A MEDIUM - TERM DYNAMIC SIMULATION MODEL OF COMECON FOREIGN TRADE

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This paper deals with a possible application of dynamic simulation modelling for medium-term projections of COMECON foreign trade flows. The internal consistency of the projections has been achieved by linking the trade model with multi - sector production models of the COMECON countries. The international consistency is also satisfied through the relationships of a simplified three-region version of a world trade model. Various techniques of mathematical systems theory have been employed in model validation and understanding of the dynamic behaviour of the overall system as well as in searching for the most advantageous economic policies for COMECON countries at an international level.

INTRODUCTION

In a previous work by the author (Biray, 1976) the short term trade projections of the COMECON countries were obtained by three simple but limited models. The limitations stemmed from their disadvantages in the context of medium and long term predictions and their inability to relate the trade flows to the domestic supply and demand factors of the socialist economies. In order to overcome these problems a number of proposals were advanced of which the most promising appeared to be the development of individual regional models for the socialist countries which could then be associated with a separate trade model to be constructed in such a way that the outputs of the regional models (i.e. domestic production capacities, capital stocks, consumption etc.) would be represented as 'internal' activities of the trade model. In addition, a simple model representing the 'rest of the world' countries, (i.e. production levels of the major trading partners, commodity markets etc.) would be used to represent 'external' activities of the trade model. The final system could be restructured in such a way that a complete foreign

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trade model of the COMECON countries would be obtained by linking the regional models in a closed system which could be viewed as a simple world model. Such a system with commodity disaggregation could be complicated but would have the potential : to obtain both internally and internationally consistent trade projections, to project COMECON trade over sufficiently long periods, to allocate labour and investment resources according to the international trade flow patterns, to simulate the economies of the COMECON community and analyse the effects on their multicommodity foreign trade flows, and to investigate the most advantageous foreign trade policies for COMECON countries under different objectives and constraints.

Such an approach seemed to offer a basis for the analysis and later the control of the overall system and it is the purpose of this paper to describe the integrated system that has been developed. For reasons also detailed in the previous work cited, two economic regions only are distinguished within the COMECON community, viz. the U.S.S.R. and secondly the other Eastern European countries excluding Albania because of its negligible share of COMECON trade. The rest of the world countries are then taken as a third region within which EEC countries are singled out as a subregion. The final forms of the regional models are each tested against the period of the time-series data on which they are based (1955-69). The trade model is also based on corresponding time-series data and its consistency is tested against actual trade flows in the observation period. Then, socialist production capacities in several sectors and their multicommodity trade flows are projected up to 1984 by the final system developed. Finally, dynamic simulations of the system are obtained under 25 different hypotheses of investment and labour supply allocation policies.

The study has also been extended to investigate methods for the disaggregation of the regional trade flows, and as an example, the imports of the COMECON countries from the EEC subregion are evaluated. Next, the paper considers the sensitivity of the projections with respect to the stochastic parameters of the overall system.

The approach indicated above has some features in common with a 'gravitational trade network' (Linneman, 1966), however, it is the author's view that the method, as suggested, has greater flexibility than a pure gravity model and moreover greater freedom

is given in the choice of variables which are estimated within the totality of the system, thereby ensuring an internal consistency as well as an international consistency, (with a gravitational model internal consistency cannot be satisfied in general).

Owing to the lack of data for the trade in different commodity groups of the socialist countries, the approach used in this paper has, as far as the author is aware, not been adopted by other western model builders for medium to long term prediction of socialist trade flows. However, it is believed that a similar approach has been attempted in some COMECON countries using inter-sector balances (Szkolszai, 1972) and (UNCTAD, 1972), though not entirely satisfying the international consistency requirement.

PRODUCTION MODEL

1. Explanation of Symbols

$j = 1$	:	Agricultural sector
$j = 2$	:	Industrial sector
$j = 3$	:	Other material sectors
$j = 4$	:	Non-material sectors
$s = 1$	:	The USSR
$s = 2$	:	The other COMECON countries
P_{sj}	:	Production of region s in sector j
K_{sj}	:	Fixed capital stocks of region s in sector j
N_{sj}	:	Working population of region s in sector j
NT_s	:	Total population of region s
NW_s	:	Total working population of region s
$Nnm_s = N_{s4}$	:	Total working population of region s in non-material sectors
Nm_s	:	Total working population of region s in material sectors
V_{sj}	:	Gross investments of region s in sector j
$VN_s = V_{s4}$	:	Gross investments of region s in non-material sectors
CF_s	:	Total final consumption of region s
IM_s	:	Total imports of region s
EX_s	:	Total exports of region s
t	:	Simple time trend
${}^{N}u_{sj}$, ${}^{V}u_{sj}$	:	Control parameters for employment and investment policies of region s in sector j.
VT_s	:	Total investments
YN_s	:	Gross national income of region s
CP_s	:	Productive consumption of region s

2. General Description

The models constructed for the two regions, namely the USSR and the other COMECON countries, are very similar except for minor changes in some of the equations. A brief description is given below of the main features and the common structure of the regional production models.

The production model is disaggregated into three major productive sectors; the industry, the agricultural sector, and the rest of the material sectors including construction. The fourth and final sector of the economy is assumed to be the non-productive sector. The model is designed in such a way that the production and supply factors of the economy can be estimated effectively by the basic input quantities which are investments and labour supply, and the controlled development of the economy can be studied by simulating various hypotheses on the allocation of investments and manpower to different sectors. The general equations of the model are as follows :

Investments :

$$V_j = {}^{V}a_j \, YN\,(t\text{-}1) \qquad (1)$$

where

$${}^{V}a_j = ({}^{V}\alpha_j + {}^{V}\beta_j \, t)\,[1 + {}^{V}u_j \, f(t)]$$

and

$${}^{V}u_j = 0 \text{ for } j = 2,4$$

$${}^{V}e_j \leq {}^{V}u_j \leq {}^{V}e_j' \text{ for } j = 1,3$$

${}^{V}\alpha_j$, ${}^{V}\beta_j$ are constants

e_j, ${}^{V}e_j'$ are lower and upper limits set for policy decisions

$$VT = \sum_{j=1}^{4} V_j$$

Capital stocks

$$K_j = K_j\,(t\text{-}1) + {}^{K}a_j \, V_j \qquad j = 1, \ldots, 3 \qquad (2)$$

where

$${}^{K}a_j = [0.2 \sum_{\tau=t-5}^{t} V_j(\tau) / \Delta K_j(\tau\text{-}1)] + {}^{K}\beta_j \, t$$

