i, \ldots, p^L_n) \]  
\[ (n+s) \text{ equations} \]  
\[ (19) \]

\[ c^K_{ij} = b^K_{ij} (Y^*_j, p^K_i, \ldots, p^K_n) \]  
\[ (n+s) \text{ equations} \]  
\[ (20) \]

when \( Y^*_j \) and \( Y^*_j \) is total labor and capital income spent on consumption. The units of consumption are world market composite goods bought at composite prices, \( p^*_i \). For example, \( c^*_i j \) is the demand by labor in country \( j \) for composite good \( i \). The expenditure equations for each group must satisfy the aggregation condition that the value of total expenditure must equal
the value of total purchases:

\[ Y_j^L = \sum_i P_i C_{ij}^L \]

\[ Y_j^K = \sum_i P_i C_{ij}^K \]

The definition of the prices of the composite goods ensure the equality of the total value of composite goods with the total value of domestic goods (from whose sale the incomes \( Y_j^L \) and \( Y_j^K \) are derived).

Aggregating across demanders and regions yields the total consumption demands for composite goods:

\[ C_i = \sum_j C_{ij}^L + C_{ij}^K \quad \text{n equations} \quad (21) \]

To this must be added intermediate demands and investment demands. The former being linear functions of output levels and the latter depending on the exact specification of the dynamic capital accumulation equations.

This would complete the specification of the regional models. For each region, given world prices of all goods including world goods, we could solve equations (12) to (16) to find wages, employment, and outputs such that all factor markets are cleared. We then could solve equations (17) to (21) to get the functional distribution of income and the demand for world goods.
Clearing the World Markets

Returning to our metaphorical world department store we can now calculate world excess demands for all goods. Each region demands world goods according to equations (19) and (20). Each region sells the store \( S_{ij} \) at prices \( P_{ij} \). For each region, it is true that the total value of sales to the world store equals the total value of demand for world goods.

The world market now takes the demand for world goods as given and derives its demands for regional goods using the equations in the previous section. This yields a set of demands for regional goods, \( X_{ij} \) and \( X_{ik} \) (putting back the country subscripts), and one can calculate the excess demands for goods from each region. The problem is then to find a set of world prices to yield zero excess demands for all goods from all regions. This problem is a generalization of the problem of finding market clearing prices in a single country CGE model and should be susceptible to solution by analogous methods.

Discussion of the Core Model

In the core model presented above, each region sells all its goods to the world store and receives in exchange supplies of the composite goods. A more traditional view of trade can be included in this framework by assuming that the world store has branches in each region which buy what they can locally and import whatever else they need, with all branches combining goods in exactly the same proportions to make up
composite goods. Imports are thus goods from other regions demanded by the local branch and exports are those domestic goods which are offered for sale abroad after satisfying the local branch store's demands for domestic goods. By Walras' law, the value of exports and imports must always be equal.

It is assumed that each country has a balance of payments equilibrium. It is easy to specify exogenous balance of trade surpluses and deficits for different regions. They can be modelled simply as income transfers among regions and, of course, must sum to zero across all regions.

The treatment of capital in the model has been left purposely vague. There are a number of issues concerning the treatment of heterogeneous capital goods that will have to be dealt with in each of the region models. ¹ There is the general question of capital mobility both within regions and across regions. It is feasible, following recent work with dynamic CGE models to assume capital to be fixed by producing sectors and hence immobile within periods but to be mobile between periods dynamically. It is clearly worthwhile to make the trade model dynamic by introducing a set of submodels which will handle the intertemporal linkages for each regional model. Such submodels would yield the amount and sectoral allocation of investment, the growth of the labor force by type including migration and human capital formation; and technical change through changes in productivity

¹See Dervis (1975) for a treatment of heterogeneous capital within the context of a single country CGE model.
in production or changes the elasticity of substitution in use between imported and domestic goods.

As a first step it may be useful to start by assuming that capital is perfectly mobile across sectors within any region. This requires a view of capital as homogeneous and malleable. Having explored the workings of such a simple model as a first step one can then add a sub-model of the workings of markets for heterogeneous capital goods. A similar two stage approach may in fact turn out to be useful as a general treatment of factor markets including labor.\(^1\)

Modelling international capital flows constitutes another important direction in which the core model needs extension. Such flows can be modelled as movements of composite capital goods among regions with the result that the lending region receives a claim against future profits from the recipient country. One can easily distinguish between fixed interest claims (loans) and those which represent a claim on future profits (foreign investment).

