A C T A U N I V E R S I T A T I S L O D Z I E N S I S
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III. WORLD AND REGIONAL MODELS

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A SIMPLIFIED MODEL OF WORLD TRADE

The world market price and visible trade flow model described below has been specified with a view to obtain a simple and handy tool for eveluating variants in planning and decision making in foreign trade.

The model involves the foreign trade sector of the world economy, assuming exogenously all domestic activities. Thus the model might be considered as a pre-linkage entry to a global world economy model. Domestic activities and policy variables form here scenarios given in a number of variants. Each variant must represent a consistent set of assumptions concerning output by sectors, inflation, exchange rates and balance of payments constraints. E.g. in any scenario the growth of non-oil developing countries must be consistent with a proper variant of the financial aid policy depicted here in the balance of trade constraints, taking into account the necessary debt service requirements. Assumption about inflation rate in the United States must be consistent with that about the dollar exchange rate etc.[1] Comparison of variants allows for investigating the sensitivity of the model to domestic activities and policy decisions.

The model is specified in such a way that official United Nation's (and its specialized agencies) publications are a sufficient source of statistical information.

An advanced personal computer can be successfully used for computation.

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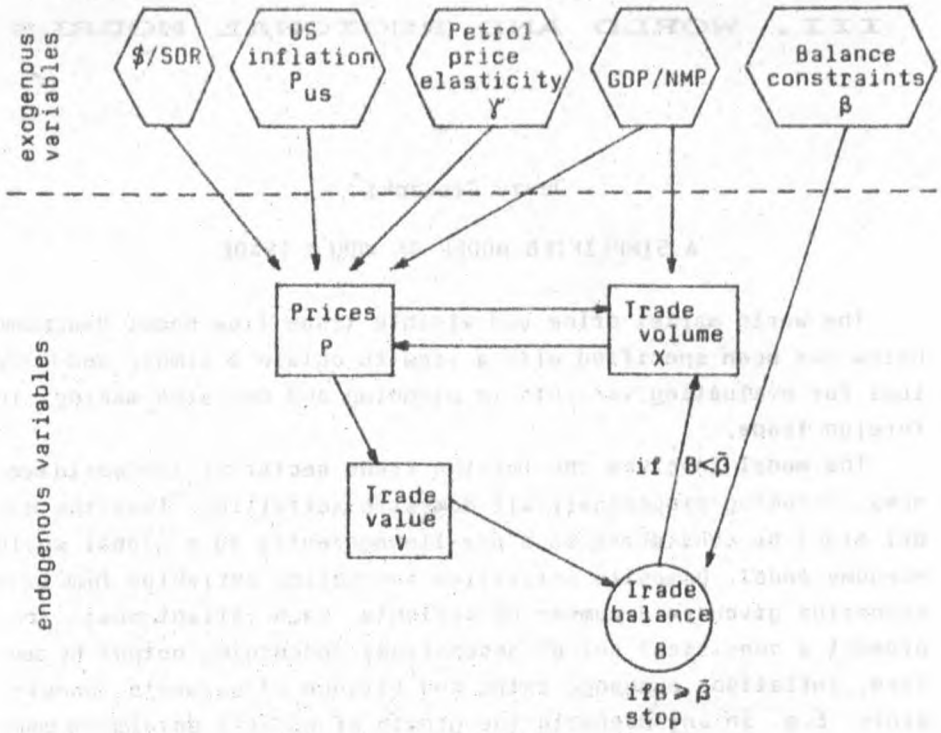
[1] Compare scenarios in the 1985 world economic outlooks of IMF, World Bank and UNCTAD.

The diagram below shows the concept of the model.



The model involves four world regions and 41 commodities aggregated into 6 commodity groups. More formally the model can be presented as follows:

D i m e n s i o n s:

k = 1, ... 41 - number of primary commodities

h = 0, 1, 2, 3 - number of sectors of domestic activity
- 0 = all sectors (GDP/NMP)
- 1 = output of agriculture
- 2 = output of mining
- 3 = output of manufacturing

l = 1, ..., 6 - number of commodity groups
- 1 = SITC 0 + 1 - food
- 2 = SITC 2 + 4 - industrial raw materials
- 3 = SITC 3 - fuels

4 = SITC 68 - non-ferrous metals
5 = SITC (5 + 6 + 7 + 8) - 68 - manufactures
6 = SITC 9 - not specified

i, j = 1, ..., 4 - number of world regions
1 = OECD
2 = OPEC
3 = non-OPEC developing countries
4 = socialist countries of Europe and Asia

E x o g e n o u s v a r i a b l e s:

Y_{hi} - GDP (total and by sectors of origin) of region i (j) (net material product for socialist countries);

P_{us} - GDP deflator in the USA;

$/SDR - index of US dollar vis á vis SDR;

γ - elasticity of petroleum price vis á vis price of manufactures in exports of OECD;

$\bar{B}_i$ - balance of trade constraint for region i (i = 2, 3, 4).