Labour supply :

$$NW = {}^{NW}a + {}^{NW}b\ t \quad (3)$$

$$N_4 = {}^{N}a_4\ NW \quad (4)$$

$$N_m = NW - N_4 \quad (5)$$

$$N_1 = {}^{N}a_1\ Nm \quad (6)$$

$$N_2 = ({}^{N}a_2/K_2) + {}^{N}b_2 \quad (7)$$

$$N_3 = Nm - (N_1 + N_4) \quad (8)$$

where

$${}^{N}a_j = ({}^{N}\alpha_j + {}^{N}\beta_j\ t)\ [\ 1 + {}^{N}u_j\ f\ (t)\ ]$$

and

$${}^{N}e_j \leq {}^{N}u_j \leq {}^{N}e_j' \quad \text{for } j = 1,4$$

Production :

$$P_j = {}^{P}a_j\ K_j + {}^{P}b_j\ N_j + {}^{P}c_j \quad \text{for } j = 1,3 \quad (9)$$

$$P_2 = {}^{P}a_2\ P_2\ (t\text{-}1) + {}^{P}b_2\ N_2 + {}^{P}c_2 \quad (10)$$

and

$$PT = \sum_{i=1}^{3} P_j$$

Consumption :

$$CF = {}^{CF}a\ YN\ (t\text{-}1) \quad (11)$$

$$CP = \sum_{i=1}^{3} CP_i \quad (13)$$

$$CP_i = \sum_{i=1}^{3} {}^{CP}a_j\ P_j \qquad i = 1, \ldots, 3 \quad (12)$$

External trade :

$$IM_s = X_{TsK} \quad (14)$$

$$EX_s = X_{sTk} \quad (15)$$

where X_{TsK} and X_{sTK} are estimated by the trade model

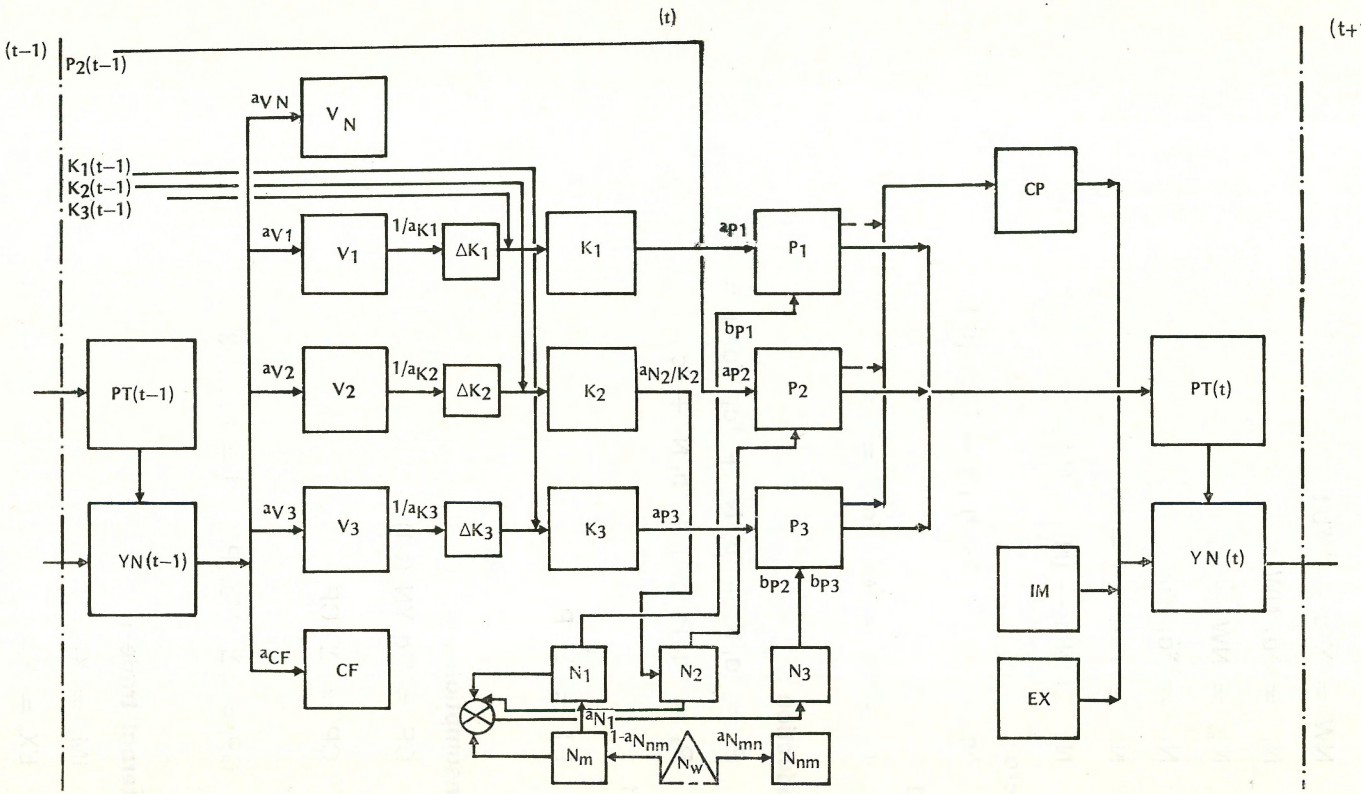


Figure 1. The block diagram of the production model

Gross national income :

$$YN = PT - CP + IM - EX \qquad (16)$$

The equations (14) and (15) are initially replaced by stochastic equations for the total imports and exports of each region in order to test the validity of the production model. The model is then a recursive one, and the ordinary least squares method can efficiently be applied for the estimations of the parameters in the stochastic equations. The data used for the estimations is the time-series of annual returns for the period 1955-1969. The model is dynamic because it includes lagged variables, and the parameters of non-stochastic equations are regular time functions. A block diagram of the model is shown in Figure 1.

A MULTICOMMODITY MODEL OF COMECON TRADE

1. Explanation of Symbols

$k = 1$	:	Commodity group 1 = SITC 0,1 (food, beverages and tobacco)
$k = 2$	:	Commodity group 2 = SITC 2,4 (crude materials excluding fuels and oils, and fats)
$k = 3$	:	Commodity group 3 = SITC 3 (mineral fuels, lubricants and related materials)
$k = 4$	:	Commodity group 4 = SITC 5-9 (all manufactured goods)
$s = 1$	:	The USSR
$s = 2$	:	The other COMECON countries
S	:	COMECON countries, $S = \{1, 2\}$
R	:	Rest of the world countries
T	:	All the countries in the world
K	:	Total trade flows
E	:	The EEC Region
X_{Rsk}	:	The imports of region s from the rest of the world in commodity k
$X_{s's k}$	:	The imports of regions s from region s' in commodity k;
X_{Tsk}	:	The total imports of region s in commodity k
X_{sRk}	:	The imports of the rest of the world countries from region s in commodity k

X_{sTk} : The total exports of region s in commodity k

X_{Esk} : The imports of region s from the EEC countries in commodity k;

X_{sEk} : The export of region s to the EEC countries in commodity k

X (t-1) : One year lag introduced to the variable X

X_{TTk} : Total world trade in commodity k

F : The external activities of the COMECON community

Y : The domestic supply and demand variables

L : Lagged endogenous variables

D : Dependent explanatory variables

m : A subregion of non-COMECON area

n : A country in the COMECON region

a_{nmk} : The share coefficient for the exports of the COMECON country n to the subregion m of non-COMECON area

M_s : Production model for COMECON region s

2. General Description

The dynamic input-output tables are considered as one of the most appropriate methods to project the external trade of the COMECON countries and they have been widey used by some centrally planned countries in recent years (Morva, 1972) and (—,1970). The other two methodological approaches to the projections of socialist trade are the delta coefficients method and gravitational models. The experiments on projecting COMECON trade using delta coefficients show that corrections to the delta coefficients, compared with previous trends, are often necessary and more precise methods of taking into account the expected deviations should be developed. It is proposed here that gravity models would be more suited to the projection of COMECON trade when a number of other important methodological problems are solved. The disaggregation of mono-product gravity models into the commodity ones might be the first step to improve the methodology. Moreover, the COMECON trade model could be based on basic assumptions which are implied to a complete closed world system where a balance between the total turnover of the COMECON countries and that of the world is struck.