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\(^1\)For a general discussion of the structure of two stage CGE models see Robinson (1976). For an application analyzing trade policy in a model with heterogeneous capital goods see de Melo and Dervis (1976).
V. Extensions of the Core Model

1. Non-traded Goods

The addition of goods which are not traded across regions adds to the theoretical interest of the model and does not complicate our specification. Such non-traded goods would not enter into any composite good and would simply be marketed locally. The market clearing prices for such goods would be determined by clearing only the local market.

2. National Currencies and Exchange Rates

As the model is specified above, all transactions are in the world currency and there are no exchange rates. The dollar value of exports always equals the dollar value of imports and there is no exchange rate adjustment mechanism. The simplest way to introduce national currencies and an exchange rate is to specify a separate price normalization equation for each country. This adds $m+s-1$ additional price normalization equations and $m+s-1$ new exchange rate variables. One country's currency will serve as numeraire and all exchange rates will be measured against it.

The specification of separate price normalization equations for each country is equivalent to specifying a very simple monetary system for each country. One could, for example, specify a money demand and money supply equation for each country which serves to determine the country's average price level. The exchange rate simply adjusts to keep the domestic and world prices in domestic currency identical. If money
is "neutral" in each economy in the sense that doubling all wages, prices and the exchange rate leaves all real variables unchanged, then the exchange rate will be purely a "monetary phenomenon." In the region models described above, money is neutral as merely adding regional currencies and flexible exchange rates does not affect the real behavior of any regional model.


The addition of price distortions that affect regions or products differently is essential and will have important effects on real variables. The inclusion of these variables does not pose any problems but requires additional specification in the regional models. First, it is necessary to add a government sector which collects taxes and spends the revenue. This is necessary to maintain the flow of funds balance equations within each region and is easy to specify.

Second, the addition of parameters which "distort" local prices means that local economic agents will no longer be confronted by the same prices as those confronting other regions. Such distortions will affect the equilibrium solution within each region and hence will also affect the overall solution.

Through the inclusion of taxes, tariffs, subsidies, and a fixed exchange rate variant, the regional models will simply look more like the various country CGE models that have already been built. The speci-
fication of aggregate composite goods does raise some interesting problems. Since all users do not now face the same relative prices, they will not choose to combine goods in the same proportions to make up the composite goods they want. In the earlier metaphor, the world department store made up composite goods using one set of proportions regardless of who demanded the good. Now, different demanders facing different domestic relative prices will want to combine goods in different proportions in making up their desired composite goods.

In terms of our metaphor, the way to handle this problem in the model is to assume that the world department store has a branch in each country. These branch stores are autonomous and all use the same aggregation function. However, they are located in different regions and must buy all their inputs in local markets at local prices. They will thus each make up composite goods using different proportions of input goods. In specifying the international trade of each region, all importing will be assumed to be done by the local branch of the world store. The branch store also buys the domestic goods it needs to make up composite goods and domestic production above domestic needs is assumed to be supplied to the world market. World prices still adjust to clear world markets and the exchange rate adjusts to equate the value of exports and imports in world prices.

In this extended model, each region is more insulated from the world market in the sense that the model now permits wedges to be driven between domestic and world prices. These wedges can arise from
tariffs, subsidies, or local indirect taxes. Fixing regional exchange rates is slightly more complicated since each regional model must then include a balance of payments surplus or deficit. Surpluses and deficits must add to zero across the world, with the numeraire region having its balance of payments determined residually. Within each region, the surplus or deficit must be financed by some economic agent. One possible assumption to make is that the government sector always either holds a surplus or spends a deficit.
VI. Focus of Analysis and Policy Experiments

We propose to focus the experiments with our global model on an exploration of the effect of alternative trade strategies and alternative patterns of international investment on long-run welfare and growth trends. These sets of issues are clearly interrelated and together raise a wide range of important policy questions.

The time unit for our experiments will probably be a decade although it may be worth exploring a 5 year time unit as well. We shall first fit the model to the 1960 - 1980 period and then use it to project 1990 and perhaps 2000.

Trade Policy and Trade Strategies

The first major aim of our experiments will be to explore the quantitative results of alternative trade policies adopted by the individual regions in our model. During a first phase of experimentation we shall keep factors internationally immobile while analyzing the effects of commercial policy on growth performance and the international distribution of income. The traditional tools of commercial policy include protective tariff structures, export subsidies and quantitative restrictions. We shall try to add consideration of government sponsored price agreements on international markets, a problem area that has really never been analyzed in a true general equilibrium setting.
The net effect of trade policy, in particular of tariffs and export subsidies on the economic performance of any one region, will depend on the interaction of 4 essential factors:

   a. The static resource allocation effects.
   b. The dynamic resource allocation effects.
   c. The dynamic resource growth effects.
   d. The terms-of-trade effects.