Prices.

$$P_k/P_{man} = f(Q_k, Y_k) \qquad k \neq \text{petroleum} \qquad (1)$$

Deflated price of commodity k.

$$Q_k = f(X_{1\ldots-1}, Z_k)$$

Z_k - set of optional explanatory variables (e.g. time) (2)

World output of commodity k.

$$\dot{Y}_k = \sum_j a_{jk} Y_{o_j}$$

Y_{o_j} - exogenous (3)

a_{jk} - market share of region j in imports of k

$(\sum_j a_{jk} = 1.0)$

Demand for commodity k.

$$P_{man}/P'_{us} = f(\$/SDR, P_1 \qquad 1 = 2, 3, 4 \qquad (4)$$

Deflated price of manufactures.

$$P_{petr} = P_{man}^{\gamma} \qquad \gamma \text{ - exogenous} \qquad (5)$$

Price of petroleum.

$$P_{li.} = f\left(\sum_k b_{kli} P_k\right) \qquad \sum_k b_{kli} = 1.0,\ P_k \in P_1 \qquad (6)$$

Price of commodity group l in exports of i (to all regions).

$$P_{lij} = f(P_{li.}) \qquad i, j \neq 4,4 \qquad (7)$$

Price of commodity group l in exports from i to j.

$$P_{l.j} = \sum_i c_{lij} P_{lij} \qquad \sum_i c_{lij} = 1.0 \qquad (8)$$

Price of commodity group l in imports of j (from all regions).

$$P_{l44} = (P_{li.-1} + P_{li.-2} + P_{li.-3} + P_{li.-4} + P_{li.-5})/5.0 \qquad (9)$$

Price of l in CMEA intra trade. i = OECD

Trade flows.

$$X_{l.j} = f(Y_{hj}, P_{l.j}/P_{man}, Z_j) \qquad l \neq 5 \text{ (manufactures)} \qquad (10)$$

Volume of imports in commodity group l to region j.

$$X_{man.j} = f(Y_{hj}, P_{man.j}/P_w, Z_j) \qquad P_w = \text{aggregated index of world export prices} \qquad (10a)$$

Volume of manufactured imports to region j.

$$X_{li.} = f(Y, P_{i.}/P_{man}, Z_i) \qquad l \neq 5 \text{ (manufactures)} \qquad (11)$$

Volume of exports in commodity group l by region i.

$$Y = \begin{cases} Y_{hi} & \text{- in supply-type functions} \\ \sum_j (X_{lij_{-1}}/X_{li._{-1}})\, Y_{hj} & \text{- in demand-type functions} \end{cases}$$

$$X_{\text{man i.}} = f(Y, P_{\text{man i.}}/P_w, Z_i), \tag{11a}$$

Volume of manufactured exports from region i.

$$\sum_j X_{l.j} = \sum_i X_{li.} = X_{l..} \tag{12}$$

Matrix identity condition for margins in commodity group l.

$$\delta_{lij} = \hat{X}_{ij}/(\hat{X}_{l.j}\ \hat{X}_{li.}/\hat{X}_{l..}) \tag{13}$$

Estimated delta coefficients.

$$X_{lij} = \delta_{lij}(X_{l.j}\ X_{li.}/X_{l..}), \tag{14}$$

Volume of trade flows in group l from region i to j.

$$\begin{cases} \sum_j X_{lij} = X_{li.}, \\ \sum_i X_{lij} = X_{l.j} \end{cases} \tag{15}$$

$$V_{lij} = X_{lij}\ P_{lij} \tag{16}$$

Value of trade flows.

$$\begin{cases} V_{l.j} = \sum_i V_{lij} \\ V_{li.} = \sum_j V_{lij} \end{cases} \tag{17}$$

Value of margins of the trade flows matrix.