The following assumptions are therefore made in the present model :

1. The world countries are divided into two major groups. Group S denotes the COMECON countries and gorup R represents the rest of the world.
2. The intra-trade of non-COMECON countries is not considered.
3. Exports of socialist countries are both supply and demand determined, but more attention is given to the internal supply factors.
4. The disaggregated trade network is based on export and import shares.
5. Imports of COMECON countries are determined by the internal demand, the world market, and the payment possibilities.
6. The system of international economic relations among the countries of COMECON and with the rest of the world countries are based on stabilized prices agreed and fixed for long periods and are not influenced by short-term fluctuations.
7. A uniform decomposition of imports is used having four main commodity groups for all the countries: SITC 0, 1; SITC 2,4; SITC 3; SITC 5-9.

In formal terms the COMECON trade model may be stated as follows:

$s, s' = 1, 2 \qquad k = 1, \ldots, 4$

$$X_{Rsk} = f(F_{Rsk}, Y_{Rsk}, L_{Rsk}, D_{Rsk}) \tag{17}$$

$$X_{RsK} = \sum_{k} X_{Rsk} \tag{18}$$

$$X_{s's k} = f(Y_{s's k}, L_{s's k}, D_{s's k}) \tag{19}$$

$$X_{SsK} = \sum_{s'} \sum_{k} X_{s's k} \tag{20}$$

$$X_{Tsk} = X_{Rsk} + X_{s's k} \tag{21}$$

$$X_{TsK} = \sum_{k} X_{Tsk} \tag{22}$$

$$X_{sRk} = f(F_{sRk}, Y_{sRk}, L_{sRk}) \tag{23}$$

$$X_{sRK} = \sum_{k} X_{sRk} \tag{24}$$

$$X_{sTk} = X_{ss'k} + X_{sRk} \tag{25}$$

$$X_{sTk} = \sum_{k} X_{sTk} \quad (26)$$

$$Z_{Rsk} = \sum_{k} (X_{sRk} - X_{Rsk}) \quad (27)$$

$$Z_{s,sK} = \sum_{k} (X_{ss,k} - X_{s,sk}) \quad (28)$$

$$Z_{TsK} = Z_{RsK} + Z_{s,sK} \quad (29)$$

$$X_{msk} = a_{msk} X_{Rsk} \quad (30)$$

$$X_{Rnk} = a_{Rnk} X_{Rsk} \quad (31)$$

$$X_{nmk} = a_{nmk} X_{sRk} \quad (32)$$

$$F_{ijk} = f(t) \quad (33)$$

$$Y_{ijk} = f(M_s) \quad (34)$$

The methodology adopted to project COMECON foreign trade is as follows : first the imports of the COMECON regions from the rest of the world are estimated, secondly the intra-trade of the socialist community is projected and using the import vectors of the rest of the world countries, which could be obtained from the LINK system as explained in (Ball, 1973), the exports of the COMECON regions are calculated. In this study, however, the imports of the rest of the world countries are also projected within the overall trade model.

LINKAGE OF REGIONAL MODELS

A simple three-region world model can be obtained by linking

1. a country model for the USSR
2. a regional model for the other COMECON countries
3. a regional model for the non-COMECON area

The regional models, and therefore the overall system, are obtained by combining the regional production models with parts of the COMECON trade model. The final form of the system is then as follows :

$$\mathbf{X}_1 = f[\mathbf{X}_1, \mathbf{X}_2, \mathbf{X}_1(t-1), \mathbf{X}_2(t-1), \mathbf{X}_R, \mathbf{u}_1, t] \quad (35)$$

$$\mathbf{X}_2 = f[\mathbf{X}_2, \mathbf{X}_1, \mathbf{X}_2(t-1), \mathbf{X}_1(t-1), \mathbf{X}_R, \mathbf{u}_2, t] \quad (36)$$

$$\mathbf{X}_R = f[\mathbf{X}_1, \mathbf{X}_2, \mathbf{X}_1(t-1), \mathbf{X}_2(t-1), \mathbf{X}_R(t-1), t] \quad (37)$$

where

$\mathbf{X}_1$ = a vector of m_1 endegenous variables

$\mathbf{X}_2$ = a vector of m_2 endogenous variables

$\mathbf{X}_R$ = a vector of n exogenous variables

$\mathbf{u}_{1,2}$ = vectors of k control variables

and when the models are linked :

$$\mathbf{X} = f(\mathbf{X}, \mathbf{X}(t-1), \mathbf{u}, t)$$

where

$\mathbf{x}$ = a vector of r (equal to $m_1 + m_2 + n$) variables

$\mathbf{u}$ = a vector of p (equal to 2k) control variables

A state-space representation of the above system is not possible unless some important structural changes are introduced into the models. As the models are non-linear including time-variant parameters, and dimensionally large, no attempt has been made to restructure the models at this stage of the study. Nevertheless, a matrix-notation formulation of the final system could be obtained as follows :

$$\mathbf{X}(t) = \mathbf{A}_o \mathbf{X}(t) + \mathbf{A}_1 \mathbf{X}(t-1) + \mathbf{B}_o \mathbf{LX}(t) + \mathbf{C}_1 \mathbf{U}(t-1) + \mathbf{D}_1 \mathbf{EY}(t-1) \quad (39)$$

where

LX : a vector of h non-linear dependent explanatory variables.

u : a vector of p input variables

EY : a vector of s exogenous variables

$\mathbf{A}_o$ $\mathbf{A}_1$: r x r matrices of constant and linearly time-variant parameters

$\mathbf{B}_o$: an r x h matrix of constant parameters

$\mathbf{C}_1$: an r x p matrix of time-variant parameters

$\mathbf{D}_1$: an r x s matrix of constant parameters

The elements in the control matrix are in the form

$$c_{ij} = u_j f(t) (a_{ij} + b_{ij} t) \quad (40)$$

where the control parameters u_j are chosen as

$$P = \{{}^{V}u_{s1}, {}^{V}u_{s3}, {}^{N}u_{s1}, {}^{N}u_{s4}\} \quad , \quad s = 1,2$$

PARAMETER ESTIMATION AND MODEL VALIDITY

The validity of the models and the performance of the final system depend mainly upon the efficiency in estimating the stochastic parameters of the model. Considering the complexity and the size of the system the following procedure has been followed in order to obtain a significant explanation for each individual economic relation within the restrictions set by economic theory and statistical tests.

(i) A factor analysis method has been used to establish the significances of a number of variables in explaining the variation of each dependent variable in the models.

(ii) The stochastic parameters are then estimated by using the ordinary least squares method, and an initial structure of the model is formed by selecting the best possible explanations of the dependent variables, verified by statistical tests.

(iii) The initial forms of the individual models are then linked, and all the stochastic parameters are re-estimated within the closed form of the system by using a two-stage least squares method.

(iv) The computation of parameters are made continuously as various minor modifications are introduced until a reasonably satisfactory final form of the system is reached.