The nature of these effects in turn often crucially depends on the workings of labor and capital markets within the various regions. Possible imperfections in factor markets sometimes reverse the expected direction of the effects of trade policy and our analysis will take into account the large literature on trade policy and domestic distortions.\(^1\) We expect the dynamic resource allocation effects and resource growth effects of changes in trade policy to be substantial. A satisfactory modelling of intra-regional capital markets and investment allocation is therefore indispensable.\(^2\) From the point-of-view of the South the major policy question to be dealt with in this section will relate to the optimal amount and structure as well as the time-phasing

\(^1\)See for instance Bhagwati, (1971) and Magee, (1973) for excellent surveys of this literature.

\(^2\)See De Melo and Dervis, (1977) for a single-country model analyzing the interaction between trade policy and investment allocation.
of protection to be accorded to infant industries, be it in the form
of tariffs to promote import substitution or subsidies to promote export
expansion. Putting it differently and on the assumption that greater
trade liberalization will turn out to be desirable, the challenge will
be to determine the optimal timing and structure of liberalizing measures.

We expect the purely static resource allocation effects of
trade policy to be small in themselves. But when combined with dynamic
resource growth affects via an endogenous savings mechanism, these effects
may become significant. Thus it may pay to protect an infant industry
in spite of the static misallocation of resources created if favourable
dynamic allocation effects outweigh the static costs of protection. But
these dynamic gains may themselves be outweighed if the initial loss of
income leads to a decline in investment and slower resource growth. Thus,
at given terms-of-trade, the unfavourable static allocation effects and
the possibly unfavourable growth effects of protection may combine to
outweigh the possibly favourable dynamic allocation effects based on an
infant industry specification.

Finally, it should be stressed that the terms-of-trade effects
are likely to play a substantial role in determining the relative

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1 The relative insignificance of purely static effects has been
documented in many studies. For a survey see De Melo, (1977).

2 See De Melo and Dervis, (1976) page 33, 34 and Chart 3 for a
detailed analysis of the interaction.
desirability of alternative trade policies and strategies. Indeed it is in the evaluation of alternative growth strategies for the South as a whole that a global model would seem to be indispensable. Single country models can reasonably make the "small country" assumptions and take world prices as given. But clearly when alternative growth strategies for the South as a whole or large portions of it are at stake, the analysis of world prices and their determination becomes crucial.

We propose to analyze at least three global southern strategies:

1. An import substituting strategy.
2. An export promoting strategy.
3. An equilibrium strategy.

The degree of success of any one of the possible southern strategies will of course depend, among other things, on northern actions and reactions.

We shall therefore experiment with two northern strategies:

4. A neutral northern strategy.
5. A favourable northern strategy.

A neutral northern strategy would essentially be "status quo" oriented. It would not regard favourably either an aggressive export promotion strategy by the South or the continuation of southern protection. The North would open its markets only in exchange for an equilibrium southern strategy. Trade liberalization would have to be
"balanced" and "mutual".

A favourable northern strategy on the other hand would grant free access to northern markets and tariff reductions without insisting on reciprocity. It would be tolerant of aggressive southern export promotion.

We would expect the optimal southern strategy to depend significantly on the strategy adopted by the North. Thus it may well be that a global policy of export promotion of manufactured goods is a desirable strategy for the South in spite of probably adverse terms-of-trade effects provided a favourable northern strategy can be assumed. The same strategy may however be unviable in the absence of a favourable northern strategy.

Throughout our experiments exploring alternative trade policies we shall impose international (i.e. interregional) immobility of capital (and labor). Individual regions will essentially have to balance their trade within every decade. Many of the most interesting issues relating to the world's economic order and its future depend however on the degree of international capital mobility and on the pace of technology transfers that may (or may not) be tied to such capital flows. It is to this set of issues that we will turn in a second set of experiments.

**International Investment and Transfers of Technology**

It is clear that one of the more important determinants of the structure of international production and income is going to be the pattern
of international investment and the nature of technology transfers that are at least partly linked to capital flows.

Trade policy itself will influence international capital flows and the first set of experiments above therefore constitute only a first approximation to the full effects of alternative trade and growth strategies. It is for instance clear that foreign investment constitutes an integral part of a Brazilian-type growth strategy.

The challenge will be to make at least part of private international investment endogenous in the model responding to such factors as regional profit rates, tax and profit repatriation laws and degrees of perceived risk. This constitutes an uncharted area for general equilibrium practitioners providing a difficult but exciting new challenge for modelling. With the short-term and long-term debt of many developing countries having reached the danger zone; even an approximate treatment of this problem will greatly add to the usefulness of a global model.