Balance of trade.

$$B_i = \sum_l V_{li.} / \sum_l V_{l.j} \qquad i = j,\ i, j = 2, 3, 4 \quad (i \neq \text{OECD}) \tag{18}$$

Relative balance of trade of region i.

$$B_i \geq \bar{\beta}_i \qquad \bar{\beta}_i \text{ - exogenous (constant or vector)} \qquad (19)$$

Constraint of the balance of trade for i (j).

if

$$B_i < \bar{\beta}_i :$$

$$\begin{cases} X^{norm}_{1i.} = (1.0 + 0.5(1.0 - \bar{\beta}_i/B_i)) * V_{1i.}/P_{1i.}, & i = 2, 3, 4 \\ X^{norm}_{1.j} = (1.0 + 0.5(1.0 - B_j/\bar{\beta}_j)) * V_{1.j}/P_{1.j}, & j = 2, 3, 4 \end{cases}$$

or e.g.:

$$X^{norm}_{man.j} = (V_{man.j} - (\sum_i V_{1.j} - (\sum_j V_{1i.}/\bar{\beta}_j)))/P_{man.j} \qquad \begin{matrix} i = j \\ i, j = 2, 3, 4 \end{matrix} \qquad (20)$$

Balance of trade adjustment for OPEC, non-OPEC developing countries and socialist countries. The adjustments may need iterations.

The price block. The model consists of two recursively interdependent blocks: price and trade flows.

The price block (estimated in rates of growth) consists of 40 mini-models for individual primary commodities solved simultaneously with the price deflator in form of an aggregated price (unit value) of manufactured exports.

The deflated price of each primary commodity (P_k/P_{man} - in terms of US dollars) is assumed to be a function of output (Q_k) and demand (Y_k), the latter approximated by import-weighted GDP of consuming regions - equation (1).

Output of each commodity (2) is assumed to be a function of a lagged level of world demand in a respoctive sector of economy, approximated by export volume in a corresponding commodity group (given endogenously from the trade flow block).

The aggregated price of manufactured exports deflated by the US inflation rate (US GDP deflator) is assumed to be a function of the dollar/SDR rate and of raw material - and fuel prices (4).

As it was found, the price of manufactures is sensitive to fluctuations of the dollar exchange rate and is instrumental in transmitting them into commodity prices and trade flows.

Price of petroleum, representing here prices of energy, is calculated by means of exogenously given elasticity vis á vis prices of manufactures (5).

Prices of individual primary commodities are aggregated into unit value indices for commodity groups (using UN Statistical Office weights) and transformed into entries matching the trade flow matrix (6-8). Unit values for socialist countries intra trade (9) are calculated using the CMEA price formula for primary commodities (five year moving average of world market prices) - with proper adjustment for the historical period.

As it can be seen, the price block has a simultaneous structure of equations (mainly because of the feed-back of the deflator).

The trade block. The trade flow block involves 48 stochastic equations for margins of the volume matrices[2], procedure for computing bilateral flows of these matrices and identities for calculating values of the flows. Thus, the number of vectors in the trade flow matrices (including margins) is 256 + 150 (each for volume, prices and values).

Volume of total imports to each region in each commodity group is explained in a standard form by the level of economic activity (sectoral GDP) of the region and by the import price deflated by aggregated price of manufactures (10). Additional axplanatory variables (as interactive variables, distributed lags, time, zeroone variables, etc. - symbolized by Z_j) are used in case of need. For import of manufactures (10a) a variant with prices deflated by a global index of world export prices is used. Since the demand - type function is used here, the parameter standing by GDP must be positive and that standing by prices - negative.

For the volume of exports both demand and supply functions are envisaged, the latter being implemented practically for some socialist countries' exports only (11,11a). Thus, the supply-type function involves as explanatory variables sectoral output of the

[2] 2 x 4 regional margins x 6 commodity groups.

exporting region (push effect) and the deflated export price - with both parameters positive. The predominantly used demand--type function for export volume involves import weighted output of the importing regions (pull effect) with a positive sign, and deflated price with a negative one.

To reach matrix identity import and export margins of the volume matrix must be normalied (12). A simple (quasi-optimization method for distributing the error is implemented.

Computation of the bilateral flows of the volume matrix is done in the flowing steps:

a) the so called "delta coefficients" (see J. K o t y ń s k i (1985)) are estimated as a ratio of actual and "normative" bilateral flows (13); the "normative" flows are defined for every commodity group as a product of total imports and total exports of each region divided by total trade in this commodity group;

b) bilateral flows are computed as a product of "normative" flows and delta coefficients (14);

c) the consistency of the matrix is reached applying the RAS method (15).

The marit of the above mentioned procedure is a standard way of calculating reliable bilateral flows. Otherwise, using e.g. a direct estimation method for individual flows, calculation of some entries could be very difficult in case of strong fluctuations in trade volumes in the historical period (typical e.g. for some trade flows of socialist countries).

The value matrices of the trade flows are computed in the opposite direction:

a) in the first step, the value of bilateral flows is calculated by multiplying volume by price matrices (16);

b) in the second step, the margins of the value matrices are computed by summing up the bilateral flows.