The best way to test the consistency of the system developed is to project the dependent variables in the observation period and compare the predictions with actual values. The comparisons can be illustrated either graphically or by computing the predictive accuracy over the sample period according to the formula :

$$PE = \frac{[n \Sigma (XP_i - XA_i)^2]^{1/2}}{\Sigma XA_i} \times 100$$

where

PE : average prediction error

XA_i : actual values of the variables

XP_i : predicted values of the variables

$i = 1, \ldots, n$: number of observations and predictions in the sample period

The performance of the system is investigated in the final two-thirds of the sample period as 1960 is taken to be the base year

and the values of the input variables and the time-variant parameters are adjusted accordingly. All the dependent variables are projected in the period 1960-72 and the computer results are plotted for a graphical analysis; additionally, the average prediction errors are computed for each stochastic relationship. The results indicated that the overall performance of the system was quite satisfactory. However in some commodity trade flow equations, standard errors in parameters as large as their own values could not be avoided. For these commodities the unpredictable and highly fluctuating nature of the historical development of trade makes it almost impossible to fit a linear or a simple non-linear stochastic relationship in order to obtain a significant explanation. The poor explanation is also generally due to the fact that the models lack a mechanism to explain short-term fluctuations as well as structural changes in the COMECON economies and their international policies.

PROJECTIONS

The base year for the projections up to 1984 is taken to be 1967 in order to see how closely the predictions match with the actual values between 1967 and 1969 and with the previous projections when the base year is 1960 in the period 1967-72. The computer results have been plotted for the long-term projection of each dependent variable (Biray, 1973). The long-term growth pattern of the socialist economies and their international trade flows in each commodity group depending upon the growth of domestic supply and demand factors, and also the external activities could be analysed individually from these graphs thereby giving an economic interpretation for each graph. However, this kind of detailed economic interpretation would be meaningless unless the error space for the projections is sufficiently narrowed. The comparison of the predictions for the export vectors which were computed by two different ways would also be of great interest. Generally, it is observed that the results are reasonably close, which indicates the internal consistency of the system, except for the exports of manufactured goods for which the exporting capacity of the COMECON countries has been found to be slightly more than the external demands.

1. Comparison of Results with ECE Projections

Projections of international trade flows have been made by ECE (1973) making use of the delta coefficients method. The base year

is taken to be 1967 and the projections are obtained for 1980. In the ECE Model of world trade a geographical breakdown of ten regions are assumed and regional trade flows are disaggregated into three commodity groups. The projections are obtained for two alternative variants defined by different assumptions of growth rates of GDP of the regions involved. Comparison of the predictions can only be made for aggregated trade flows, because in the ECE model all of the COMECON countries are taken as one separate region and a different classification of commodity breakdown is accepted. The following table is derived to illustrate the possible comparison of the predicted regional trade flows :

Table 1
Some Comparisons with ECE Projections

	Average Growth Rate of COMECON Trade %, (1967-80)		COMECON Trade % of World Trade in 1980	
Model	**Exports**	**Imports**	**Exports**	**Imports**
ECE Model 1	8.6	8.4	10.8	9.9
ECE Model 2	6.4	6.5	10.0	5.0
COMECON Model	7.1	7.3	10.5	10.3

COMECON Trade Forecasts for 1980
(in millions of 1967 US $)

Model	Exports	Imports
Actuual Values in 1967	21262	20558
ECE Model 1	62248	58767
ECE Model 2	47429	46480
COMECON Model	56802	55960

2. Comparison of Results with UNCTAD Projections

UNCTAD has also developed a detailed gravity model to project the foreign trade of COMECON countries. The numerical results of UNCTAD-74 Model (Glowacki, 1974) are given in 7 variants, but only one of the variants (Variant I) is used for comparison purposes because its assumptions for the domestic activity levels are closest to the ones projected by the COMECON Model. The COMECON foreign trade was projected by UNCTAD only up to 1976 by taking 1970 as the base year, therefore comparisons are tabulated in Table 2 for the period 1970-76.

Table 2
Some Comparisons with UNCTAD Projections

	Total COMECON Trade			
	Exports		Imports	
	Growth Ratio 1976-70	Compound Growth Rate	Growth Ratio 1976-70	Compound Growth Rate
Intra-COMECON				
UNCTAD Model	1.521	7.2 %	1.521	7.2 %
COMECON Model	1.446	6.6 %	1.446	6.6 %
Non-COMECON				
UNCTAD Model	1.757	9.8 %	1.816	10.5 %
COMECON Model	1.552	7.6 %	1.653	8.8 %
Total				
UNCTAD Model	1.611	8.3 %	1.629	8.5 %
COMECON Model	1.497	7.0 %	1.514	7.2 %

Balance of Trade Forecast for 1976
(in billions of 1970 US $)

	With Non-COMECON Area	Regional Total	Cumulative Export-Import Ratio (1970-76)
The USSR			
UNCTAD Model	1.439	0.753	1.240
COMECON Model	1.176	1.105	1.067
COMECON excluding USSR			
UNCTAD Model	-0.644	0.042	0.903
COMECON Model	-0.001	0.071	1.003

It is clearly noted that UNCTAD-74 Model predicts larger growth rates for COMECON trade flows, especially for the imports of COMECON excluding USRR from non-COMECON and for the exports of USSR to non-COMECON. The main reason for this lies in the fact that in the UNCTAD-74 Model assumed growth rates of the domestic demand and supply factors for the COMECON regions have higher values than those projected by the COMECON Model, and they are also kept constant throughout the prediction period.

DISAGGREGATION

1. General Methodology

In the previous section, trade flows in every commodity group were projected seperately for the COMECON and non-COMECON areas, subject to decomposition by countries and subregions.

Within the COMECON area, two subregions were distinguished for the regression analysis considering the difference in the trade behaviour between the USSR and the rest of the COMECON countries. Various disaggregation methods can be employed for the decomposition of the intra-COMECON trade (exluding the USSR) and the non-COMECON trade by countries. However, in this study, due to the large amount of analytical work required only the projections of COMECON imports from the EEC countries are evaluated in order to investigate the applicability of these methods.

Export-shares matrices are the basis in obtaining disaggregated export forecasts from the regional imports projected by the COMECON trade model. The reliability of the export forecasts largely depends upon how well the shares matrix itself is projected. The projected shares matrix must have two characteristics. Firstly, all shares must be non-negative and not greater than one; secondly, the sum of shares in any market must be equal to one. These two conditions can be satisfied simply by using a shares matrix of some previous period, or average of previous periods as the forecast matrix. One of the most popular methods for the projection of export-shares ccefficients is based on a Koyck-type formulation (Armington, 1969) and it is designed to modify the export-shares matrix by both current and lagged price effects. A similar but a logarithmic version of this approach is currently used in the LINK system by Moriguchi (1973) in the following form :

$$\ln (a_{rsk}) = e_{rsk} + b_{rsk} \ln [a_{rsk} (t-1)] + c_{rsk} \ln (PM_{sk}/PX_{rk}) + d_{rsk} \ln (X_{rTk}/X_{Rsk}) \quad (42)$$

where

PM_{sk} : The import price of COMECON country s exluding exports from non-COMECON country r for commodity k

PX_{rk} : the export price of country r for commodity k

X_{rTk} : total exports of country r in commodity k

X_{Rsk} : totai imports of COMECON country s from the rest of the world countries in commodity k.