Official bilateral and multilateral assistance flows may then be treated as exogenous or as residually determined given some global exogenous growth targets.
VII. Relation to Other Global Models

This section briefly relates the methodology and main features of the model presented above to some of the existing work in the field of global modelling. The models that are probably closest in spirit, at least in terms of their global development form, to our proposed research are the SIMLINK model developed by N. Hicks and others at the World Bank, Leontief's international model developed for the United Nations and the GEM WT (General Equilibrium Model of World Trade) model developed by Ginsburg and Waelbroeck at the Cowles Commission and the World Bank.

The SIMLINK model focuses on a simulation of trade linkages between developed and developing countries, emphasizing primary commodity exports of developing countries. The model is designed for medium-term projections based on exogenously determined growth rates of OECD countries and petroleum prices. It computes capital requirements to achieve target growth rates under the assumption that foreign exchange rather than savings, capital or labor, is the binding constraint that limits growth. We shall attempt to build on the careful work done on commodity markets but, contrary to SIMLINK, our emphasis will be on the industrial sector and industrial performance in the South. Industrial growth and structure is essentially

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1 The multi-country model developed by Deardorff, Stern and Baum is a short-run model focusing on the effects of multi-lateral tariff reductions among developed countries negotiated under the auspices of GATT. The published materials relating to the LINK project indicate that it focuses on linking short-term Keynesian macro-models emphasizing effective demand in the short-run Keynesian sense rather than the long-run structural trends in the world economy.
projected in a partial equilibrium framework in SIMLINK while we shall attempt to model a great deal of general equilibrium interaction and policy alternatives.

The model developed by Leontief is extremely ambitious in terms of disaggregation by regions, sectors and over time. It provides detailed explorations of the implication of different scenarios regarding growth-rates of G.D.P. per capita in different regions and includes an analysis of the constraints imposed on world growth by limited supplies of agricultural goods and minerals as well as by requirements of environmental preservation. The detailed projections derived from the model are based on a generalized input-output methodology and are tied together by the requirement of intersectoral consistency on a global scale. As in other input-output models however, the price mechanism is not explicitly modelled and neither intersectoral nor interregional changes in the terms of trade can be discussed. This severely limits the applicability of generalized input-output models in analyzing questions of commercial policy and trade strategy that will be the most important focus of our own research.

The GEM WT model developed by Ginsburgh and Waelbroeck is no doubt the closest in spirit to our own model although the specifications and computational approaches have quite different starting points. GEM WT is formulated to examine the effects of tariff cuts on developing countries. It is, to our knowledge, the first linear programming type model that correctly incorporates the effects of tariffs in its specification. It is

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1 For an earlier attempt see Evans (1972). For a critique of this approach see De Melo (1977).
also a multi-sector linear programming model that elegantly satisfies the conditions of competitive equilibrium that require the budget constraints of several economic "actors" to be satisfied when evaluated at the shadow prices that are derived from the primal formulation already containing a vector of price weights in the objective function. The iterative technique devised to adjust the primal weights until a competitive equilibrium is found is reported to perform satisfactorily for GEM WT.

Despite the elegance of the formulation and the advantage of having access to standard simplex subroutines between iterations, the linear programming framework would still seem inflexible in three important respects. First, piecewise linearization of a set of inherently non-linear relations very quickly increases the size and cost of the problem. Second, the GEM WT model distinguishes only one "actor" per region. We propose to distinguish explicitly between the government, the private firms, and at least two classes of consumers. Although GEM WT could probably be extended to include these same economic actors the formulation would seem to make such an extension very difficult. Finally, and perhaps most importantly, the handling of bilinear constraints involves alternating between solving mathematical programs giving market clearing prices and revising the bilinear constraints by replacing these prices at each iteration. This clearly limits the flexibility of the linear programming approach while in a CGE approach bilinear constraints do not create any special problems.

Moreover in terms of empirical implementation, the CES Aggregation approach to distinguish commodities of the same category by region of
origin provides further flexibility and will allow a fair amount of sectoral disaggregation. The specification of product differentiation and imperfect substitution will be essential in a study that emphasizes the manufacturing sectors and industrial performance. Although the estimation of elasticities for the CES aggregation will be a difficult task, the model will provide us with a two-way pattern of trade observed in world-wide matrices of trade flows. In addition the assumption of constancy of trade shares found in virtually all multi-region trade models will be relaxed since these shares will be determined by relative prices, themselves determined so as to clear world markets.

Inclusion of more than one actor per region should provide valuable insights on functional distributional issues. For instance it is not clear that policies aiming towards reducing income disparities between regions would also reduce income disparities within regions. Here the distinctions between consumer classes may play a crucial role in determining the net distributional effect of a selected trade strategy.
References