Dividing value by volume in all margins, a new consistent set of margin prices can be optained. This new set would differ slightly from the originally estimated one and could be substituted for the latter in the next iteration step of the whole computation. However, since the difference turned out to be negligible (predominantly much below one percentage point) feed-back to the price block calculation is exercised in practice.

The balance of trade adjustment. The extrapolated model has to be adjusted for the balance of trade minimum requirements given exogenously in a parametric-type form for world regions, except OECD (18, 19).

The balance of trade constraints have to be imposed for the sake of the feasibility of projections from the point of view of debt service - or absorbtion capacity of the economy.

The adjustment procedure can be exercised in various ways, of which two are given in (20).

The first one involves a standard normalization of all trade flows (proportional distribution of the required adjustment).

The second one concerns adjustments of slectively chosen flows. In the example given in (20) only imports of manufactures are assumed to be adjusted.

Performance of the model. The performance of the model can be judged when comparing historical and computed trade flows, using the flowing formulae for the prediction error:

formula 1 = 100 quadratic mean of differences between computed and historical rates of growth;

formula 2 = 100 quadratic mean of differences between computed and historical value divided by arithmetic mean of historical values.

The results obtained in the inter-sample simulation covering yearly observations for 1965-1981 are as follows Table 1.

Table 1

World trade by regions in current US dollars

Specification	Prediction error, percentage			
	formula 1		formula 2	
	exports	imports	exports	imports
1	2	3	4	5
Food (SITC 0 + 1)				
World	2.8	2.8	1.4	1 4
of which:				
. OECD	4.3	3.9	2.2	2 7
OPEC	6.5	7.8	5.5	6 4

Table 1 (contd.)

1	2	3	4	5
non-OPEC developing countries	3.3	6.6	3.8	6.0
socialist countries	6.4	8.2	6.0	4.9
Industrial raw materials (SITC 2 + 4)				
World	4.6	4.6	4.1	4.1
OECD	5.6	5.5	4.8	4.1
OPEC	5.5	12.0	2.2	8.9
non-OPEC developing countries	5.8	6.3	5.4	15.4
socialist countries	5.9	4.4	3.3	7.2
Fuels (SITS 3)				
World	4.3	4.3	3.6	3.6
OECD	5.9	5.2	3.5	2.1
OPEC	7.7	7.4	6.1	9.2
non-OPEC developing countries	8.7	7.5	6.8	7.8
socialist countr.	5.5	9.5	10.5	8.4
Non-ferrous metals (SITC 68)				
World	5.7	5.7	5.4	5.4
OECD	7.8	7.0	6.8	6.3
OPEC	16.8	13.8	20.3	5.1
non-OPEC developing countries	6.1	9.1	4.8	4.5
socialist countries	7.1	5.5	5.4	3.4
Manufactures (SITC 5 + 6 + 7 + 8 - 68)				
World	3.1	3.1	0.9	0.9
OECD	3.7	4.3	1.2	1.9
OPEC	7.9	5.9	4.5	8.1
non-OPEC developing countries	7.9	3.2	5.0	3.9
socialist countries	4.1	4.5	3.1	2.5

To illustrate the performance of the procedure for calculation of the bilateral flows a matrix of prediction errors according to formula 2 for trade in manufactures is presented in Table 2.

T a b l e 2

Trade in manufactures (SITC 5+6+7+8-68) in current US dollars
Prediction errors according to formula 2 (percentage)

Exports \ Imports	OECD	OPEC	Non-OPEC developing countries	Socialist countries
OECD	2.1	8.3 (6.1)	3.3	4.5
OPEC	6.9	6.7	6.3	6.8
non-OPEC developing coun.	4.1	10.6	8.5 (7.7)	4.2
Socialist countries	4.5	7.0	7.4 (5.3)	2.8

N o t e: In brackets according to formula 1.

References

[1] K o t y ń s k i J. (1985), Intensity of Trade Among the CMEA and the EEC, Warszawa.

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UPROSZCZONY MODEL HANDLU ŚWIATOWEGO

Model opisuje sektor handlu w gospodarce światowej. Przy założeniu egzogenicznych wielkości aktywności gospodarczych może on stanowić "wejście" do modelu gospodarki światowej. Zmienne polityki gospodarczej i działalności ekonomicznej określają wielowariantowe scenariusze, zawierające produkcję, inflację, kursy walut i ograniczenia bilansu płatniczego.

Model składa się z dwóch współzależnych bloków: cen i strumieni handlu. Przeprowadzone warianty symulacyjne pozwalają na prześledzenie "czułości" modelu na zmiany w wielkościach wyrażających aktywność ekonomiczną świata i polityk gospodarczych.