2. Estimation of COMECON Imports From the EEC Countries

Two different disaggregation methods are used to obtain the forecast of the exports of the EEC countries, which are taken as a subregion of the non-COMECON area, to the COMECON community from the regional import projections estimated by the COMECON trade model. Obviously, the historical data for the share coefficients will be the basis of any kind of forecast for the future period. The share coefficients in the observation period (1955-69) are obtained simply as follows :

$$a_{Esk} = \frac{X_{Rsk}}{X_{Esk}} \quad , \quad s = 1,2 \quad k = 1,\ldots,4 \tag{43}$$

The first method to be applied is a simple lagged shares estimation procedure :

$$\triangle a_{Esk}(t) = \tfrac{1}{2}\, \triangle a_{Esk}(t\text{-}1) + \tfrac{1}{2}\, \triangle a_{Esk}(t\text{-}2)$$

with the computer algorithm,

$$a_{Esk}(t) = 1.5\, a_{Esk}(t\text{-}1) - 0.5\, a_{Esk}(t\text{-}3)$$
$$s = 1,2 \quad k = 1,\ldots,4 \tag{44}$$

Secondly, Moriguchi's method was used, however, excluding the term with export and import price variables. The parameters of the multicommodity disaggregation equations are estimated and the results are included in the final form of the system. The projections of the EEC exports to the COMECON regions are computed first within the observation period and then up to 1984. Some of the actual and projected values of the multicommodity exports of the EEC countries to the COMECON regions are compared in Table 3.

SENSITIVITY ANALYSIS

The models constructed in the previous sections were viewed as deterministic systems whose parameters were known exactly and fixed. This assumption is, however, not a fair one, because the equations of each model were estimated statistically, therefore the parameters of the system are random variables and their values should be considered as numbers which are known only within some margin of error. For this reason, the sensitivity of the system's behaviour to each and every parameter value should be analysed in a systematic way. This would be a very difficult task because of the lar-

Table 3
Projection of COMECON Imports from the EEC Community (in millions of current US $)

Trade Flow	Actual Values			Projection by Method 1			Projection by Method 2		
	1960	1964	1969	1960	1964	1969	1960	1964	1969
X_{E11}	7	33	24	13	17	28	11	13	20
X_{E12}	9	17	12	11	12	15	13	15	17
X_{E13}	0	0	1	0	0	0	0	0	0
X_{E14}	394	330	1023	293	400	683	300	432	757
X_{E21}	26	112	111	82	95	118	39	61	104
X_{E22}	53	69	88	62	68	92	60	66	88
X_{E23}	3	6	15	3	4	8	3	4	8
X_{E24}	445	643	1426	480	689	1323	505	710	1294

ge number of stochastic parameters involved. Therefore, in this section the sensitivity of the system is explored only to the changes in the parameters of the regional production models. This analysis leaves out at least 100 other stochastic parameters. Nevertheless, it gives enough information on the validity of the models and to judge to what extent the results of the simulation experiments, which will be undertaken in the next section, could be relied upon for a macroeconomic policy analysis.

1. Methodology

A simple analytical technique for the application of sensitivity theory to our discrete-time system would be to obtain the elasticity-type coefficients computed according to the formula :

$$\varepsilon_{ij} = \frac{(X_i - X'_i) / X_i}{(P_j - P'_j) / P_j}$$

$i = 1, \ldots, n$

$j = 1, \ldots, m$

where $\mathbf{X}_t$: the state vector

$\mathbf{P}_t$: the parameter vector

This analytical procedure will enable us to compute the n x m matrix of sensitivity coefficients ε_{ij} for each year of the prediction period. The investigations are then carried out in the following order by examining :

(i) the sensitivity of the endogenous trade variables to the changes in the domestic production levels,

(ii) the sensitivity of the system to the variations of stochastic parameters when the deviations are taken as

a. 5 % of the values of parameters

b. 10 % of the standard errors of the parameters.

2. The Sensitivity to Domestic Activities

The sensitivity coefficients in this analysis are computed by using the formula,

$$\varepsilon = \frac{(X_{max}/X_{min}) - 1.0}{(P_{max}/P_{min}) - 1.0} \qquad (46)$$

where X_{max} and X_{min} stand for trade flows and P_{max} and P_{min} for production capacities in the highest (max) and lowest (min) projection variants respectively. As an example, the sensitivities of the multicommodity import projections of COMECON countries to the changes in regional NMP levels are investigated and the computed coefficients are listed in Table 4 for 1975.

Table 4
Sensitivity of COMECON Import Projections to the Changes in Regional NMP Levels

	Imports from non-COMECON Area		Intra-COMECON Imports	
Commodity Group	USSR	COMECON exc. USRR	USSR	COMECON exc. USRR
SITC 0,1	2.44	0.00	0.03	0.56
SITC 2,4	6.06	2.62	2.24	0.98
SITC 3	9.00	1.45	0.44	1.45
SITC 5-9	1.61	1.30	0.71	1.21
SITC 0-9	2.05	1.24	0.65	1.13

It is interesting to note that mainly the imports of crude materials of both COMECON subregions are very sensitive to domestic production levels. The highest elasticity observed is in the imports of fuels of the USSR from the non-COMECON area. However, this

coefficient should be ignored entirely by considering the fact that the volume of this particular bilateral trade flow is negligibly small.

3. The Sensitivity to Stochastic Parameter Values

The sensitivity experiments are carried out in two groups. In the first group, the parameters are increased or decreased by 5 % of their values. In the second group of experiments, the standard errors of the parameters are taken as the basis for the computations of incremental changes. Considering the fact that "t-ratio" value should be at least 2.0 for a statistically significant parameter, the incremental change for each parameter is calculated as 10 % of its standard error, which corresponds to maximum of 5 % change in the parameter value.

The parameter vector of interest for the analysis includes the following stochastic parameters of the regional production models:
$P = \{{}^{K}a_{s2}, {}^{P}a_{s1}, {}^{P}b_{s1}, {}^{P}a_{s2}, {}^{P}b_{s2}, {}^{P}a_{s3}, {}^{P}b_{s3}\}$ $s = 1,2$

Sensitivity coefficients of the variables X_i relative to parameters P_j can be viewed as functions of time and changing parameter values. If m is the number of variables, n is the number of experiments, and T is the number of years in the projection period, then

$$\varepsilon_{ij}(t) = f(P, t) \quad i = 1, \ldots, m \; i = 1, \ldots, n \qquad (46)$$

$t = 1, \ldots, T$ N = Total number of experiments

Therefore, the results of the computations of $\varepsilon_{ij}(t)$ could be tabulated in T nxm matrices. A small part of the computed sensitivity matrix for some selected variables in 1975 is tabulated in Table 5. The entire set of simulation experiments, N, includes cases when more than one stochastic parameter values are changed. This enables us to investigate how much the sensitivity of the system is affected when a number of stochastic parameters of the system are allowed to vary at the same time on their limits of statistical significance.

The results indicate that the model is generally not very sensitive to the stochastic parameters of regional production models, except for the coefficient of marginal productivity of labour supply in the industrial sector of the USSR's economy. The reason for this high sensivity lies in the fact that the estimation of the industrial production by the present form of the equation is clearly dominated by this particular autoregressive coefficient, and the level of the

Exp. No.	P_{11}	P_{12}	P_{13}	P_{21}	P_{22}	P_{23}	X_{R1K}	X_{21K}	M_{1TK}	X_{R2K}	X_{12K}	X_{22K}	X_{2TK}	X_{1RK}	X_{2RK}
21	0.01	-0.91	0.02	-0.01	-0.73	0.24	-0.26	-0.10	-0.03	-0.06	-0.05	-0.17	-0.19	0.01	-0.33
22	0.01	-0.91	0.02	-0.01	-0.74	0.24	-0.26	-0.10	-0.03	-0.05	-0.05	-0.17	-0.19	0.01	-0.34
23	-0.69	-0.09	-0.17	0.82	0.07	0.19	-1.04	0.23	-0.57	0.77	0.66	0.56	0.90	-1.39	1.36
24	-0.72	-0.09	-0.18	0.82	0.07	0.19	-1.12	0.23	-0.60	0.76	0.66	0.56	0.90	-1.45	1.35
25	4.23	0.52	1.05	0.87	0.08	0.23	7.29	0.47	4.27	0.83	0.71	0.60	1.09	8.53	1.45
26	3.47	0.44	0.86	0.87	0.08	0.23	4.91	0.44	3.53	0.83	0.71	0.60	1.06	6.98	1.45
27	-0.03	4.14	0.31	0.06	1.47	0.10	1.32	0.17	0.08	0.26	0.24	0.48	0.43	-0.06	0.69
28	-0.03	3.09	0.24	0.05	1.30	0.09	1.00	0.15	0.07	0.23	0.21	0.43	0.38	-0.05	0.59
29	0.03	-3.28	-0.25	-0.04	-0.93	-0.06	-1.06	-0.16	-0.08	-0.16	-0.15	-0.31	-0.27	0.05	-0.42
30	-0.03	3.28	0.25	0.04	0.93	0.06	1.06	0.16	0.08	0.16	0.15	0.31	0.27	0.05	0.42
31	-0.03	0.13	2.07	0.14	0.08	2.15	0.98	0.18	0.34	0.56	0.52	0.65	0.34	-0.05	0.33
32	-0.03	0.13	2.06	0.14	0.08	2.13	0.97	0.18	0.34	0.56	0.52	0.64	0.34	-0.05	0.33
33	0.01	-0.04	-0.60	-0.03	-0.02	-0.41	-0.28	-0.05	-0.10	-0.11	-0.10	-0.12	-0.07	0.02	-0.06
34	-0.01	0.04	0.60	0.03	0.02	0.41	0.28	0.05	0.10	0.11	0.10	0.12	0.07	-0.02	0.06
35	3.50	-10.74	-1.32	0.79	-8.71	-6.04	1.48	0.11	3.09	-1.58	-1.57	-3.62	-1.64	7.02	-2.29
36	2.76	11.08	2.81	2.40	9.01	6.78	8.25	1.27	3.49	4.59	4.14	5.80	5.42	15.58	7.57
37	-0.22	30.12	0.98	0.01	3.34	-1.30	9.32	0.36	-0.15	0.07	0.07	0.54	0.74	-0.39	1.42
38	-0.12	10.06	2.11	0.28	3.10	2.24	4.14	0.58	-0.44	1.08	1.00	1.65	1.24	-0.21	1.72
39	0.00	0.01	0.20	0.12	0.07	1.76	0.09	0.12	0.22	0.47	0.43	0.54	0.29	0.00	0.28
40	0.00	0.01	0.20	0.12	0.07	1.74	0.09	0.11	0.22	0.46	0.43	0.53	0.29	0.00	0.27

Table 5. Sensitivity coefficients of some selected variables in 1975 - when parameters are varied by 10 % of their standard deviations.

industrial production of the USSR plays an important role in the projections of COMECON trade, especially of the trade of the USSR with the non-COMECON countries.

Although it is generally satisfactory to compute the prediction errors and then decide whether or not a model is acceptable on the basis of estimated errors, for complex economic models such as the one constructed in this study more sophisticated validation tests are absolutely necessary. The simulation approach to carry out an extensive sensitivity analysis is often a time consuming task. Nevertheless, the application of sensitivity theory is a very powerful tool in assessing the validity of the model. One can also learn which parameters are most critical, as sometimes a small change in a parameter value can result in a large change in the projections of some dependent variables and therefore causing a considerable effect on the behaviour of the system.

SIMULATIONS

The object, here, is the simulation of various hypotheses on the allocation of investment and manpower to different sectors of the COMECON countries and the analysis of the results obtained for the effects on the production and supply aspects of the economies as well as on their international trade flow patterns. There are four input quantities in each production model which are simulated by introducing suitable values of the control parameters. Two kinds of formation of variants appear suitable to develop a multivariate analysis of the economic development of the COMECON community. The firs one is the formation of variants of partial deviations; i.e., all the input variables subjected to simulation experiments are set to their average values except for one of them, which is deviated by maximum or minimum trend values resulting in two variants of the economy. Therefore, a pair of variants is generated for each input variable while its variable trend is given a positive or negative value, and the other variable trends set equal to zero. If the simulation experiment applies to n variables, $2n + 1$ variants will be generated by this method. The second type of formation of variants is obtained by considering the combined deviations in the control parameters. In this case, all the combinations of upper and lower deviations are substituted and none of the quantities involved remains at its mean value. Therefore the number of variants generated will be

2^n, for n input variables, and the total number of variants of the system will then be $(2n + 1) + 2^n = 25$ for $n = 4$.

For experimentation around the basic variant, 8 % 'upper' and 8 % 'lower' deviations are chosen in the case of parameters ${}^{V}u_{11}$, ${}^{V}u_{13}$, ${}^{V}u_{21}$, ${}^{V}u_{23}$ (investment), whereas 4 % 'upper' and 4 % 'lower' deviations are accepted for the parameters ${}^{N}u_{11}$, ${}^{N}u_{14}$, ${}^{N}u_{21}$, ${}^{N}u_{24}$ (labour supply). The projections of the 25 variants are computed first in the observation period 1960-72 and then in the prediction period 1967-84. The results of the simulation experiments are tabulated by using two main criteria in sorting out the variants; (a) the percentage distribution of national income as total investments, whereby five groups of variants are obtained each containing five variants, (b) within each group the variants are sorted out according to the rate of growth of the output variable investigated. As an example the annual growth rates of the regional trade flows are computed for all the variants, and the simulated percentage growth of the total imports in 1980 are tabulated in Table 6 for the USSR and in Table 7

Percentage of accumulated income	17.2	16.8	16.4	16.0	15.6
Rates of growth of total imports for each variant	7.65 [23]	7.51 [16]	* 7.34 [8]	7.45 [15]	7.31 [24]
	7.39 [10]	7.25 [21]	* 7.12 [7]	7.18 [19]	7.03 [12]
	* 7.12 [2]	* 7.08 [4]	* 7.00 [1]	* 6.93 [5]	* 6.89 [11]
	6.98 [13]	6.82 [18]	* 6.89 [6]	6.74 [20]	6.58 [11]
	6.78 [25]	6.62 [14]	* 6.68 [9]	6.53 [17]	6.37 [22]

Table 6. Simulated growth rates of the total imports of the USSR in 1980.

Percentages of accumulated income	23.2	22.6	22.2	21.7	21.1
Rates of growth of total imports for each variant	7.25 [23]	7.03 [16]	* 6.92 [8]	6.86 [15]	6.64 [24]
	7.20 [10]	6.99 [21]	* 6.82 [7]	6.81 [19]	* 6.60 [3]
	7.00 [13]	* 6.91 [4]	* 6.80 [1]	* 6.69 [5]	6.60 [12]
	* 6.99 [2]	6.78 [18]	* 6.78 [6]	6.60 [20]	6.38 [11]
	6.96 [25]	6.74 [14]	* 6.67 [9]	6.56 [17]	6.34 [22]

Table 7. Simulated growth rates of the total imports of the COMECON excluding the USSR in 1980.

for the other COMECON countries. Significantly large and equably distributed variations around the basic variant can be clearly observed for both subregions of the COMECON community. The corresponding GNP growth rates of both regions are also tabulated in Tables 8 and 9. The squares with "*" sign indicate the variants of partial deviations. The third column in the tables contain only this form of variants under a zero deviation of investment but lower and upper deviations of labour supply variables. The basic variant, denoted by (1) is naturally at the centre. The effects of labour supply policy for individual fixed investment policies can be investigated by moving down in the columns. Similarly, by moving from left to right in the rows the investment policy is changed for each fixed labour supply policy.

Finally, the success of COMECON foreign trade is investigated relative to their economic development under various different eco-

Percentages of accummulated income	17.2	16.8	16.4	16.0	15.6
Rates of growth of national income for each variant	5.89 [23]	5.68 [16]	* 5.66 [8]	5.93 [15]	5.72 [24]
	5.60 [10]	5.39 [21]	* 5.41 [7]	5.64 [19]	5.43 [12]
	* 16.9 / 5.25 [2]	* 16.5 / 5.37 [4]	* 16.3 / 5.27 [1]	* 16.1 / 5.16 [5]	* 5.29 / 5.29 [3]
	5.08 [13]	4.87 [18]	* 5.13 [6]	5.12 [20]	4.91 [11]
	4.83 [25]	4.60 [14]	* 4.86 [9]	4.86 [17]	4.64 [22]

Table 8. Simulated GNP growth rates of the USSR in 1980.

nomic policies on the allocation of investment and labour supply resources. This is simply done by assuming that the net material product volumes of both COMECON subregions can be accepted as the main indicator of their economic development, and the total balance of trade of the COMECON block with the rest of the world countries can be taken as the main factor in judging the success of their international trade policies.

The balance of trade with the non-COMECON area is plotted in Graph 1 against the total production of the whole COMECON region for the 25 variants. In Graphs 2 and 3 regional policies are investigated for both COMECON subregions by plotting the regional net material production volumes instead of the COMECON total. It is clearly observed that the balance of trade with the non-COMECON area increases with growing NMP in favour of the COMECON block. However, the cyclic nature of the response shows that a larger NMP

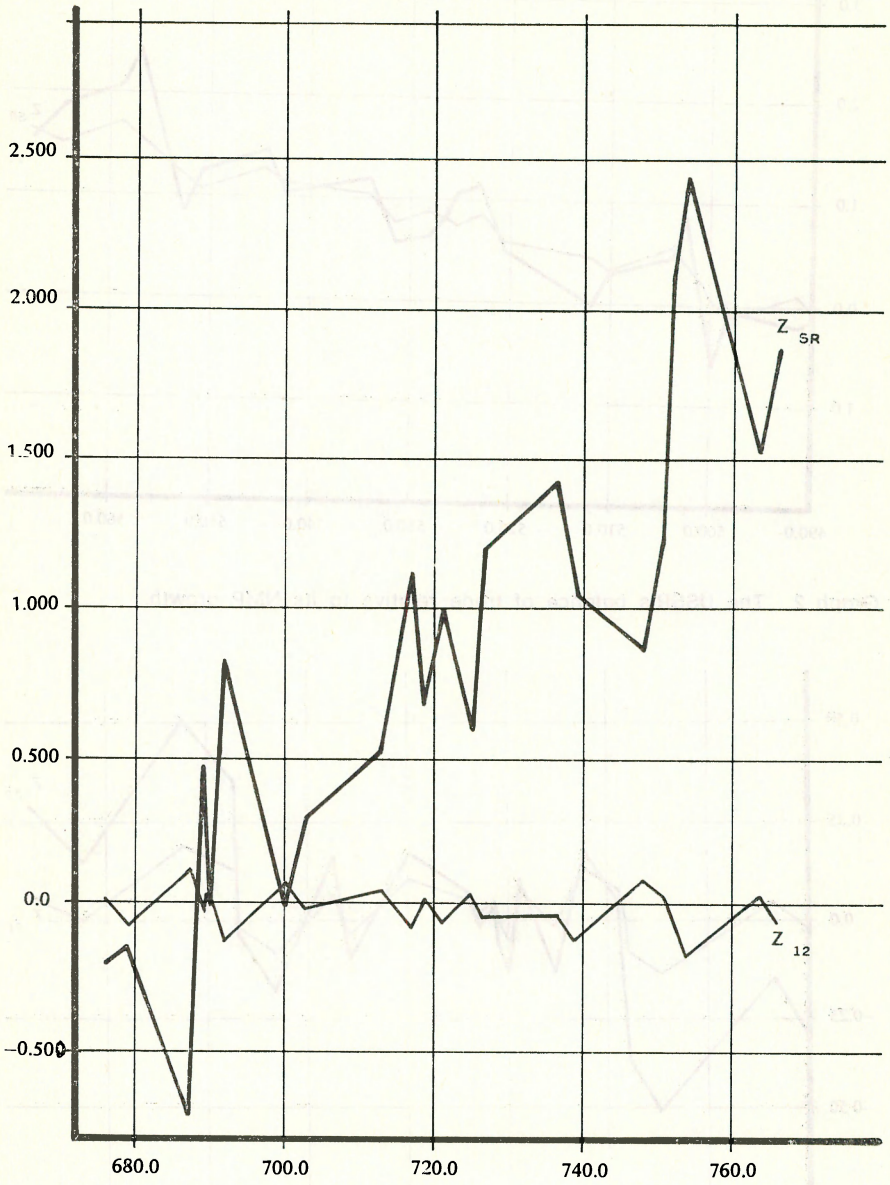
Percentages of accumulated income	23.2	22.6	22.2	21.7	21.1
Rates of growth of national income for each variant	6.55 [23]	6.28 [16]	* 6.24 [8]	6.23 [15]	5.96 [24]
	6.52 [10]	6.25 [21]	* 6.13 [7]	6.20 [19]	* 21.4 5.95 [3]
	6.31 [13]	* 22.4 6.25 [4]	* 22.1 6.13 [1]	* 21.9 5.98 [5]	5.92 [12]
	* 22.9 6.28 [2]	6.63 [18]	* 6.10 [6]	5.98 [20]	5.70 [11]
	6.27 [25]	6.00 [14]	* 5.99 [9]	5.95 [17]	5.67 [12]

Table 9. Simulated GNP growth rates of the COMECON excluding the USSR in 1980.

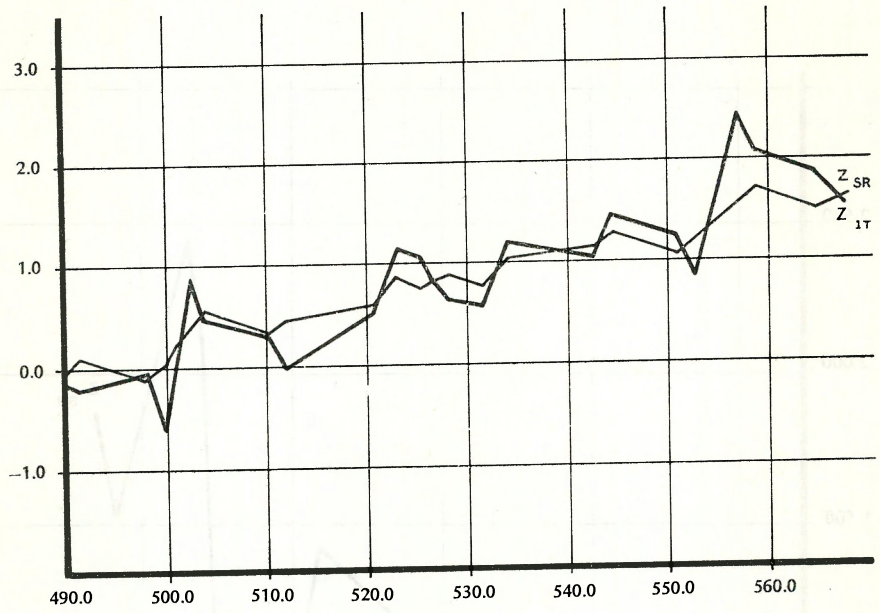
growth does not necessarily result in reaching a better balance of payments position. Once the main objectives of the economic development are decided and the lower and upper bounds of the input quantities are set to their acceptable values, it may be necessary to develop optimality criteria to search for the best variant to reach the maximum efficiency in trading with the non-COMECON area. However, the information obtained from a multivariate analysis with 25 variants is very limited and to be able to reach a reasonable sub-optimal solution the number of variants should be sufficiently large.

CONCLUSIONS

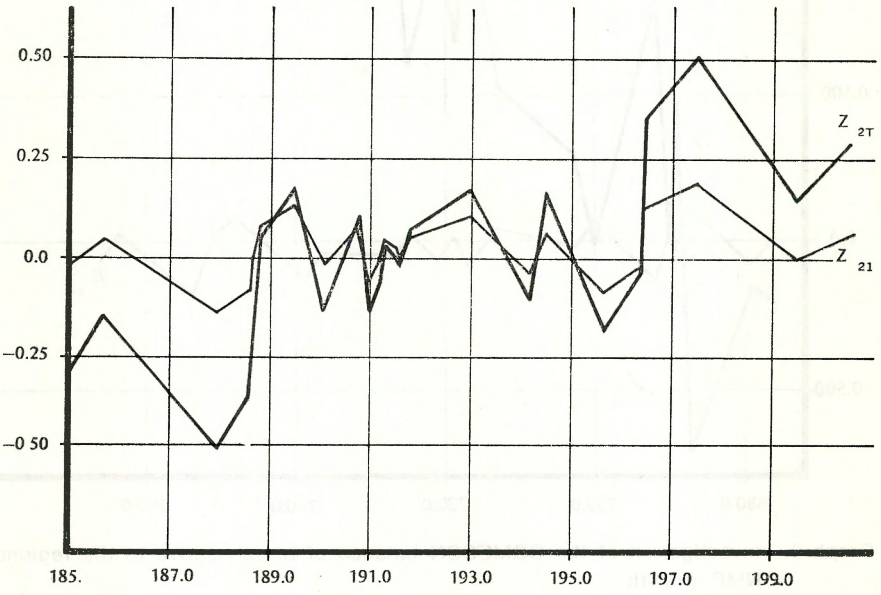
The dynamic simulation model of the COMECON multicommodity trade flows developed in this study represents one of the first attempts to link multi-sector socialist country models with the available national models of the rest of the world countries. However,



Graph 1. Investigation of the COMECON balance of trade relative to the regional NMP growth.



Graph 2. The USSR's balance of trade relative to its NMP growth.



Graph 3. The balance of trade of the COMECON excluding the USSR relative to its reginal NMP growth.

the usefulness of this study is restricted by the fact that the present role of the COMECON foreign trade in the world model is quite small, and one cannot be too optimistic about the future unless some structural changes are introduced by the socialist governments in order to weaken the present trade barriers with the West. On the other hand, the role of price fluctuations in world markets are unquestionably very important for some of the Eastern European countries. Therefore, a dynamic simulation analysis of their exports and imports referred to relative world market prices and the economic development of their trading partners could provide an ideal basis for the selection of the most efficient foreign trade policies.

The trade model constructed in this study has been based on several important simplifying assumptions, which unfortunately weaken the significance of the numeric results, on the specification and parameter estimations of the models. Nevertheless, despite all the assumptions made and the poor quality of the available time-series data the results obtained with various policy simulations of the COMECON models within the simplified version of the world model provide some useful information to the socialist planners on the dynamic behaviour of the system under different policies of economic development.

Dynamic simulation methods have been used extensively in this study, and the author firmly believes that simulation is a very powerful tool for economic analysis and model building; particularly in dealing with the dynamic behaviour of complex economic systems over time. In contrast to some other mathematical approaches to the analysis of dynamic systems, simulation enables the investigator to determine not only the long-run state of the system, but also the trajectory through which the system travels to reach the final state.

The explanatory power of an econometric model such as the COMECON Model which uses autoregressive terms extensively cannot be indicated only by the standard regression statistics. Therefore, unless the validity of a complex macroeconomic system is verified by an extensive statistical simulation analysis, the usefulness of the econometric model would be very much in doubt. Sensitivity analysis in this respect has been found very promising to ascertain the systems properties to variations of the parameters within the the limits of statistical significance.

For a possible implementation of the proposed methodology of foreign trade model building for COMECON countries within the

LINK project or in their central plans, more team research supervised by international and socialist planning organisations should be undertaken along the following main lines in order to improve the present over-simplified form developed in this study of the actual dynamic system; (i) the region representing the COMECON countries excluding the USSR should be disaggregated into individual country models, (ii) each model should be respecified to suit the economic development of the socialist country concerned including price relationships for the trade with the non-COMECON area, (iii) detailed, preferably quarterly national data should be available from each centrally planned country, (iv) considerable amount of statistical and econometric work is required in the modelling of each economy, (v) a stochastic analysis is inevitable in order to set safety levels in decision making owing to the uncertainty involved in the estimations, (vi) in order to solve the final system for optimal foreign trade policies, the models should be suitably respecified so that the system could be solved as a large dynamic linear programming problem in primal and dual directions by using a suitable iterative solution algorithm. The development of research in the above directions is of course not possible without the full cooperation of the socialist planning organizations.

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ÖZET

COMECON DIŞ TİCARETİNİN BİR ORTA - DÖNEM DİNAMİK BENZEŞİM MODELİ

Bu çalışmada COMECON ülkelerinin iç ve dış ticareti çok ürünlü (multicommodity), bölgelerarası (interregional) bir çözümlemeyi içeren dinamik bir benzeşim modeli çerçevesinde incelenmektedir. Modelin ulusal veya bölgesel düzeydeki tutarlığı (internal consistency) COMECON ülkelerinin çok-sektörlü (multi-sector) üretim modellerinin sisteme dahil edilmeleri ile sağlanmıştır. Çalışma kapsamında, uluslararası tutarlılık (international consistency) şartı ise ancak LINK Sistemi yöntemlerine uygun bir şekilde düzenlenen üç bölgeli basit bir dünya modelinin geliştirilmesi ile gerçekleştirilebilmiştir. Sistemin tasarımında, olurluluğunun denenmesinde ve dinamik yapısının incelenmesinde çeşitli ekonometrik, istatiksel ve sistem çözümleme yöntemleri kullanılmış, sonuçlar değerlendirilerek gerçek sisteme yeterli bir düzeyde uyumun sağlanması için modelde gerekli görülen bazı değişmeler yapılmıştır. Çalışmada son olarak COMECON ülkelerinin sektörel, insan gücü ve kapital yatırımlarındaki değişik varsayımların ekonomik gelişim hızları ve dış ticaret dengelerine olan etkileri benzeşim modeli çerçevesinde deneysel olarak araştırılmıştır.